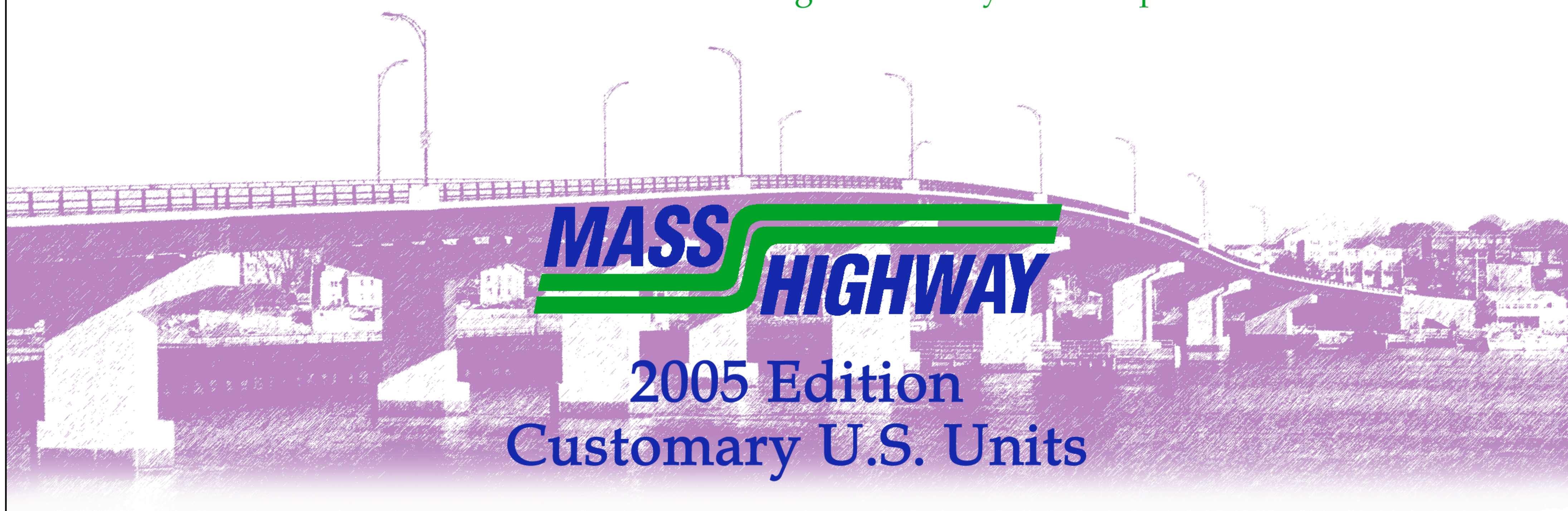
The Commonwealth of Massachusetts

Bridge Manual

Part I & Part II

Massachusetts Highway Department



2005 Edition

Customary U.S. Units

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BRIDGE MANUAL
PART I: DESIGN GUIDELINES
TABLE OF CONTENTS

CHAPTER 1: BRIDGE SITE EXPLORATION

CHAPTER 2: PRELIMINARY ENGINEERING GUIDELINES

CHAPTER 3: BRIDGE DESIGN GUIDELINES

CHAPTER 4: CONSTRUCTION DRAWINGS

CHAPTER 5: SPECIAL PROVISIONS AND ESTIMATE (Revised June 2007)

CHAPTER 6: SHOP DRAWINGS, CONSTRUCTION PROCEDURES, AND OTHER SUBMISSIONS

CHAPTER 1
BRIDGE SITE EXPLORATION

1.1 SURVEY FOR BRIDGES

1.1.1 General

The following are the minimum survey requirements for bridge projects and the reasons for them. Additional survey beyond these requirements may be needed depending on the complexity of either the proposed bridge structure or the site.

1.1.2 Bridge Grid Survey

The bridge grid is taken in order that the proposed bridge may be fitted to the topography and an accurate calculation can be made of excavation quantities. It shall be plotted to either ⅛" = 1'- 0" or ¼" = 1'- 0". The frequency of shots and extent must be a matter of judgment of the survey party. In general, shots should be taken on a 10 foot grid with additional shots as necessary for abrupt changes in contour. They should extend at least 50 feet beyond the edges of the highway or 25 feet beyond the anticipated end of splayed wingwalls, whichever is furthest, and should cover enough ground for any type of structure. The grid should be extended to reflect topography under existing structures.

1.1.3 Bridge Detail Survey

The following survey information shall be requested when: a new superstructure is to be built on existing substructures; an existing bridge is to be replaced in stages; an existing bridge is to be widened, repaired, or rehabilitated; or when the underclearances for the existing bridge are important to the underclearances to be provided at the replacement, such as for replacement bridges over water or railroads. The accuracy of surveys on bridge locations shall be greater than on general highway work. A copy of all field notes shall be provided to the Designer.

1. The angles of the abutments with the baseline, the location of tops and bottoms of batters, the widths of bridge seats and backwalls, the location of the angles of the wingwalls with abutments, the length of wingwalls and widths of copings shall be measured and the footings located if possible. The type of masonry in the substructure and its condition should be noted.

2. Detail shall be provided for all main superstructure elements, including beam lines, girder lines, truss lines, floorbeam lines, curb lines, sidewalks, fascia lines, utilities, copings, ends of bridge, etc. The stations of the centerlines of bearings and the skew angle between them and the survey baseline shall be established or verified at each abutment and at piers.

3. Bottom of beam elevations shall be taken on every beam at: the face of each abutment, both sides of each pier and span quarter points for spans less than 50 feet, span eighth points for spans over 50 feet. These elevations are needed for calculating the depth of haunches and top of form elevations.

4. Elevations shall be taken of all parts of the substructure and superstructure, such as the bridge seats, tops and ends of wingwalls, gutters, top of curb at intermediate points and at the ends of curbs, tops of slab and footings, if possible. All elevations shall be referred to the North American Vertical Datum (NAVD) of 1988. If only the National Geodetic Vertical Datum (NGVD) of 1929 is available at the site, the Designer shall contact the MassHighway Survey Engineer and obtain the relationship between NAVD and NGVD at the site.

5. Locate and establish the minimum horizontal and vertical underclearances of the existing structure.

1.1.4 Additional Survey for Bridges over Railroads

Whenever a railroad is crossed, the railroad baseline should be reproduced and sections taken a minimum of 50 feet perpendicular to and on both sides of the exterior rails for a distance of about 300 feet left and right of the survey baseline.

1.1.5 Survey for Stream

The stream shall be surveyed for a distance up and downstream of at least 500 feet either side of the baseline. Elevations should be taken on a 10 foot grid. Any tributary entering the stream near the bridge site, either above or below, shall be surveyed for a distance of at least 500 feet from its junction. Locations and size of visually accessible drain pipes should be noted. Where there is any possibility of a relocation of existing stream, adequate survey shall be taken to encompass the relocation.

If there is a dam or other water flow control device within 1500 feet either up or down stream, the survey shall include: its distance from the bridge; elevations of the spillway, the top of the dam, water and riverbed soundings both upstream and downstream of the dam.

1.2 BORINGS FOR BRIDGES

1.2.1 General

No structure can be stronger than the founding of its substructure elements. Borings are taken for these elements and the study of the results and samples aids in the determination as to the type of foundation support.

In general, all design borings are typically made at one time. On major projects involving the construction of multiple bridges, pilot borings may be required.

1.2.2 Boring Plan

Boring plans for bridges shall be prepared as outlined in Section 1.3 of Part II of this Bridge Manual. They will be drawn on a single sheet of paper no smaller than 8½” x 11” and shall contain the following information:

1. The standard title block (Drawing No. 1.3.1 of Part II).

2. A 1” = 40’ plan view of the proposed structure, with the boring locations indicated by the standard symbol and a table indicating: boring number, station and offset from baseline,

approximate surface elevation, and specified highest bottom elevation (Drawing No. 1.3.2 of Part II).

3. Boring Request Notes, from Drawing No. 1.3.3 of Part II of the Bridge Manual, and modified as indicated on the drawing.

Four copies of the proposed boring plan shall be submitted to the MassHighway Project Manager who will transmit 2 copies to the Geotechnical Section and 1 copy to the Bridge Section for review. The Geotechnical Section shall review the proposed boring plan in the office and in the field, shall accept the Bridge Section's comments, and shall transmit all comments to the Designer for boring plan modification and resolution. The Designer shall then forward the revised (if applicable) boring plan to the Geotechnical Section for acceptance. Upon acceptance, the Geotechnical Section shall initiate and conduct the subsurface investigation through its drilling contractor.

1.2.3 Definitions

1.2.3.1 Pilot Borings. Major projects involving the construction of multiple bridges may require pilot borings, which are those made during the preliminary stage of a project. These borings shall be located by the Designer as scattered points, to yield only sufficient soil information to enable the Designer to:

1. Prepare a preliminary foundation assessment.
2. Fix the profile, alignment of the highway, and position of the structures.
3. Prepare a preliminary cost of the project.

1.2.3.2 Design Borings. Design borings are made to furnish all subsurface data and soil samples required by the Designer to complete the design of the project. Design borings may also consist of control and complementary borings as defined below. These borings are to be made after the profile, alignment, location, and type of structure have been approved. Borings in the pilot set that fit into the pattern of the design borings shall not be duplicated.

1.2.3.3 Control Borings. Control borings are the initial design borings. The results obtained from control borings are reported immediately to the Designer so that, at each area and location, the depth to which all remaining complementary borings should be taken can be determined.

1.2.3.4 Complementary Borings. Complementary borings are the remaining design borings required for design and construction purposes. They are made after an analysis of the results obtained from the control borings, to the depth specified by the Engineer. Usually, the Designer and the MassHighway's Geotechnical Section and/or Bridge Section jointly review the results of the control borings to determine the depths of the structural complementary borings. Generally, all bridge complementary borings are made. Complementary borings are not used for a pilot boring program.

1.2.4 Depth and Location

1.2.4.1 Pilot Borings.

Depth: For structures, the specified highest bottom elevation shall be set 10 feet below the preliminary footing elevation at the boring location. Each boring shall be made to the specified highest bottom elevation or to refusal, whichever is deeper. Refusal is defined as 120 blows for 12 inches of penetration by using the Standard Penetration Test (SPT). If rock is encountered above highest bottom elevation, a 10 foot long rock core is taken and the bore hole is terminated.

Location: One boring per bridge site. Consideration of a rock core should be made at this time if rock would influence the foundation design.

1.2.4.2 Design Borings.

Depth: For structures, the specified highest bottom elevation shall be set 10 feet below the preliminary footing elevation at the boring location. For perched abutments, the specified highest bottom elevation shall be set 15 feet below existing ground. At least one boring shall be made to bedrock at each bridge location. Where a viaduct of considerable length is to be designed, every other pier may have one boring made to bedrock, if deemed necessary by the Engineer. Where structure foundations may be pile or drilled shaft supported, one boring shall be made to bedrock under each substructure unit.

Location: Borings shall be taken for every bridge, metal arch, box culvert with a span greater than 8 feet, retaining wall, and "highmast lighting foundation". Borings may be required for sign supports. For smaller structures, engineering judgment should govern.

One boring shall be made at each end of each pier or abutment and at the outer end of each wingwall more than 30 feet long. Where piers and/or abutments are more than 100 feet long, additional borings may be required.

For retaining walls up to 100 feet in length, at least one boring shall be taken at each end of the wall. For walls longer than 100 feet, borings shall be spaced no more than 100 feet apart. Wall borings shall be alternately control and complementary.

For culverts up to 50 feet in length, two borings will be required. For culverts longer than 50 feet, three borings will be required.

The preceding description is given as a guide and should not pre-empt sound engineering judgment. Likewise, the depth to which borings are carried may vary, depending on design requirements. Where utilities are present, the borings shall be accurately located no closer than 5 feet from the nearest edge of the utility.

1.2.5 Other Subsurface Exploratory Requirements

1.2.5.1 The additional subsurface explorations outlined below will be included as part of the boring program. Any laboratory test program on the recovered boring samples required by the Designer which is to be done at an outside testing laboratory shall be approved by MassHighway before any work is done.

1.2.5.2 Under certain conditions, test pits may be needed to disclose certain features of existing structures that may be retained. Test pits shall be dug to establish the elevations of the top and bottom of the footing toe as well as the projection of the toe from the face of the abutment or wall. A minimum of two test pits shall be dug at each abutment, one approximately at each end of the abutment.

1.2.5.3 Exploratory probes will be taken, in conjunction with horizontal cores if required, for all abutments and walls which may be retained and for which accurate plans do not exist. These exploratory procedures are needed to determine the cross sectional geometry of the wall, such as width, batter and footing thickness, from which the re-use potential of the structure can be evaluated. Provisions for this type of investigation will be included as part of the boring program.

1.2.5.4 If a clay stratum or other compressive material is encountered, in-situ tests and/or undisturbed samples may be required for laboratory tests and analysis. Generally, this type of work is accomplished in the complementary boring program after the results of the control borings are reviewed.

1.2.6 Ground Water Observation Wellpoint

Ground water level as reported during a soil-test boring operation may not be accurate, since the water level in a test boring may not have had sufficient time to stabilize or may be affected by the use of water in the drilling process. When a study of the pilot or control borings indicates that an excavation in granular soil must be made below ground-water-level, observation wellpoints should be installed. Not more than one (1) observation wellpoint should be installed at a bridge except with prior approval of the Engineer. Unless otherwise directed, the bottom of the point shall be located approximately 10 feet below the proposed bottom of footing.

District personnel will measure and report water levels monthly to the Engineer, unless more frequent readings are required. This information is to be tabulated on the Sketch Plans and Construction Drawings (see Paragraph 2.7.3.3 for Sketch Plans and Paragraph 4.2.2.3 for Construction Drawings).

1.2.7 Inaccessible Boring Locations

Because of certain physical conditions, such as existing buildings, overhead wires, or because of problems with abutters, boring crews may have no access and certain borings specified for the structure cannot be taken. In such cases, the additional required borings may be included in the construction contract. This allows the successful bidder for the contract to take these additional borings without interference, since the project site must be cleared of all structures prior to commencing construction.

The additional borings shall be examined in the Bridge Section to determine if any changes will be required in the design of the foundations. The estimated linear footage of the borings and their cost shall be included in the Designer's estimate. The location of these additional borings shall be shown on the contract plans. It should be noted, however, that every possible effort should be made to obtain the required substructure information during the design stage.

1.2.8 Presentation of Sub-surface Exploration Data

All borings, test pits, or seismic information that have been taken must appear on the plans, even though some of the borings may be exploratory. This is true even though some of the borings are taken for one site and later the line is changed so that new borings are required. It is mandatory that borings for both lines be shown on the plans.

The exact logs, as specified in the boring contract, must be shown on the plans. If the logs are transcribed on plan sheets, the transcriptions must copy all information exactly as it appears on the logs, including any abbreviations and misspellings. It is not necessary to show the blow count for driving the casing. Data relative to core recovery shall be shown on the boring log. It is the responsibility of the boring contractor to accurately describe the soils obtained with the sampler. In printing the description of soils, abbreviations shall be avoided.

The elevations of ground water level at the completion of the boring, unless otherwise specified on the log, shall be shown on the boring log. This elevation may be of great importance in order to determine water control measures for constructing the footing in the dry.

The bottom (top if on ledge) of the proposed footing of each element of the substructure shall be plotted adjacent to the appropriate boring log. Borings shall be plotted in groups as they apply to substructure units for ready reference. In the case of a trestle, the bottom of each pile cap shall be shown on the boring logs.

Boring results shall be plotted to true relative elevation to a scale of not less than ⅛" = 1'- 0". Deep borings may offset or show discontinuity only in the event that they cannot be completed in one column.

When posting boring logs on the plans the Designer shall post both depth and elevation at each change in strata.

1.3 HYDROLOGY AND HYDRAULICS

1.3.1 Introduction

The purpose of this section is to provide guidance regarding the performance of hydraulic studies for MassHighway bridges. These studies are required under the Federal Aid Policy Guide, 23 CFR 650A and the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Highway Bridges*, Article 1.3.2. The detail of hydraulic studies should be commensurate with the significance of the structure to the transportation network and with the risks associated with its failure. The guidelines contained herein are not intended to address all contingencies associated with the hydraulic design of bridge structures. In atypical situations, early consultation with the MassHighway Hydraulic Engineer is recommended.

1.3.2 Hydraulic Design Criteria

Hydraulic design criteria to be used for MassHighway bridges are enumerated below. These criteria are consistent with the AASHTO *Hydraulic Design Guidelines*. These criteria are subject to change when conditions so dictate as approved by MassHighway.

1. To the extent practicable, the proposed facility shall not cause any significant change in the existing flow regime over the range of discharges considered. At sites covered by the National Flood Insurance Program (NFIP), conformance with Federal Emergency Management Agency (FEMA) regulations and regional policy is required.

2. To the extent practicable, pier spacing and orientation, and abutments shall be designed to minimize flow disruption and potential scour.

3. Bridge foundation scour shall be evaluated considering the magnitude of flood, through the 500 year return frequency event, that generates the maximum scour depth.

4. Where practicable, a minimum of 2 feet shall be provided between the design approach water surface elevation and the low chord of the bridge for the final design alternative to allow for the passage of debris and ice. Where this is not practicable, the clearance should be established by the Designer based on the type of stream and level of protection desired as approved by MassHighway. For navigational channels, a vertical clearance conforming to Federal requirements should be established based on normally expected flows during the navigation season.

5. The proposed facility shall have minimal disruption of ecosystems and values unique to the flood plain and stream.

6. Design choices should support costs for construction, maintenance and operation, including probable repair and reconstruction and potential liability, that are affordable.

1.3.3 Hydraulic Study Procedure

1.3.3.1 Although each individual crossing site is unique, the following procedure should be applied to MassHighway bridges unless indicated otherwise by MassHighway.

1.3.3.2 Data Collection. The purpose of this phase is to gather all necessary information regarding the crossing site. The effort expended should be commensurate with the significance and complexity of the project. The following categories of information should be considered.

1. Historic

    1.1. Topographic/photogrammetric maps.
    1.2. Surfical/subsurface Geologic maps.
    1.3. Documented highwater marks.
    1.4. Anecdotal or documented history of debris accumulation, ice, and scour.
    1.5. Maintenance/inspection records of existing structures (consult MassHighway or Town Maintenance officials as well as MassHighway Bridge Inspection database).
    1.6. Aerial photographs (consult MassHighway survey).
    1.7. Rainfall and stream gage records.

2. Field Survey

    2.1. Topographical/bathymetric including channel profiles, cross sections, spot soundings, waterway opening geometry.

2.2. Tidal monitoring (if applicable).

3. Studies by MassHighway and other agencies

3.1. National Flood Insurance Program (NFIP) Flood Insurance Studies (FIS).
3.2. Federal Flood Control Studies by the U.S. Army Corps of Engineers (USACOE) and National Resource Conservation Service (NRCS).
3.3. State and Local Flood Plain Studies.
3.4. MassHighway hydraulic studies of existing adjacent or hydraulically similar bridges.
3.5. National Oceanic and Atmospheric Administration (NOAA) National Ocean Service database.
3.6. United States Geological Survey (USGS) National Water Data Exchange (NAWDEX), Hydrologic Data Reports, Hydrologic Investigation Atlases.

4. Influences on Hydraulic Performance of Site

4.1. Other streams, reservoirs, water intakes.
4.2. Structures upstream or downstream.
4.3. Natural features of stream and flood plain.
4.4. Channel modifications upstream or downstream.
4.5. Flood plain encroachments.
4.6. Sediment types and bed forms.
4.7. Storm surge (if applicable).
4.8. Daily and Spring tidal cycle (if applicable).

5. Environmental Impact

5.1. Existing bed or bank instability.
5.2. Flood plain land use and flow distribution.
5.3. Environmentally sensitive areas (fisheries, salt and fresh water wetlands, endangered species habitat).
5.4. Hazardous materials.
5.5. Land use and culture in the vicinity of the project site.
5.6. Recreational/Navigational use.

1.3.3.3 Hydrologic Analysis.

1. Watershed Morphological Considerations

1.1. Drainage area.
1.2. Watershed and stream slope.
1.3. Channel geometry.
1.4. Degree of urbanization/regulation.
1.5. Soil/vegetation cover.
1.6. Natural/built flood storage areas.
1.7. Natural/built flow controls.

2. Hydrologic Computations. Recommended methods include:

2.1. United States Geologic Survey (USGS) Open Report 80-676 (Reference 19) (Note: this recommendation is interim pending the publication of upgraded USGS rural regression equations).
2.2. NRCS Technical Releases 20 and 55 (References 10 and 11).
2.3. USACOE HEC-HMS (Reference 17).
2.4. Log Pearson III Flood Frequency Analysis at sites on gaged waterbodies (Reference 18).
2.5. Other standard engineering methods may be used subject to approval by the MassHighway Hydraulic Engineer.

3. In general, results from several methods should be compared (not averaged) so as to identify the discharges that best reflect local project conditions with the reasons documented. Further, to establish the existing flow regime at the crossing site, it will be necessary to estimate at least the 10-, 50-, and 100-year return frequency discharge peaks.

4. Design Frequency. The design frequency is the recurrence interval of the flood for which the bridge structure is sized to assure that no traffic interruption or significant damage will result. The overtopping flood and the design frequency flood may vary widely depending on the grade, alignment and classification of the road and the characteristics of the water course and floodplain. See Subsection 1.3.4, *Design Flood or Storm Selection Guidelines*.

5. At sites within a Regulatory Floodway, discharges from the associated FIS should be evaluated and adopted if judged reasonable by the Designer. If the FIS flows are determined to be unreasonable and new flow estimates are developed, coordination with FEMA officials will be required.

6. In the case of tidal crossings, the influence of the tide on flow regime shall be considered. Because many tidal bridges are influenced by freshwater as well as tidal flows, the return frequency of the design event is not well defined. The joint probability of riverine floods occurring simultaneously with storm tides, high tides, low tides, and maximum flood and ebb flows must be assessed to determine the magnitude and return frequency of the design event.

1.3.3.4 Hydraulic Analysis.

1. Computer Modelling. A crossing site is subject to either free-surface flow or pressure flow through one or more bridge openings with possible embankment overtopping. It is impractical to perform the hydraulic analysis for a bridge by manual calculations due to the interactive and complex nature of those computations. These hydraulic complexities should be analyzed using water surface profile computer programs such as USACOE HEC-RAS (Reference 12) unless indicated otherwise by MassHighway.

2. Hydraulic performance for existing and proposed conditions under at least the 10-, 50-, 100-, and 500-year discharge peaks should be evaluated for all alternatives considered in the hydraulic study.

3. If a bridge site is located on a waterway reach designated as a regulatory floodway within the NFIP, then the hydraulic model of existing conditions must be calibrated against the waterway's flood profile as illustrated in the associated (FIS).

4. At tidal crossing sites, the time dependent correlation between tide stage, discharge, and velocity must be evaluated. The detail of analysis should be commensurate with the significance of the structure and the complexity of site hydrodynamics. In general the use of one dimensional dynamic computer models such as ACOE's UNET (Reference 13) is recommended. However, large and complicated tidal bridge projects may warrant assembly and calibration of a two dimensional finite element model (References 4 and 15). Early consultation with the MassHighway Hydraulic Engineer to determine an appropriate level of project specific hydrodynamic analysis is recommended.

1.3.3.5 Scour/Stability Analysis.

1. Reasonable and prudent hydraulic analysis of a bridge design requires that an assessment be made of the proposed bridge's vulnerability to undermining due to potential scour. Scour assessment should be consistent with the guidelines set forth in the FHWA's Hydraulic Engineering Circular No. 18 (HEC-18), "Evaluating Scour At Bridges" (Reference 6), HEC-20, "Stream Stability at Highway Structures" (Reference 7), and HEC-23, “Bridge Scour and Stream Instability Countermeasures (Reference 8). All alternatives considered should be assessed for scour potential.

2. Even where there are relief structures on the flood plain or overtopping occurs, some flood other than the 500-year flood or "super flood" may cause the worse case bridge opening scour. This situation occurs where the bridge opening will pass the greatest discharge just prior to incurring a discharge relief from overtopping or a flood plain relief opening. Conversely, care must be exercised in that a discharge relief at the bridge due to overtopping or relief openings may not result in reduction in the bridge opening discharge. Should a reduction occur, the incipient overtopping flood or the overtopping flood corresponding to the 500-year flood or "super flood" would be used to evaluate the bridge scour.

1.3.4 Design Flood Or Storm Selection Guidelines

Inundation of the travelway dictates the level of traffic service provided by the facility. The travelway overtopping flood level identifies the limit of serviceability. Table 1.1 below relates desired minimum levels of protection from travelway inundation to functional classifications of roadways. The Designer shall note that Federal law requires interstate highways to be provided with protection from the 2% flood event.

A. TABLE 1.1 DESIGN STORM SELECTION GUIDELINES

Roadway Classification	Exceedence Probability	Return Period
Rural Principal Arterial	2%	50 year
Rural Minor Arterial	4% - 2%	25 - 50 year
Rural Collector, Major	4%	25 year
Rural Collector, Minor	10%	10 year
Rural Local Road	20% - 10%	5 - 10 year
Urban Principal Arterial	4% - 2%	25 - 50 year
Urban Minor Arterial Street	4%	25 year
Urban Collector Street	10%	10 year
Urban Local Street	20% - 10%	5 - 10 year

1.3.5 Hydraulic Study References

1. AASHTO, Volume VII-Highway Drainage Guidelines, *Hydraulic Analyses for the Location and Design of Bridges*, AASHTO Task Force on Hydrology and Hydraulics, 1999.

2. AASHTO, *Model Drainage Manual*, 1999.

3. AASHTO, *Standard Specifications For Highway Bridges*, 17th Edition.

4. FHWA, FESWMS-2DH, "Finite Element Surface Water Modeling System: Two Dimensional Flow in a Horizontal Plane", User's Manual, 1996.

5. FHWA, FHWA-IP-89-016, "Design of Rip Rap Revetment", HEC-11, March 1989

6. FHWA , NHI 01-001, "Evaluating Scour at Bridges", HEC-18, May 2001

7. FHWA , NHI 01-002, "Stream Stability at Highway Structures", HEC-20, May 2001

8. FHWA , NHI 01-003, "Bridge Scour and Stream Instability Countermeasures", HEC-23, May 2001

9. FHWA, NHI 01-004, "Highways in the River Environment-Hydraulic and Environmental Design Considerations", Hydraulic Design Series No. 6 (HDS-6), 2001

10. NRCS, "Computer Program for Project Formulation Hydrology", Technical Release No.20 (TR-20), 1983

11. NRCS, "Urban Hydrology for Small Watersheds", Technical Release No.55 (TR-55), 1986.

12. USACOE, HEC-RAS, "River Analysis System", Hydraulic Reference Manual Version 3.0, Hydrologic Research Center, Davis , CA , 2001.

13. USACOE, UNET, "One Dimensional Unsteady Flow Through a Full Network of Open Channels", Report CPD-66, 1993.

14. USACOE, DYNLET1, "Dynamic Implicit Numerical Model of One-Dimensional Tidal Flow through Inlets", Technical Report CERC-91-10, 1991.

15. USACOE, "User's Manual for the Generalized Computer Program System; Open Channel Flow and Sedimentation, TABS-2, Main Text and Appendices A through O", Instructional Report HL-85-1, 1985.

16. USACOE, "User's Guide to RMA2 WES Version 4.3", Waterways Experiment Station, Vicksburg, MS, 1997.

17. USACOE, "Hydrologic Modelling System", HEC-HMS, 2002.

18. USGS, "Guidelines for Determining Flood Flow Frequency", Bulletin 17B, 1982

19. USGS, "Estimating Peak Discharges of Small Rural Streams in Massachusetts", Open File Report 80-676, 1982

1.4 SITE SPECIFIC SEISMIC EVALUATION

1.4.1 General

On projects involving the construction or rehabilitation of large, critical, or complex bridge structures, a Site Specific Seismic Evaluation shall be prepared as directed by MassHighway**.**

1.4.2 Site Specific Seismic Evaluation Outline

The Site Specific Seismic Evaluation report shall include the following major elements:

1. PROBABILISTIC SEISMIC HAZARD ASSESSMENT (PSHA)

   1.1 Seismic design criteria including the peak ground acceleration (PGA) will be derived using the following levels of exposure:
   a. Functional Evaluation Earthquake - 10% probability of being exceeded in 50 years (475-year earthquake) as required by the AASHTO standard specifications.
   b. Safety Evaluation Earthquake - 2% probability of being exceeded in 50 years (approx. 2500-year earthquake).

   1.2 The results of the PSHA will be compared with the accelerations obtained by the USGS (1996), and others. The synthetic CA/T, Saguenay 1988, and other artificially generated rock outcrop motions developed for New England, will be considered as input ground motions (scaled to the proper PGA) to perform the 1-Dimensional Response Analysis. It is anticipated that 2 ground motions will be used for each level of exposure (approximately the 500 and 2500 year earthquake).

2. SITE SPECIFIC SOIL/ROCK CONDITIONS.

2.1 Dynamic Geotechnical Properties - In-situ cross-hole seismic velocity measurements will be performed at the site. The objective for the cross-hole seismic velocity measurements is to provide accurate seismic shear wave velocity values for the entire depth of borehole array. To obtain a realistic distribution of seismic velocity measurements, two locations should be selected. The testing will provide P and S-wave velocity measurements (1-D Compression and Shear Moduli at low strains) for soil and underlying bedrock. In addition, empirical correlations between moduli/shear wave velocity and index geotechnical properties (SPT blow count, PI, etc.) that are available from a Subsurface Investigation Program and a Geotechnical Report will be used to determine and confirm the cross-hole seismic velocity wave measurements.

2.2 Based on 2.1, two dynamic soil/rock profiles will be compiled for the site.

3. SOIL RESPONSE ANALYSES (FREE FIELD).

3.1 The objective of this task is to propagate the input motions selected in 1 through the soil/rock columns developed in 2.2. Time histories of accelerations, cyclic shear stresses and strains at different soil profile levels and elastic response spectra (5% structural damping) are calculated. These results can be used to perform the dynamic analysis of the structure. These site-specific response spectra will be compared with the AASHTO provisions.

4. SUMMARY

CHAPTER 2
PRELIMINARY ENGINEERING GUIDELINES

2.1 GENERAL

2.1.1 Purpose of Preliminary Engineering

The purpose of Preliminary Engineering is to obtain sufficient information about the project parameters, through site investigations, material testing, limited structural analysis, and hydraulic and geotechnical studies, to make an informed decision regarding the scope of the project and/or type of structure to be pursued in subsequent phases of the design process.

2.1.2 Goal of a Bridge Project

The goal of any bridge project undertaken in accordance with this Bridge Manual shall be as follows:

- NEW BRIDGE OR BRIDGE REPLACEMENT: to provide a bridge structure that has been designed in accordance with the latest applicable AASHTO and MassHighway Bridge Manual requirements for design and load carrying capacity and which can reasonably be expected to achieve a minimum service life of 75 years.

- REHABILITATED BRIDGE: to provide a bridge structure where all existing structural deficiencies have been repaired, which has been brought up to the latest applicable AASHTO and MassHighway Bridge Manual requirements for design and load carrying capacity and which can reasonably be expected to have its service life extended for a minimum of 75 years after the conclusion of construction.

A "deficiency" is defined as a defect requiring corrective action. For the purpose of this Chapter, Superstructure Replacement and Deck Replacement projects are considered as subcategories of bridge rehabilitation. Under some circumstances, the goal for a rehabilitated bridge may not be fully achieved due to significant project constraints, such as historic considerations. In these situations, MassHighway will work with the Designer to arrive at more realistic project specific goals.

Bridge Betterment and Bridge Preservation Projects are maintenance projects and are not intended to bring the bridge up to the latest applicable AASHTO and MassHighway Bridge Manual requirements for design and load carrying capacity, hence they are not required to meet these goals.

2.1.3 Preliminary Engineering Decision Making Methodology

2.1.3.1 When performing Preliminary Engineering, the Designer must first identify all of the parameters and constraints that either affect the bridge project or that may be affected by the type of project and/or type of structure selected. The Designer must also ascertain how absolute is a project constraint: is there room for compromise or not. Next, the Designer must determine how important each parameter is overall. Finally, the Designer must develop a project solution that optimizes as many of the parameters as possible without violating the constraints. When identifying the parameters and constraints, the Designer must be realistic and practical and should consider actual, real-world problems and situations. The Designer should refrain from giving inordinate consideration to hypothetical, "what if" problems that have little or no possibility of occurring within the life span of the structure.

2.1.3.2 NEW BRIDGE AND BRIDGE REPLACEMENT PROJECTS: Preliminary Engineering is used to select the structure type to be pursued in subsequent phases of the design process that best addresses the project constraints and parameters and best fits the site conditions. This is important because the selected structure type will be easier to design, easier to construct and will be more durable since it will work with the site, not against it. However, the Designer should not select a structure type before starting preliminary engineering and carry it through design, ignoring its incompatibility with the site parameters and constraints. Rather, the Designer should use the Preliminary Engineering process to determine the most appropriate structure type for the given site.

2.1.3.3 BRIDGE REHABILITATION PROJECTS: Preliminary Engineering shall establish all of the deficiencies that need to be addressed by the rehabilitation project, including structural, physical and code/load carrying deficiencies, and will develop strategies of addressing these deficiencies to be pursued in subsequent phases of the design process.

2.1.4 Preliminary Engineering Phase Deliverables

At the conclusion of the Preliminary Engineering Phase, the Designer will provide the following deliverable reports and plans:

- NEW BRIDGE AND BRIDGE REPLACEMENT PROJECTS: Bridge Type Selection Worksheet.
- BRIDGE REHABILITATION PROJECTS: a Preliminary Structure Report. May also require a Bridge Type Selection Worksheet if choosing between Replacement and Rehabilitation.
- Hydraulic Report (if the bridge is over water)
- Geotechnical Report
- Sketch Plans

The requirements for each of these deliverables shall be specified under the applicable Subsection of this Chapter.

2.2 CONTEXT SENSITIVITY AND AESTHETICS

2.2.1 General Objectives

Bridges are highly visible elements of the transportation infrastructure in the surrounding landscape. Often they traverse environmentally and ecologically sensitive sites, culturally or visually significant areas or are visually prominent features in communities and other developed settings. Although bridges can have negative impacts on these environments, they can also be designed in such a way that they are pleasing or welcome additions to the landscape or community.

Achieving this requires that the Designer pay careful attention to the details starting from an understanding of the setting within which the structure will be built to the design and detailing of the bridge structure itself. Bridges can be designed to blend into the surrounding natural or built environment, if that is what is desired, or they can serve as signature elements of the community by standing out from their surroundings.

In either case, the Designer must remember that a bridge can last many decades. The Designer has the power to make the bridge structure be a source of pride and admiration or be a lasting monument to a Designer's insensitivity and brutalism.

2.2.2 Understanding the Context

The first task that the Designer must perform is to understand the context of the site within which the bridge is to be built. If it is in a natural area, the Designer should map out the topography and natural features of the site. A bridge should be designed to fit into its setting rather than have the setting altered to fit a bridge structure selected without regard for its context.

In a developed or urban setting, the bridge is typically part of a grade separation. This change in elevation can result in either embankments or walls that create visual and functional barriers between different parts of a community. In some cases, the barrier effect from a grade separation can intensify the barrier effect of the roadways themselves. On the other hand, longer grade separations, such as an elevated or depressed high speed, high volume roadway through a developed area can improve community connectivity if the crossings of the facility are well designed and at appropriate locations.

When rehabilitating existing bridges, or when re-using existing substructure elements as part of a new bridge structure, the Designer should attempt to preserve the architectural elements as much as possible. If existing features must be cut back to allow for the construction of new elements of the structure, such as when the pylons of the existing substructure are cut back to construct a new superstructure, the Designer should reconstruct the cut off portion of that feature so that it still looks complete and in keeping with its original architectural detailing.

Similarly, if new elements must be added to an existing structure that has prominent architectural features, the Designer should attempt to incorporate those architectural features into the new element so that the structure maintains a consistent architectural look overall, rather than being a mismatched jumble of incompatible architectural styles.

2.2.3 Bridge Aesthetics

The true aesthetics of a bridge start with the design of the bridge structure itself. Those bridges that are considered to be today's best examples of an aesthetic bridge are the ones whose primary structural systems follow and physically manifest the basic structural mechanics of how the structure carries all applied loads down to the foundations. Therefore, a well-designed and aesthetically pleasing bridge is not one that is based on some abstract physical form, but rather one that expresses natural, physical principles that people intuitively relate to.

However, this alone is not sufficient to make a bridge structure aesthetically successful. In order for a bridge to be truly aesthetically satisfying, the Designer must remember that there are three levels on which the public experiences a bridge. These are:

1. The overall view of a bridge and how it relates to its setting.
2. The personal experience of someone driving over or under a bridge.
3. The human level experience of a pedestrian walking over, under or beside a bridge.

Each of these requires a level of detail that a person can relate to and be visually engaged by. Failure to adequately address the aesthetic expectations at any one of these levels will result in a bridge that people will find fault with, no matter how aesthetically successful the bridge may be on the other levels.

Aesthetics on all levels are achieved by attention to detail and consideration of how each element of the bridge relates to the others, since the design of the bridge structure must present a coherent overall vision of what each component part should represent and all architectural surface treatments should be consistent with this vision. A bridge's aesthetics are vastly improved when all of the component parts, the piers, abutments and superstructure, are designed to work together and complement each other visually. Therefore, the decisions that the Designer makes regarding structure type and substructure configuration and location will determine the aesthetics of a bridge, and not the application of superficial decoration after the basic bridge has been designed.

MassHighway has used this philosophy in developing the standard details of Part II of this Bridge Manual. The piers and abutments are the bridge's supports, thus they must contain and emphasize vertical elements, while the superstructure represents the horizontal spanning element and, thus, should have details that accentuate the horizontal. The lines of the bridge sidewalk or coping are carried over the wingwalls, thereby creating a sense of flow from one touch down point to the other. Thus, it is visually clear what each element represents and it is easier to unite their separate functions into one structure without creating visual conflict.

2.3 NEW BRIDGE AND BRIDGE REPLACEMENT PROJECTS

2.3.1 General Objectives

2.3.1.1 In selecting a structure type for a bridge project, the Designer shall endeavor to provide the most serviceable structure, in terms of constructability, safety, minimized long term maintenance, historic issues, right of way and environmental impacts while optimizing sight distance, design speed and clearances at the proposed structure site. It is MassHighway and Federal Highway Administration (FHWA) policy to design structures of multiple stringer, deck type construction wherever possible due to their structural redundancy and ease of construction, inspection and maintenance. The structures evaluated shall consider only those superstructure and substructure options that are most appropriate for the site. Cost considerations shall balance initial cost as well as future maintenance costs, however, cost alone should not drive the decision making process but rather it should be used only to select between equal, appropriate alternatives.

For bridge replacement projects, if the condition of some or all of the existing substructure units is such that they can potentially be rehabilitated to have their service life for at least another 75 years, the merits and cost of rehabilitating them should be considered. This evaluation must include all of the investigation, testing and analysis required for a Preliminary Structure Report, since technically the project will be a Superstructure Replacement Project. If the existing substructure is not deemed to be serviceable for reuse as part of a new bridge structure, the merits of re-using the existing abutments and wingwalls as an earth retaining structure or scour protection independent of the new bridge structure should be considered.

2.3.1.2 The Designer shall consider the following items when selecting the structure type:

- Open the bridge to maximum extent for sight distance.
- Consider possible future widening of the roadway under the bridge.
- Provide a structure requiring minimum future maintenance.
- Wherever possible, eliminate roadway joints in the bridge deck.
- Provide a structure that allows for adequate hands on inspection access.
- Minimize environmental impacts.
- Minimize water control during construction.
- Eliminate elements in the substructure that are a hazard to traffic.
- Provide a type of structure that is both functional and architecturally aesthetic and contextually sensitive to the location that it will be constructed in.
- Provide for placement of utilities in the superstructure.
- For bridges with sidewalks, consideration will be given for adequate and safe access for persons with disabilities on both the bridge and its approaches.
- Provide the required horizontal and vertical clearances in accordance with the Highway Design Manual and Part II of the Bridge Manual.

2.3.2 Bridge Type Selection Process

After identifying all of the project parameters and constraints, the first step in selecting a bridge structure type is to develop a preliminary bridge layout which includes possible span arrangements (single versus multiple span) and preliminary span lengths. The bridge geometrics and clearance standards given in Chapter 2 of Part II of this Bridge Manual must be considered in combination with the site data, profiles and cross sections of the feature being crossed as well as the roadway on the bridge to establish the span arrangement and lengths.

Since span lengths, skew, clearances, structure depth and profile impacts are interrelated, this exercise should consider all these factors in developing the preliminary bridge layout. It is also important that the structure type be selected and approved before the final profiles are set, since the depth of the superstructure could greatly influence the profile.

Next, the Designer must establish the locations and the type of the substructure units. This effort must consider the foundation type, support of excavation and its impact on surrounding features, environment and property. Finally, the Designer must select the most appropriate superstructure type for the span arrangement and length, taking into account the effect of structure type and depth on the clearances, roadway profile, utility requirements, and environmental impacts. Superstructure type also has an impact on the ability to construct a replacement bridge structure in stages. This process may require several iterations, as the possible superstructure types may require reconsideration of the substructure location and arrangement.

2.3.3 Appropriate Bridge Structure Types by Span Range

2.3.3.1 SINGLE SPAN - LENGTHS LESS THAN 40'.

1. Structural Plate Pipes: (aluminum and steel), generally under 20' in span. These are available as pre-engineered structures in various shapes and sizes and can be used for fills as shallow as 24". They can be used for pedestrian, bike and animal underpasses; vehicular tunnels; and overflow relief structures. They have also been used as structural liners for masonry and concrete arches and other pipes. These structures should generally not be used for water crossings since they have reduced life span due to deterioration of the metal at the water line. For this same reason, they should not be used on Interstate or other limited access highways in such applications. Environmental and size constraints normally dictate whether to use steel or aluminum. For details on this type of structure see the latest manufacturer's catalogs.
2. Concrete Four Sided Box Culverts: (precast or cast-in-place). They can be used for pedestrian, bike and animal underpasses; overflow relief structures; and are preferred for water crossings, especially where a low structure profile is desired. Shipping considerations usually limit precast boxes to spans of less than 15'. Larger overall openings are made possible by using multiple boxes set side by side, however multi cell culverts are more prone to trapping debris. The concrete inverts may raise objections in sensitive fishing areas, where a natural stream bed is preferred. Various programs can be used to design these boxes.
3. Precast Concrete Three Sided Culverts: These units include flat top frames and arched top shapes that have a maximum span of approximately 40'. These units are supported on strip footings founded on gravel, rock, or piles. However, due to their fixed span to depth ratios, it may be difficult to ship the larger size units to the construction site. Both of these units can be used in low fill areas. In areas of high fill (>16') there may be design problems with flat top units with long spans. Skewed arrangements must be considered in design as not all manufacturers produce units with skewed end walls. The design should be coordinated with the appropriate manufacturers.
4. Slabs or Composite Deck/Stringer Designs: Prestressed adjacent deck beams on abutments are applicable for this entire span range. Steel stringers or spread prestressed deck beams with composite concrete decks are also applicable, especially for spans greater than 25'. Conventional reinforced concrete slabs on abutments are inefficient for spans greater than 25' due to their excessive depth and heavy reinforcement.

2.3.3.2 SINGLE SPAN - LENGTHS BETWEEN 40' AND 110'.

1. Adjacent prestressed concrete deck beams can be used up to a maximum span of about 55'. Adjacent prestressed concrete box beams can be used for the remainder of the span range. Both can be used with conventional abutments only.
2. Spread prestressed concrete deck beams with a composite concrete deck or spread prestressed concrete box beams with a composite concrete deck can be used with the same span ranges as for their adjacent beam configurations. Can be used with both conventional abutments and integral abutments.
3. Steel stringer and prestressed concrete NEBT girders with a composite concrete deck can be used for the entire span range. Rolled beam sections can be used up to about 90' and welded plate girders for the remainder of the range. Steel box beams with a

composite concrete deck may also be used starting at about a 90' span. Can be used with both conventional abutments and integral abutments.

4. Special prefabricated bridge panels with concrete decks and steel beams can reach spans approaching 100' and have the advantage of reduced field construction time. Can be used with conventional abutments only.

All of the beams listed can potentially be shipped in one piece to the construction site.

2.3.3.3 SINGLE SPAN - LENGTHS BETWEEN 110' AND 150'.

1. Steel plate girders and steel box girders with a composite concrete deck can be used for this entire span range, however, the girders must be shipped in pieces and spliced together in the field. Can be used with both conventional abutments and integral abutments.
2. Prestressed concrete NEBT girders with a composite concrete deck can span up to about 125'. If the NEBT girders are to be spliced together to form a continuous multi-span girder, then the single clear opening of this girder can span up to about 150'. Can be used with both conventional abutments and integral abutments.

2.3.3.4 SINGLE SPAN - LENGTHS GREATER THAN 150'. Single spans greater than 150' are rarely built in Massachusetts. If a bridge needs to span that distance from abutment to abutment, consideration should be given for evaluating a multi-span structure. If a single span in this range is still required, then a special study will need to be made to determine the most appropriate structure which will balance superstructure and substructure costs to achieve an optimum design, as well as balancing aesthetics and constructability.

2.3.3.5 MULTIPLE SPAN ARRANGEMENTS. For multi-span bridges, a continuous design shall be used wherever foundation conditions warrant and the span ratios are satisfactory to eliminate deck joints. However, unbalanced span ratios in a continuous beam can result in uplift and should be avoided. Steel beam bridges can be designed to take full account of moment distribution resulting from continuity and thus can reduce the depth of the beam. Prestressed concrete bridges are typically erected as simple spans for self dead load and are then made continuous for superimposed and live loads by closure pours and additional reinforcement at the piers.

The preceding guidelines for single span structures can still be used to select the appropriate multi-span structure type with the following modifications for steel beams. Based on the number of spans, the span ratio and the table below, the longest span of a continuous steel beam can be equated to a shorter, equivalent simple span, which is then used to select the structure. These ratios are only to be used as a guide for preliminary design and are not intended to exclude other span ratios necessitated by site conditions as long as uplift is avoided.

Number of Spans	Ratio of Spans	Equivalent Simple Span
2	1.0 : 1.0	0.90 x 1.0 span
3	0.75 : 1.0 : 0.75	0.85 x 1.0 span
4	0.80 : 1.0 : 1.0 : 0.80	0.75 x 1.0 span
5	0.60 : 0.80 : 1.0 : 0.80 : 0.60	0.60 x 1.0 span

2.3.3.6 CURVED SINGLE AND MULTI-SPAN BRIDGES.

1. Steel plate I-girders and steel box beams can be curved to follow the horizontal curvature of the road, which allows the deck to be built to a constant width, and can be designed to be continuous for multi-span bridges. The deck overhangs are constant and can be set as specified by the Bridge Manual, which improves the overall aesthetics of the structure. Steel box beams are torsionally stiff and, because of this, are preferred for horizontally curved bridges, especially for long, multi-span bridges. However, because of the expense of fabricating the curved beams, curved steel plate I-girders and steel box beams are not economical for short spans and/or large radius curves.
2. Adjacent prestressed deck and box beam systems must be set on chords while the curb lines are set to follow the curve of the roadway. As a result, the overall width of the sidewalk and/or safety curb varies. The disadvantage is that the out to out width of the adjacent beam system must be set wide enough so that the minimum sidewalk and/or safety curb dimensions are met. Because of this, adjacent beam systems are not recommended for curved roadway applications except for large radius curves or short spans, so that the width of the sidewalk and/or curb behind the railing or barrier is not excessive, or where there is a need for a shallow superstructure.
3. Prestressed concrete spread deck beams, spread box beams and NEBT girders can only be set on chords, while the composite concrete deck is set to a constant cross section to follow the curvature of the roadway. Similarly, steel rolled beams, plate I-girders or box beams can be set on chords in situations where fully curved beams are not needed. All of these superstructures have variable width deck overhangs, which makes the Designer responsible for making sure that the maximum overhang dimensions as specified by the Bridge Manual are not exceeded. Also, the variable width overhangs create curved shadows on the fascia beams, which may be aesthetically objectionable. As a result, these types of superstructures are more applicable for shorter spans or large radius curves or where aesthetics are not that important.

2.3.3.7 RAILROAD BRIDGES OVER HIGHWAYS. On some occasions, MassHighway may need to build a bridge for an operating railroad for the purposes of a grade separation or to construct a new segment of roadway. In such cases, the standards of the railroad company for whose use this bridge is being built will be used. However, all railroad bridge structures over highways will be of the ballast deck type to prevent ballast, water and/or icicles from falling onto the roadway traffic below.

2.3.4 Substructure Location Guidelines

2.3.4.1 General Considerations. The locations of the abutments and piers are dependent on balancing the required clearances as specified in Chapter 2 of Part II of this Bridge Manual, the foundation type, which is dependent on the subsurface exploration and assessment, constructability, which may be complicated by stage construction considerations, and span length, which impacts superstructure depth and can raise the approach roadway profile thereby creating undesirable impacts on the approaches.

Where the existing bridge structure to be replaced is historic, found in a historic area, or is in sensitive wetlands, the abutments may be retained without being incorporated into the new structure to minimize the impacts to these resources. The replacement bridge structure may be supported on integral abutments or on piles or drilled shafts placed behind and/or adjacent to the existing substructures or on mini-piles or small diameter drilled shafts drilled through the existing substructure. In such cases, adequate inspection access, as specified in Chapter 2 of Part II of this Bridge Manual must be provided.

2.3.4.2 Abutments shall be located where a logical transition from bridge structure to the approach topography can occur. This first requires a good understanding and mapping of the topography within the bridge project area, not just at the bridge site itself. Full height abutments are expensive to construct, require longer wingwalls and extensive excavation and backfill to construct. They should be used primarily where the topography does not permit a stub abutment or integral abutment and where there is ample room to provide for the excavation. Stub, mid-height, or integral abutments are preferred due to the reduced expense of their construction and impacts on topography and because they do not require long wingwalls. Integral abutments should be considered whenever possible where soil conditions are favorable to the development of the fixity of the pile. Integral abutments are also ideal for bridge sites where there is limited room for excavation or there is a need to minimize the impacts of abutment construction on existing surrounding structures.

2.3.4.3 Wingwalls can be either splayed or U-shaped. Splayed wingwalls are more economical to construct, however, because they angle away from the abutment they need a wider right of way so that all of the structure, including the wingwall footings are within it. U-wingwalls are appropriate for restricted right of way situations, since they follow the roadway, and they can be used to retain the approach embankment fill from spilling into environmentally sensitive areas. However, they are more expensive to construct because of their height and they require additional length of bridge railing or barrier to be provided to the end of the U-wingwall. Also, the Designer must make sure that the U-wingwall footing is fully within the right of way layout. For both types of wingwalls, the taller the abutment, the longer the wingwalls and the greater the impacts described above.

2.3.4.4 When developing a span arrangement, generally the fewer the piers the better, since this opens up the underside of the bridge to sight distances, eliminates roadway hazards for bridges over roadways, eliminates visual clutter, and reduces the potential for scour, aggregation of the channel, and prevents the trapping of floating debris for bridges over water. However, fewer piers result in longer spans, which result in deeper superstructures. This can raise a profile and move the toe of slope out, thereby encroaching on environmentally sensitive areas such as wetlands, or require additional right of way takings or require a retaining wall. Therefore, span length and structure depth must be carefully balanced to arrive at an optimal structure.

For multi-span curved girder structures, it is preferred that the piers and pier caps be oriented radially to minimize the skew effects. If the piers cannot be oriented radially, then the effects of the skew combined with the effects of curvature must be taken into account in the design of all main structural components using an appropriate curved girder software that can fully model the bridge superstructure in 3D.

2.3.4.5 The type of foundation has a major impact on the location and number of substructure units.

1. Spread footings are the most economical where soil conditions permit, however, they require large excavations to construct, and may require extensive and costly support of excavation.
2. Deep foundations using piles, either concrete filled steel pipe piles, steel H-piles or prestressed concrete piles require less complex equipment than that required for drilled shafts to install, however, they may be difficult to design for a combination of loadings, including seismic and scour. Pile foundations also require large excavations similar to spread footings to provide for the pile cap. Piles shorter than 10' should be avoided.
3. Drilled shafts require less area for their excavation and so can be installed in constrained construction sites. They also produce less excavation material, which is advantageous if the site contains hazardous waste whose disposal must be mitigated. Drilled shafts are also better for situations where the effect of scour on the stability of the abutment or pier is of a concern. Drilled shafts can be used as a foundation for either abutments, where they are used with a pile cap, or with piers, where the pier column is a continuation of the drilled shaft. However, drilled shaft construction quality is highly dependent on the contractor. Therefore, the Designer must make sure that the drilled shaft equipment can access the construction site so that the shafts can be readily constructed.
4. If competent ledge is encountered close to the surface, consideration should be given to a spread footing founded directly on the prepared ledge surface. If the ledge drops off from one end of the abutment to the other, then a concrete leveling slab should be cast and the footing founded on it. If there is a competent ledge outcrop that can be retained, consideration should be given to a stub or mid-height abutment founded directly on the outcrop.
5. For bridge replacement projects, stage construction considerations must take into account interference between the existing and proposed features, (e.g., substructures, beams, pier caps, pile driving - especially battered piles, etc.) as well as utilities that must remain in service. Accurate survey data on existing features is essential for stage construction projects.

2.3.4.6 Support of Excavation. The Designer must be mindful of the support of excavation that the foundation type will require for construction and whether the site can accommodate it. For example, support of excavation for staging and substructure construction may consist of cantilever sheet piles, tied-back sheet piles and whalers, or pile and lagging. For in-water construction, support of excavation may take the form of a cofferdam with a tremie seal. Stage construction may require support of excavation to retain the existing roadway while the new structure is being constructed. In these cases, the Designer must consider the depth of the excavation that the new structure's foundation will require and the live load surcharge that must be retained. In extreme situations, the required support of excavation required may be so massive that it cannot be physically constructed within the site constraints. In such cases, an alternate substructure type or bridge configuration must be utilized that will minimize the support of excavation.

2.3.4.7 Utility Conflicts. The Designer must locate the substructure units to avoid utilities that would require costly relocations. Also, some construction activities, such as pile driving and sheet pile placement, bridge demolition or beam erection may be limited by overhead or underground interference.

2.3.4.8 Skews. The substructure units shall be placed parallel with the feature crossed, which will determine the skew of the bridge. This helps maintain consistent sight lines for bridges over highways, and helps avoid the creation of eddies and turbulence, which can result in scour for bridges over water. This also allows for the shortest span length over the feature, which is important in those situations where the depth of structure must be kept small. Skews over 40° can create structural problems with acute corners, horizontal twisting movement of the superstructure under thermal movement and fatigue problems with diaphragms and their connections to the beams. Special attention should be paid to mitigating these effects when designing structures with such skews. Bridges can be built on smaller skews than the intersection of the road with the feature crossed, however this will produce longer spans. For horizontally curved bridges, a radial orientation of the substructure units is preferred.

2.3.4.9 Water Crossings. The first parameter to be established for a water crossing is the navigational requirements for marine traffic. The United States Coast Guard is responsible for all rules and regulations for bridges over navigable waterways, such as establishing channel width, horizontal clearances from fender to fender, vertical clearances for fixed span bridges and/or the need for a movable bridge. Constructing a fixed span bridge at a higher elevation should be considered in place of a movable bridge, where possible. If an existing movable bridge has been closed to marine traffic for years, consideration should be given to obtaining Coast Guard approval to permit the construction of a fixed span bridge, if this approval has not been officially obtained previously. In addition, Chapter 91 of the Massachusetts General Laws, Sections 14 and 23, requires an Act by the General Court for the construction of a bridge without a draw span over a tidal river, cove, or inlet, except when a fixed bridge, dam, or other structure is in existence downstream of the proposed bridge.

In locating substructure units, and where clearance conditions warrant, long spans should be used to open up the waterway from obstructions, reduce the potential for scour and trapping debris and to keep the substructure construction in the dry, where possible. For multi-span bridges, two piers close to each shore line may be more hydraulically efficient and economical to build than one deep water pier. Piers in the water should typically be solid, however, a column bent on top of a solid stem should be used if the top of the pier is 22' above the design storm elevation. The use of a short column bent can result in shrinkage cracks in the columns. Shore line piers can be column bents with a drilled shaft foundation, with the column being a continuation of the shaft. This reduces the size of the excavation and the amount of dewatering required to construct the pier.

Where the wingwalls of an abutment are at or near the water's edge, the wingwalls on the upstream side should be splayed to improve the hydraulic entrance condition and should be aligned to direct the flow through the bridge opening. If possible, the elevation of the end of the wingwall should be higher than design storm elevation or, at a minimum, the ordinary high water. In such cases, the downstream wingwalls should also be made splayed for ease of design and construction.

2.3.4.10 Bridges over Railroads. Typically, a three span structure is more economical to construct than a simple span with full height abutments. Where site conditions restrict the construction of a multi-span bridge, mid-height abutments should be considered if geotechnical conditions are favorable, otherwise full height abutments should be considered.

For new bridges, Massachusetts General Laws, Chapter 160, Section 134A specifies a clearance of 22'–6" above top of rail. For those bridges that were acquired by MassHighway from the railroad companies and municipalities under Chapter 634 of the Acts of 1971, this Chapter authorizes

MassHighway to replace these bridges at the existing horizontal and vertical clearances. Generally railroad companies desire more vertical clearance and may be willing to reduce the horizontal clearance for a gain in the vertical.

Typically, MassHighway attempts to improve the vertical clearance where right of way, approach roadway geometry and site conditions allow. On certain railroad lines that have been identified as potential double stack routes, MassHighway attempts to provide a minimum vertical clearance of 21' from top of rail. If the clearance cannot be improved to this height, the foundations of the abutments and/or piers should be set so that the railroad company can undercut the tracks to achieve this clearance without impacting the stability or performance of the bridge structure.

Wherever possible, the construction of the bridge should avoid impacting the railroad roadbed. Chapter 2 of Part II of this Bridge Manual provides the influence slope requirements for all major railroads operating within Massachusetts. Abutments and/or piers should be located so that their foundation excavations stay outside this slope line. Drilled shafts should be considered in constricted site conditions, since they do not require a wide excavation to construct a spread footing or pile cap, and so the pier can be located closer to the track. However, if the railroad face of any pier is located within a distance of 25' from the centerline of the track, AREMA requires that the pier be protected by an integral crash wall.

2.3.5 Superstructure Selection Guidelines

2.3.5.1 The final step in the Bridge Type Selection Process is to select the superstructure type that will fit the project parameters, roadway geometry, site accessibility, constructability and the arrangement, spacing and span of the substructure units. The following guidelines are to be used in determining the superstructure type that best meets all of these requirements. If two or more superstructure types equally meet the project requirements, then total cost should be used to make the final selection. In determining this total cost, the Designer must add to the cost of the superstructure all consequential costs, including the cost of any adjustments to the approach roadway profile, substructure and foundations necessitated by the given superstructure type.

2.3.5.2 Adjacent prestressed concrete deck and box beams provide the shallowest depth structure for a given span, more rapid construction since there is no structural deck slab to form and reinforce between beams, which also minimizes the required work over the feature intersected, and these systems provide a better smoother roof for the hydraulic opening. These systems typically have lower life cycle costs because they require little routine maintenance and, because they are made from concrete in a controlled environment, they are not subject to corrosion or deterioration. This makes them an ideal choice for bridges over water with high constant humidity and for areas where it is difficult to access the superstructure for maintenance work. However, if a single beam within the systems is damaged, it is difficult to replace it.

These systems have limited room for utilities, which requires that large or numerous utilities must be attached to the outside of the superstructure. Since prestressed concrete beams are essentially straight, they cannot follow the vertical roadway profile, which results in additional midspan dead load for large vertical curve middle ordinates. Skews and profile effects require special design and construction procedures for the bridge seats. Adjacent prestressed concrete beam systems are not recommended for skew angles over 45°, due to the warping behavior of the beams at the bearings from beam deflections, and the staggered beam cambers make it difficult to thread the transverse post tensioning strands through and create misalignment in the keyway details. This superstructure system may not be feasible when an existing substructure is being reused due to the greater weight of this system. A stringer type bridge with a composite deck slab would be preferred at these sites.

2.3.5.3 Prestressed concrete spread deck, spread box beam and NEBT girder bridges with a composite concrete deck have the lowest life cycle costs because they require little routine maintenance and, because they are made from concrete in a controlled environment, they are not as subject to corrosion or deterioration. This makes them an ideal choice for harsh environments, such as over roadways where there is high salt usage or over water with high constant humidity and for areas where it is difficult to access the superstructure for maintenance work. These beam types, especially the NEBT girders, also have more room for utilities than adjacent beam systems.

However, these beams generally result in deeper superstructures than steel beams for a comparable span. They are heavier, especially for longer spans and, as a result, may be difficult to ship and will require bigger cranes to erect. These beams must be shipped in one piece, because it is difficult to splice them in the field. Because these beams are essentially straight, they cannot easily follow a vertical curve. Deep haunches must be used to allow the concrete deck slab to follow the profile. The top flanges are very wide, which can also create deep haunches, especially as the cross slope increases. Both of these situations separately and in combination, will result in significant dead load. These beams are also not recommended for skew angles over 45°, due to the warping behavior of the beams at the bearings from beam deflections and because of the construction problems created by the wide beam flanges. Although superstructures using these beams may weigh less than an adjacent prestressed concrete beam system for the same span, they weigh more than steel superstructures of the same span, which may be a consideration when existing substructures are being reused.

2.3.5.4 Steel rolled beam, steel plate I-girder and steel box girder bridges with a composite concrete deck provide a shallower superstructure than the spread prestressed concrete deck and box beams and NEBT girder bridges, they can be cambered to better follow the profile of the road, which may provide additional vertical clearance under the bridge. All steel beams can be designed and fabricated to take full advantage of continuity, which can further reduce the depth of the superstructure for a given span. Plate girders can also be fabricated to any size, which allows steel to fit unique site conditions. Steel beam superstructures provide the most room for utilities than any of the other superstructure types. Steel beam superstructures have a low weight, which may make them the only feasible alternative when reusing an existing substructure. All of the steel beam types can be easily field spliced, so the beam can be divided into shorter segments for easier shipment and erection. Steel rolled beams and plate girders can more easily accommodate skew angles over 45°, however, fatigue of diaphragms and their connections becomes more of a problem as well as more pronounced deck cracking as the skews become greater.

All steel beams have higher life cycle costs because they are subject to more deterioration from corrosion and require more routine maintenance to preserve them. Although weathering steel does not require painting, the protective effect of its patina is compromised by contamination from road salt and the patina fails to form in continuously moist environments. These same factors affect coated beams as well, so steel should be used cautiously over highways with high salt usage and over water, especially in shaded locations with high constant humidity. In these locations, steel beam superstructures should be used primarily when they provide significant advantages over the other superstructure types. If steel is to be used in high humidity locations, all of the superstructure steel, including the diaphragms, should be hot-dip galvanized.

2.3.5.5 Reinforced concrete slab superstructures are typically not economical over 25' since a form must be built to support the weight of the plastic concrete until it cures. Since in most cases building falsework to support the forms from below is not feasible, either because the bridge is over water or over traffic, some type of overhead support system must be used, which limits the span of the slab bridge structure. Reinforced concrete slab bridges, however, are to be used exclusively where the new bridge structure will be entirely hidden from view and inspection, such as a bridge that is to be built within the walls of a historic arch or clapper bridge that is to be retained in its entirety in order to maintain the existing visual appearance.

2.3.6 Bridge Type Selection Worksheet

The purpose of the Bridge Type Selection Worksheet is to guide the Designer through the Bridge Type Selection Process in an organized, sequential manner. Consistent with the Preliminary Engineering Decision Making Methodology, the goal is to streamline the type selection by narrowing down the number of possible bridge structure types to only those that best address the project parameters and constraints. This worksheet is also intended to identify those bridge structure types that fail to adequately address the project parameters and constraints, thereby documenting why they should be discarded from further consideration.

The standard outline of the worksheet, as presented below, is organized by main headings, which are numbered sequentially and are in bold and all caps, and subheadings, which are numbered sequentially within the heading and are underlined. The italicized text next to each subheading is intended to provide guidance to the Designer as to what information is to be presented under each subheading and is not intended to be a complete and exhaustive summary. The Designer should provide all of the information as thoroughly and as concisely as possible, ideally in bullet form, as it applies to this specific bridge structure and site. Extensive text writing should be avoided unless it is necessary to adequately describe the decision making process. If a subheading does not apply to the specific bridge project, a notation of "Not Applicable" should be provided.

Two copies of the worksheet (three if FHWA review is required) shall be submitted to the Bridge Engineer. Each copy shall be clearly labeled, dated and bound. The worksheet shall not be protected by copyright and shall be signed by the Engineer preparing it. Upon approval, an Adobe Acrobat format (PDF) file of the report shall be submitted on CD or via email. All required drawings and diagrams should be presented in an 8½" x 11" format with an 11" x 17" format foldout used only when necessary. These illustrations should be specific to the bridge structure type being discussed and any extraneous details appropriate to highway layout, utility plans, etc. should not be submitted, unless they are required to identify a project constraint and its relationship to the bridge structure.

BRIDGE TYPE SELECTION WORKSHEET

1 PROJECT LOCATION

1.1 City or Town:
1.2 District:
1.3 Bridge Number:
1.4 BIN:
1.5 Structure Number:
1.6 Roadway on Bridge:
1.7 Feature Intersected:

2 DESCRIPTION OF EXISTING SITE CONDITIONS

2.1 Description of Existing Bridge Structure: *(Provide cross section information including dimensions, number of lanes, shoulders, sidewalks, skew, span arrangement and length(s), description of superstructure, substructure and foundation type, underclearances (horizontal and vertical), historical significance or relationship to a historic district and any other factors that are peculiar to the existing bridge structure.)*

2.2 Description of Approach Roadway: *(Provide cross section information including dimensions, number of lanes, shoulders, sidewalks, roadway system, design speed, present ADT and Percentage Truck Traffic, vertical and horizontal alignment through the bridge site, roadway system including if NHS or not, and any other factors that are peculiar to the existing approach roadway that may affect the bridge structure.)*

2.3 Description of Feature Under the Bridge Structure: *(Provide a description of the feature that the bridge structure crosses. For other highways, provide all information as specified above for the approach roadway. For railroads, provide cross section information including number of tracks, spacing between tracks, width of service roads, clearances from centerline of track to the adjacent substructure unit, vertical clearances over each track, locations of drainage swales or drainage structures within the bridge site, track alignment and location of any railroad structures for 1000' on either side of the bridge site, if bridge comes under Chapter 634 regulations, and any other factors peculiar to the railroad that may affect the bridge structure. For water crossings, provide width and depth of channel, description of channel alignment both upstream and downstream of bridge structure, condition of the banks, condition of the channel, observation of debris, beaver activity, marine traffic and navigational features, State and/or Federal Wild, Scenic or Recreational River designation and any other factors peculiar to the river that may affect the bridge structure. For other types of features, provide as complete a description as possible of all relevant characteristics of the feature to be crossed as they may affect the proposed construction.)*

2.4 Description of Existing Hydraulics at the Bridge Site: (*Provide the hydraulic information for the existing bridge hydraulic opening, identify the potential for scour or actual scour that exists or the structure is being monitored for, tidal flushing action through the existing opening, and any other hydraulic factors that may need to be addressed by the proposed construction.)*

2.5 Description of All Utilities Within the Bridge Site: *(Identify and describe all utilities, including location, type and size. This description should include all utilities that are presently on the bridge, utilities that may be buried in the vicinity of the bridge structure that could be affected by the proposed construction, including all utilities that share a railroad's right of way, and any overhead utilities.)*

2.6 Description of Environmentally Sensitive or Cultural Resource Areas Affecting the Bridge Site: *(Identify and describe all environmentally sensitive areas, such as but not limited to wetlands, vegetation and animal habitats that are adjacent or within the bridge site and that may be affected by the proposed construction; identify and describe all cultural resource* *sites including historic districts, archeological sites, historic structures and markers or any other cultural resources that may be affected by the proposed construction.)*

2.7 Hazardous Materials: *(Identify and describe all potential hazardous materials or contaminants on the existing bridge structure, on the approach roadway and in the ground within the bridge site that may be disturbed or would require disposal as a result of the proposed construction.)*

3 DESCRIPTION OF PROJECT PARAMETERS AND CONSTRAINTS

3.1 Description of Proposed Roadway Cross Section: *(Provide proposed cross section information including dimensions, number of lanes, shoulders, sidewalks, roadway system, design speed, design ADT and Percentage Truck Traffic, vertical and horizontal alignment through the bridge site, roadway system including if NHS or not, and any other factors that are peculiar to the existing approach roadway that may affect the bridge structure type selection.)*

3.2 Proposed Traffic Management: *(Provide description of how traffic is to be maintained during construction: for total shut down provide a description of the detour; for stage construction provide number of stages, number of lanes to be maintained; for temporary bridges within the bridge site, provide number of lanes to be maintained, location of temporary bridge, temporary roadway alignment; and any other factors to manage traffic that may affect the type of structure to be selected.)*

3.3 Proposed Clearances: *(Identify the required underclearances, both horizontal and vertical and the location of these clearances.)*

3.4 Hydraulic Data: *(Provide the following hydraulic data: Drainage area in square miles; Design storm frequency in years; Design storm discharge in cubic feet/second; Design storm velocity in feet/second; Design storm water surface elevation (NAVD); 100 year storm discharge in cubic feet/second; 100 year storm water surface elevation (NAVD); Flood of record frequency in years; Flood of record discharge in cubic feet/second; Flood of record velocity in feet/second; Evidence of scour and erosion; History of ice flows; Estimated scour depth.)*

3.5 Preliminary Geotechnical Data: *(Identify any preliminary geotechnical information that may affect the selection of the bridge structure type. If no borings have been taken, this information may be obtained from the borings of the existing structure or through site examination if prominent geotechnical features, such as the existence of ledge outcrops are readily visible.)*

3.6 Constraints Imposed by Approach Roadway Features: *(Identify any features that would limit the approach roadway alignment or profile, such as driveways, buildings, abutting private property.)*

3.7 Constraints Imposed by Feature Crossed: *(Provide a description of any constraints that the feature crossed imposes that would affect the construction of the bridge structure. For bridges over highways this would include traffic management during all phases of construction and any restrictions on foundation excavation. For bridges over railroad this includes the limitations on the excavation of foundations, driving sheet piling, windows of operation for the contractor, or any other factors that the* *railroad imposes that would affect the bridge structure type to be selected. For bridges over water includes considerations of marine traffic, including restrictions on contractor operations, partial or total shutdowns to marine traffic, seasonal marine traffic considerations and any other marine traffic factors that would affect the bridge structure type selected. Environmental issues affecting the construction of bridges over water should not be covered here, but rather in the* Constraints Imposed by Environmentally Sensitive Areas *subheading.)*

3.8 Constraints Imposed by Utilities: *(Identify how all utilities whether on the bridge, under the bridge, over the bridge or within the bridge site must be accommodated, including either total shut down for the duration of construction, temporary relocation, utilities that cannot be shut down or relocated and so must be remain in the their current location and any utilities that share a railroad right of way.)*

3.9 Constraints Imposed by Environmentally Sensitive Areas: *(Identify all restrictions imposed by regulations for environmentally sensitive areas that may be affected by the construction of the bridge structure and its foundations or by any approach roadway work.)*

3.10 Constraints Imposed by Cultural Resource Areas: *(Identify all restrictions imposed by cultural resource protection regulations that would affect the selection of the bridge structure type or that would be affected by the construction of the bridged structure and its foundations.)*

3.11 Hazardous Material Disposition: *(Identify the disposition requirements or mitigation strategies for all hazardous material that would be affected by the construction of the bridge structure.)*

3.12 Other Project Constraints: *(Identify any other constraints that would affect the selection of or the construction of the bridge structure.)*

4 APPROPRIATE BRIDGE STRUCTURE TYPES

4.1 *(Identify all bridge structure types that are potentially viable for this particular project site and indicate how well they address or do not address the project parameters and constraints.)*

5 PROPOSED SUBSTRUCTURE ARRANGEMENT, SPAN AND FOUNDATION TYPE

5.1 *(Identify those substructure arrangements, span lengths and preliminary foundation types that are viable for this project site and indicate how well they address or do not address the project parameters and constraints.)*

6 PROPOSED SUPERSTRUCTURE TYPE

6.1 *(Identify that superstructure type (or types) that is viable for this project site and indicate how well it addresses or does not address the project parameters and constraints.)*

7 PRELIMINARY PROJECT COST ESTIMATE

7.1 *(Provide a preliminary cost estimate of the total project cost. This would consist of an estimate of cost of the bridge structure itself, any required* *approach roadwork, and the cost of any traffic management costs. If there are several equally viable bridge structure types, then the a total project cost shall be estimated for each bridge structure type alternative and the one that has the lowest project cost will be selected.)*

8 RECOMMENDATION OF PROPOSED BRIDGE STRUCTURE TYPE

8.1 *(Recommendation of the proposed bridge structure type and a statement of why it is the most appropriate bridge structure type for this project site.)*

9 APPENDICES

9.1 Plan, Profile, Elevation and Cross Section of the proposed bridge structure *(if there are several equally viable bridge structure types, provide this for each alternative)*
9.2 Typical Approach Roadway Cross Section
9.3 Clearance Diagram for Feature Crossed
9.4 Plan, Profile and Cross Section of the feature crossed *(if it is a highway or railroad)* Channel Cross Section (*if the feature crossed is water)*
9.5 Stage Construction Diagrams *(if stage construction is proposed)*
9.6 Traffic Detour Diagram *(if a total roadway shut down is proposed for construction)*
9.7 Backup Calculations *(for the preliminary project cost estimate)*

2.4 BRIDGE REHABILITATION PROJECTS

2.4.1 General Guidelines

2.4.1.1 A bridge rehabilitation project may be a viable option and should be considered for those bridges that:

- do not have significant highway geometry deficiencies;
- have only a limited number of deteriorated bridge structure members and the rest are in satisfactory condition;
- have substructure units and foundations in satisfactory condition and do not have significant scour or seismic deficiencies;
- have structural systems that are redundant and which can be brought up to current code and load carrying requirements without extensive and expensive structural work.

A bridge rehabilitation may be the only feasible choice for historic bridges that must be retained in a highway capacity.

2.4.1.2 A bridge rehabilitation may not be feasible for those bridges that:

- have substandard horizontal and vertical underclearances;
- have a poor roadway alignment both on the bridge and on the approaches;
- have extensive deterioration of the substructure, including active scour undermining, pronounced seismic vulnerability, and/or questionable foundations;
- have numerous deficiencies throughout the superstructure and/or substructure;
- have structural systems that are non-redundant or incorporate poor details that require increased maintenance and inspection effort.

In such cases, a bridge replacement will better address the goals as stated in Subsection 2.1.2 and will pose fewer uncertainties during construction.

2.4.1.3 Accident history. The rehabilitation versus replacement decision must consider the accident history and the potential for accidents. An examination of accident reports can determine the accident history and can establish trends in accident patterns that would point to the bridge as being the cause of contributing element to them. A review of the roadway geometrics at the bridge, including sight distance, bridge width, horizontal clearances, alignments, etc., can identify the potential for accidents and those geometric elements that need upgrading.

2.4.1.4 Traffic Management. There may be several feasible alternatives to maintaining the traffic flow around the project site. They may include closing the structure and detouring traffic around the site, maintaining traffic on a temporary bridge, maintaining traffic on the existing structure while a new structure is constructed on a new alignment, or maintaining traffic on a portion of the existing structure by stage construction. These alternatives must be carefully considered as to their practicality, overall cost, delay of the traffic, and impact to the surrounding community. In some cases, the type of project will be driven by the fact that there is only one practical solution to managing the traffic.

2.4.1.5 Feature Crossed. The feature crossed can have a significant effect on the type of project selected and its cost. Environmental or Coast Guard concerns may push the decision in the direction of the rehabilitation while hydraulic inadequacies and poor stream alignment may push the decision toward replacement.

2.4.1.6 If, based on the above considerations, a bridge structure appears to be viable for a rehabilitation project, the next step is to perform an assessment of the existing structure that will include:

- a field survey of the structure in order to establish all of the deficiencies that need to be addressed during the rehabilitation;
- material testing in order to establish any potential problems that would reduce the service life of the rehabilitated structure and to establish material properties to be used as part of the rehabilitation design;
- a preliminary structural analysis in order to determine the potential load carrying capacity of the rehabilitated structure;
- a preliminary estimate of the cost of the rehabilitation project in order to compare it to a cost estimate of a comparable replacement project.

All of these investigations shall be prepared as part of the *Preliminary Structure Report*.

2.4.2 Preliminary Structure Report

2.4.2.1 All of the findings outlined below, including the results of all material testing and preliminary structural analysis, preliminary seismic analysis and preliminary cost estimate, but excluding the Geotechnical and Hydraulic Reports, shall be presented in a report called the *Preliminary Structure Report*.

Two copies of the *Preliminary Structure Report* (three if FHWA review is required) shall be submitted to the Bridge Engineer. Each copy shall be clearly labeled, dated and bound, shall not be protected by copyright, and shall be signed by the Engineer preparing it. Upon approval, an Adobe Acrobat format (PDF) file of the report shall be submitted on CD or via email. All required drawings and diagrams should be presented in an 81/2" x 11" format with an 11" x 17" format foldout used only when necessary. These illustrations should be specific to the bridge structure type, features and locations of deterioration being discussed. Any extraneous details appropriate to highway layout, utility plans, etc. should not be submitted unless they are required to identify a project constraint and its relationship to the bridge structure.

2.4.2.2 The Designer shall perform a complete field survey of the existing structure in order to establish its structural deficiencies with the intent of developing Construction Drawings and a reasonable estimate for the work. At a minimum, this field survey shall document the following:

1. Map all patches, spalls, delaminations, and any other concrete deficiencies on all concrete bridge members, including areas of deficiency in the concrete deck.

2. For prestressed concrete beams, a visual evaluation of the extent of deterioration of the beams and a visual evaluation of the condition of the bearings.

3. For structural steel, location and extent of all corrosion and measurement of loss of section, identification of fatigue prone details, location and condition of cover plate cutoffs, condition of connection details and fasteners, and presence of lead paint,

4. A visual survey of all abutments, wingwalls, pier caps and columns, in order to determine the location, extent and depth of the deterioration that would require removal and replacement in order to return the substructure to a usable condition. If a substructure replacement appears necessary, evaluate locations and feasibility of providing temporary superstructure supports.

2.4.2.3 Material sampling to establish material properties. For concrete, this will entail the taking of concrete samples to determine the quality of the concrete, the extent of any chloride contamination and to determine if there any material deficiencies that will reduce the service life of the retained concrete members. All coring or drilling of the concrete to take samples must avoid steel reinforcing. This will require the use of equipment capable of locating existing reinforcement prior to concrete sampling.

For steel, this will entail the taking of coupons of the structural steel members and of the concrete reinforcing bars if the knowledge of the actual material properties of the steel shall reduce or eliminate the need for extensive retrofitting of the steel members. Coupons shall be taken in those locations that will not reduce the capacity of the member but, at the same time, will give a reliable representation of the structural steel in the bridge structure. The method of sampling and testing shall be submitted to MassHighway for approval. At a minimum, the samples to be taken shall include:

1. Drilled concrete dust samples in order to determine salt content at various levels of all existing cast-in-place concrete members. They shall be taken on the deck, superstructure and substructure at representative locations, unless the deficiencies are so obvious and complete that re-use or rehabilitation can be dismissed.
2. Core samples in order to determine the presence of alkali-silica reactivity, the concrete's integrity and strength, and the concrete's susceptibility to freeze-thaw deterioration. These cores are to be taken on the deck, superstructure and substructure at representative locations,

unless the deficiencies are so obvious and complete that any re-use or rehabilitation can be dismissed.

3. Steel coupons to identify the steel grade and its yield stress and chemistry in order to determine the weldability of the steel if needed for any welded steel attachments, including shear studs to make the steel members composite with the concrete deck.

2.4.2.4 Preliminary steel superstructure evaluation. A structural analysis shall be performed to establish the actual present capacity of the stringers, splices, cover plates, and connection details of the members to be retained and to identify retrofitting strategies required to upgrade the structure to current load carrying requirements. These results will be used to determine the cost effectiveness, service life and resulting constructability of retaining existing steel members. The condition of any existing roadway joints shall be noted and the feasibility of retrofitting the structure to make it continuous for live load should be considered.

2.4.2.5 Preliminary concrete superstructure evaluation. A structural analysis shall be performed to establish the actual present capacity of the concrete superstructure members and to determine the need for and identify strategies of upgrading them to current load carrying requirements. This analysis should also determine the feasibility of retrofitting these members to make the structure continuous for live load.

2.4.2.6 Preliminary seismic analysis and recommendations. A preliminary seismic analysis shall be performed to establish that the structure has adequate seismic resistance assuming Seismic Performance Category C evaluation criteria or to determine those members that are deficient and to establish retrofitting strategies. For complex structures, non-regular structures and historic structures, the seismic demand used in the analysis shall be based on a site specific seismic hazard analysis. All bridge components that have the potential of being damaged during an earthquake shall be quantitatively evaluated to determine their ability to resist the design earthquake. All Seismic Performance Category C ($0.29 \geq A > 0.19$) components identified in the *Seismic Retrofitting Manual for Highway Bridges, Report No. FHWA-RD-94-052,* shall be evaluated. This analysis shall summarize the necessity, feasibility and cost of the seismic retrofit. Exemptions to this requirement must be granted from the Bridge Engineer in writing and shall only be warranted in cases where the cost of seismic retrofitting is prohibitive and/or the impact of seismic retrofitting on the historic significance of the bridge is unacceptable.

2.4.2.7 Geotechnical evaluation. A subsurface exploratory program shall be performed, which may include probes, borings and in-situ testing, to evaluate the subsurface conditions and to establish the adequacy of the foundations and of the supporting soils for the loads to be imposed by the rehabilitated structure.

2.4.2.8 Hydraulic evaluation. For bridges over water, the adequacy of the hydraulic opening shall be evaluated as well as the susceptibility of the structure to scour. If the bridge structure is found to be scour critical, strategies for retrofitting against scour shall be developed and evaluated.

2.4.2.9 Preliminary project cost estimate. A preliminary cost estimate of the rehabilitation project shall be prepared that will include all costs of addressing structural deficiencies, for upgrading the structure to current load carrying and code requirements and for retrofitting the bridge structure to address seismic resistance and scour, roadway improvements, traffic management and utility management.

2.4.3 Selecting between Bridge Rehabilitation and Bridge Replacement

2.4.3.1 Almost any structure can be rehabilitated, but the question is at what cost and whether this money will be spent wisely or would it be more economical to replace the existing structure. To make this determination the Designer must first determine which project type will best achieve the goal as stated in Subsection 2.1.2 above. If both are equally viable, the Designer must then consider constructability of each project type, accident history, utilities, the constraints imposed by the feature crossed and the constraints of traffic management. If both project types are still equal, then the Designer shall use the estimated construction cost as the deciding factor.

2.4.3.2 Establishing a bridge rehabilitation cost. It is more difficult to estimate the cost of a bridge rehabilitation than the cost of a new bridge. The rehabilitation estimate must account for many uncertainties, such as the actual condition of members that were fully or partially hidden from view during the initial field survey. The Designer should also keep in mind that the bridge rehabilitation project may be under construction several years after the field survey was originally performed. Consequently, the estimate of quantities should incorporate reasonable projections to account for continued deterioration. The unit prices used in the estimate should take into consideration the cost of the Contractor's access to the members to be rehabilitated as well as the inefficiency of working in close or constricted quarters.

2.4.3.3 Establishing a bridge replacement cost. In order to avoid excessive and needless study, a preliminary replacement cost for the structure alone can be estimated using average per square foot costs. Since the cost of construction increases annually, the Bridge Section shall provide the average per square foot cost to the Designer in order to ensure the most up to date cost. The cost for any roadway improvements, traffic management, including any temporary bridges, and demolition of the existing structure should also be estimated and added to this cost of the replacement structure to arrive at an estimated replacement project cost.

2.4.3.4 Cost based comparison and selection. If the ratio of the total rehabilitation project cost to the total estimated replacement cost is 65% or less, then rehabilitation is considered to be the most economical project type.

If the ratio of the total rehabilitation project cost to the total estimated replacement cost is greater than 65%, then a more refined estimate of the replacement project must be performed. This would entail determining an appropriate replacement bridge structure type using the Bridge Structure Type Selection Worksheet method and estimating the structure replacement cost based on estimated quantities and average unit prices for bridge items. To this estimated cost, the Designer must add estimated costs for any roadway improvements, traffic management and demolition of the existing structure.

If the ratio of the rehabilitation project cost to the refined total estimated replacement cost is 85% or less, then rehabilitation would still be the preferred project type. If this ratio exceeds 85%, then a replacement project would be considered to be more cost effective because there are more uncertainties with a bridge rehabilitation project than with a bridge replacement project.

2.5 GEOTECHNICAL REPORT

2.5.1 General

The Geotechnical Report is basic document used to present the subsurface site conditions and make design and construction recommendations for all foundation and earthwork aspects of a bridge project.

Two copies (three if FHWA review is required) of the report shall be submitted to the Bridge Engineer. Each copy shall be clearly labeled, dated and bound containing all text, graphic presentations, calculations, test data and special specifications. The report shall not be protected by copyright and shall be signed by the Engineer preparing it. Upon approval, an Adobe Acrobat format (PDF) file of the report shall be submitted on CD or via email.

The text of the report shall be concise and as definitive as possible and shall be based upon careful analysis of subsurface data and sound engineering judgment. Extraneous data or discussions should not be included. All recommendations, calculations and analyses shall be consistent with the requirements of AASHTO. All laboratory or in-situ tests conducted on rock, soil or water shall be conducted in accordance with the applicable standards of ASTM.

All geotechnical design properties, engineering values, calculations, data, and equations shall be presented using appropriate units consistent with the following guidelines:

Parameter or Property	Preferred Units
Deformation, Settlement	inches
Force	kips
Pressure, Stress, Strength	$kips/ft^2$
Modulus	$kips/ft^2$
Subgrade Reaction Modulus	$kips/in^3$
Density, ρ	lb/ft^3
Unit Weight, γ	lb/ft^3
Particle Diameter, d	inches
Coefficient of Permeability, k	in/s
Coefficient of Consolidation, c_v	ft^2/s

1. Location plans for borings and subsurface exploration program shall present a 1" = 40' plan view of the proposed structure, with the boring locations indicated by the standard symbol. Boring Logs and soil profiles shall show depth in feet.

2. The Standard Penetration Test (SPT) N values shall be stated on the plans in blows per 6" of penetration, including a description of boring equipment (i.e. spoon sampler, hammer weight and fall height, etc.).

3. Pile capacity values shall be in kips.

2.5.2 Report Outline

The report content shall include the following geotechnical elements applicable to the particular project:

1. EXECUTIVE SUMMARY

2. INTRODUCTION

- 2.1 Scope of report.
- 2.2 Subject background, proposed construction, history.
- 2.3 Site reconnaissance and overall description.

3. SUBSURFACE CONDITIONS

- 3.1 Local geology: bedrock, surficial and miscellaneous.
- 3.2 Subsurface exploration program.
  - a. Available subsurface information.
  - b. Borings/Soil and Rock samples review.
  - c. Probes/Test pits/Observation Wells.
  - d. Geophysical investigations.
  - e. Soils testing, Laboratory and/or In-situ.
- 3.3. Verification of sample descriptions on boring logs.
  - a. Statement that all soil and rock samples were visually and manually examined by the Engineer preparing the geotechnical report.
  - b. Location and date of sample examination.
  - c. Discrepancies or concurrence with boring logs.
- 3.4. Subsurface profile.
  - a. Written description, characteristics and classification of all soils and rock.
  - b. Graphic presentation showing all strata and water conditions as in Appendix 6.1.c.
  - c. Applicable design parameters for soil and rock: unit weight, gradation, strength, compressibility, moduli, rockmass rating, and jointing.
- 3.5. Seismic design parameters, liquefaction potential.

4. RECOMMENDED FOUNDATION SYSTEM

- 4.1. Retain or modify existing foundation.
  - a. Existing foundations/substructure depth, configuration, integrity and bearing material. The Designer shall design and conduct the appropriate method of investigation.
  - b. Applicable design study (see 4.2, 4.3 or 4.4.)
- 4.2. Embankment considerations (primarily for weak subsoils).
  - a. Stability - excavation/replacement, stage construction, berms, flattened slopes, lightweight fill, subsoil soil modification, fill reinforcement, erosion control.
  - b. Settlement - magnitude, primary, secondary, subsoil modification, waiting periods, surcharges, lateral movements, down-drag on piles.
- 4.3. Shallow foundation design.
  - a. Rational supporting shallow foundation selection (qualifying reasons, site and cost factors).
  - b. Bottom of footing elevation selection.

c. Ultimate soil bearing capacity and appropriate performance factor.
d. Estimate of total settlement, differential settlement and lateral movements.
e. Parameters for internal and external stability and design of abutments, walls and earth support systems.
f. Global stability (substructure-slope-subsoil system).
g. Subsoil preparation, fill material and compaction, soil/rock removal, treatment or stabilization.
h. Scour protection.
i. Special considerations.

4.4. Deep foundation design.
a. Rational supporting deep foundation system.
b. Recommended type (qualifying reasons, site and cost factors).
c. Ultimate axial capacity - static analysis, appropriate performance factor selection, stress wave analysis (piles), actual driving resistance vs. design resistance (scour), load tests.
d. Lateral load analysis.
e. Estimated lengths, depths and tip elevations.
f. Group design - group size, capacity, configuration, settlement.
g. Drilled shaft design - diameter, socket length, settlement.
h. Construction considerations - likely method of construction, pile driving criteria and procedures, negative skin friction, vibrations, predrilling, obstructions.
i. Special considerations - corrosion, coatings.
j. Other methods - pressure injected footings, jet grouting, jacked piles.

5. CONSTRUCTION CONSIDERATIONS

5.2. Water table - fluctuations, artesian conditions, effects of drawdown, pumping.
5.3. Recommended method for water control and preliminary design thereof.
5.4. Excavations - methods, earth support requirements, rock removal, OSHA requirements.
5.5. Obstructions - nature of, method of removal, break-through and payment.
5.6. Protection of adjacent structures and utilities - excavations, construction loads, settlement, vibrations, pumping.
5.7. Sequence of construction activities - stage construction, surcharging, pile installation.
5.8. Special geotechnical monitoring and instrumentation.

6. APPENDICES

6.1. Graphic Presentations.
a Project locus map.
b Site Plan showing as drilled boring locations, proposed and existing structures.
c Interpreted soil profile with foundation elements.
d Design charts and graphs.
e In-situ and lab test results.

6.2. Tables and Text.
a. Tabulated soil design parameters.
b. Tabulated in-situ and lab test results.
c. Table of foundation design alternates, criteria and costs.

d. All calculations performed by hand, spreadsheet or computer program including date performed, initials and references used.
e. Design charts or tables.
f. Final approved boring logs.
g. Applicable special provisions or specifications.
h. All special notes for plans.
i. Specific limitations.

2.6 HYDRAULIC REPORT

2.6.1 General

The Hydraulic Report will include a narrative explaining analytical methods used and summarizing results and recommendations. Pertinent information collected, computations, plans, other data should be included in the report's appendices.

Two copies of the report (three if FHWA review is required) shall be submitted to the Bridge Engineer. Each copy shall be clearly labeled, dated and bound. The report shall not be protected by copyright and shall be signed by the Engineer preparing it. Upon approval, An Adobe Acrobat format (PDF) file of the report shall be submitted on CD or via email.

2.6.2 Report Outline

An outline of the standard text plus information to be included in each section is as follows:

1. EXECUTIVE SUMMARY

This section is intended to briefly summarize the results of the study. The following items should be included:

1.1 Identification of alternatives considered.
1.2 Degree to which each alternative can practicably meet design criteria.
1.3 Special environmental, transportation, flood, or considerations affiliated with the crossing site.

2. PROJECT DESCRIPTION

This section is intended to define the site location and the objectives of the study. The following items should be included:

2.1 Bridge Number, and BIN.
2.2 Highway Number and/or Local Name.
2.3 Functional Classification of roadway, including average daily traffic.
2.4 Bridge description including date of construction, type, present AASHTO sufficiency rating, and the reason for replacement/rehabilitation (if applicable).
2.5 Waterbody/Waterway Name and watershed affiliation.
2.6 Brief description of watershed, including size, land cover, topography, and degree of urbanization.
2.7 Brief description of the waterway at the bridge site, including channel slope, stability, and bed material.
2.8 Land uses in the vicinity of the bridge.

2.9 Brief description of any special transportation environmental, flood, or scour issues associated with the crossing site and how they may affect project design, construction, and maintenance.

3. DATA COLLECTION

This Section will summarize the results of the data collection and evaluation, including the following:

3.1 Agencies contacted and data gathered from each.

3.2 Summary of the evaluation of the data collected and explanation of its use in the investigation.

4. ENGINEERING METHODS

This section will briefly discuss the computational methods used in the study including:

4.1 Hydrologic Analyses. (Discussion of methods used to compute discharge peaks.)

4.2 Hydraulic Analyses. (Discussion of hydraulic model assembly and calibration methodology.)

4.3 Scour/Stability Analyses. (Discussion of scour/stability evaluation procedure and any pertinent computation methods or field measurements/observations.)

5. CONCLUSIONS AND RECOMMENDATIONS

This section will present a tabulation of computed and compiled hydrologic and hydraulic data for posting on the bridge Sketch Plans and the Designer's recommendations for a preferred hydraulic opening alternative with consideration to minimization of:

1. Impact on the existing hydraulic regime.

2. Impact on adjacent ecosystems and developed land uses.

3. Scour/flood damage risk.

6. APPENDICES

6.1 Crossing Site Catchment (1:25000 USGS Quad).

6.2 Stream Cross Section Layout Plan.

6.3 Field Evaluation Forms.

6.4 Hydrologic Computations.

6.5 Hydraulic Computations.

6.6 Scour and/or Scour Counter Measure Computations.

6.7 Photographs and Index. *(Include a sufficient number of photographs to illustrate the road and waterway approaches to the bridge, the bridge structure, and any adjacent natural or built features that may be affected by the design.*

2.7 SKETCH PLANS

2.7.1 Introduction

2.71.1 The Bridge Sketch Plans are a preliminary presentation of the overall concept of the proposed structure or proposed rehabilitation. It allows the Designer and MassHighway to agree on the principal components of the structure type or the rehabilitation scheme to be pursued in the final design phase since the Sketch Plans show all major features to be incorporated into the Construction Drawings.

However, the approval of the Sketch Plan shall not be considered approval of non-standard details, which must be approved individually before they are used in the final design.

The Designer shall proceed with the preparation of Sketch Plans only after receiving approval of the structure type or rehabilitation scheme from MassHighway.

2.7.1.2 The Designer shall not proceed with the preparation of Construction Drawings until approved Sketch Plans have been received from the MassHighway. In addition to MassHighway approval, the Sketch Plans may require approval by FHWA.

2.7.1.3 Sketch Plans must be provided for all structures that require design. Sketch Plans are not required for structures taken from MassHighway Construction Standards. Exceptions to the above will be made only with the approval of the Bridge Engineer. Before the Sketch Plans are submitted, the Designer must obtain the Bridge Number and/or BIN (Bridge Identification Number) for each structure from the Bridge Engineer. This request must be made in writing as soon as the recommended bridge structure type has been approved.

In general, a new BIN is required for functional replacements of existing bridges where no portion of the existing structure provides direct support for the new structure. For bridge rehabilitation projects or where the existing structure remains to provide direct support for the new structure, the BIN of the existing structure is retained. For new bridges, both a new Bridge Number and new BIN are required.

2.7.2 Data Required for the Preparation of Sketch Plans

1. Borings
2. Hydraulic Data (if applicable)
3. Traffic Data
4. Highway Geometrics
5. Clearances
6. Bridge Type (approved by MassHighway)
7. Soils Report
8. Design Loading
9. Requirements of Utility Companies
10. Plot Plan (or other documentation used to determine length of walls)

2.7.3 Preparation of Sketch Plans

2.7.3.1 Sketch Plans submitted for signature shall be drafted on mylar (plastic drafting film). Sheet sizes, borders and title blocks shall be as detailed on Drawing No. 1.2.1 of Part II of this Bridge Manual. The minimum height of lettering shall be ⅛”. The Sketch Plans shall be organized as follows:

1. First Sheet
2. Boring Sheets
3. Structure Detail Sheets

2.7.3.2 First Sheet. The first sheet of the Sketch Plans shall contain the following information:

Standard Title Block: The project description shall be the same as the description to be used on the Construction Drawings. See Paragraph 4.2.2.2 for the standard project descriptions and their definitions.

Standard Data Block.

Locus. A small scale plan which serves as a map to locate the structure. Approximate scale is 1" = 2000'.

Key Plan. A plan of the proposed structure, typically drawn to a scale of 1" = 40', showing baselines, center lines of construction, curve data, roadway widths, angles of intersection to establish geometry of the structure, equation of stations of intersecting baselines, existing and relocated utilities, configuration of proposed and existing structures and their footings, topographical features, and layout lines if available. Where a waterway is involved, show the old location and the proposed location of the stream. Show riprap treatment and any channel paving. The locations of all borings, test pits and/or other subsurface investigations shall be shown on the key plan.

Profiles. A profile of each road, railroad or stream bed shall be shown with proposed and existing ground grades, outline of proposed and existing structures and limits of any preload earth embankments. Typically for most structures, the vertical scale is ⅛" = 1'- 0" and the horizontal scale is 1" = 40'.

Design Specification. The following note should appear on the first sheet:

DESIGN
IN ACCORDANCE WITH THE 20-- AASHTO STANDARD SPECIFICATIONS WITH INTERIM SPECIFICATIONS THROUGH 20-- FOR HS25 LOADING. *(Use this note for bridges carrying roadways. If the design loading is different from HS25, specify the actual design loading)*

Any design criteria that varies from AASHTO Standard Specifications or the MassHighway Bridge Manual shall be so noted on the Sketch Plan.

DESIGN
IN ACCORDANCE WITH THE 20-- AREMA SPECIFICATIONS FOR RAIL BRIDGES, WITH INTERIM SPECIFICATIONS THROUGH 20--. *(Use this note for bridges carrying railroads)*

Notes. The following notes shall appear on the first sheet:

NOTES:

1. APPROVAL DOES NOT INCLUDE THE PROFILE GRADES WHICH ARE PRELIMINARY ONLY. *(This note may be omitted if profile has been approved).*

2. APPROVAL DOES NOT INCLUDE STRUCTURAL ANALYSIS. *(Approval does not include structural analysis nor does it relieve the Designer of the responsibility for proposing an economical and buildable structure).*

3. DIMENSIONS OF STRUCTURAL MEMBERS ARE APPROXIMATE, AND WILL BE FINALIZED DURING THE FINAL DESIGN PHASE.

4. SEE GEOTECHNICAL REPORT, DATED *(give date)*.

5. SEE HYDRAULIC REPORT, DATED *(give date)*.

6. NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988 IS USED THROUGHOUT.

Hydraulic Data. For any structure over a stream the following data shall be listed on the first sheet:

HYDRAULIC DATA

DRAINAGE AREA:___________________________SQUARE MILES
DESIGN DISCHARGE:________________________CUBIC FEET PER SECOND
DESIGN FREQUENCY:_______________________YEARS
DESIGN VELOCITY:_________________________FEET PER SECOND
DESIGN HIGH WATER: ELEVATION:__________FEET

BASIC FLOOD DATA

Q (100 YEAR):_______________________________CUBIC FEET PER SECOND
WATER SURFACE ELEVATION:_______________FEET

FLOOD OF RECORD

Q = _______________________________________CUBIC FEET PER SECOND
FREQUENCY (IF KNOWN):___________________YEARS
DATE:_______________________________________
HISTORY OF ICE FLOES:_____________________
EVIDENCE OF SCOUR AND EROSION:_________

2.7.3.3 Boring Sheets. The following information shall appear on the boring sheets:

Boring Data.

Boring Logs: Boring logs shall be plotted in groups as they relate to substructure units. All boring logs shall be plotted to the same base elevation.

Water Levels: Water level at each boring should be plotted to scale and date of observation should be shown.

Footing Elevations: The elevations at the bottom of each proposed substructure unit should be plotted to scale. The approximate elevation of the pile tips or drilled shaft bottom shall be plotted where appropriate. In the case of a substructure unit founded on ledge, the elevation at the top of the footing shall be plotted.

Boring Notes. The following notes shall appear on the first sheet of the Boring Data sheets of all Sketch Plans:

BORING NOTES:

1. LOCATION OF BORINGS SHOWN ON THE PLAN THUS: *(see Drawing No. 1.3.3 of Part II of this Bridge Manual for boring symbols).*

2. BORINGS ARE TAKEN FOR PURPOSE OF DESIGN AND SHOW CONDITIONS AT BORING POINTS ONLY, BUT DO NOT NECESSARILY SHOW THE NATURE OF THE MATERIALS TO BE ENCOUNTERED DURING CONSTRUCTION.

3. WATER LEVELS SHOWN ON THE BORING LOGS WERE OBSERVED AT THE TIME OF TAKING BORINGS AND DO NOT NECESSARILY SHOW THE TRUE GROUND WATER LEVEL.

4. FIGURES IN COLUMNS INDICATE NUMBER OF BLOWS REQUIRED TO DRIVE A 1 3/8” I.D. SPLIT SPOON SAMPLER 6” USING A 140 POUND WEIGHT FALLING 30”.

5. BORING SAMPLES ARE STORED AT A STORAGE FACILITY LOCATED ON ROUTE 114 (219 WINTHROP AVE.) IN LAWRENCE, MA. THE CONTRACTOR MAY EXAMINE THE SOIL AND ROCK SAMPLES BY CONTACTING THE MASSHIGHWAY GEOTECHNICAL SECTION AT 10 PARK PLAZA, ROOM 6500, BOSTON, MA 02116-3973 AT 617-973-8836.

6. ALL BORINGS WERE MADE IN *(give month(s) and year(s)).*

7. BORINGS WERE MADE BY *(give name and address of boring contractor).*

8. THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988 IS USED THROUGHOUT.

Ground Water. If ground water observation wellpoints have been installed, the observed water levels will be tabulated on the Sketch Plans along with the following notation:

GROUND WATER

THE WATER LEVELS RECORDED IN THE TABLE ARE THOSE MEASURED ON THE DATES GIVEN AND DO NOT NECESSARILY REPRESENT GROUND WATER LEVEL AT TIME OF CONSTRUCTION.

2.7.3.4 Structure Detail Sheets. At a minimum, the following information shall be put on the structure detail sheets:

Longitudinal Section. The scale is normally ⅛" = 1'- 0", but it will vary depending upon the length of structure. This is a section taken parallel to the centerline of the structure showing its relationship to the highway, railroad, or stream under the structure. Shown on this view are the following items:

1. All square and skew horizontal dimensions and vertical clearances (if the proposed structure modifies or replaces an existing structure, show existing and proposed clearances).
2. Elevation at bottom of footings (top of footings if on ledge) or approximate pile tip of bottom of shaft elevation.
3. Location of fixed and expansion bearings.
4. Factored soil bearing pressures and capacities or factored pile or shaft loads and capacities for Group X loading (define critical group number).
5. Type of pile (if any).
6. Gravel borrow for bridge foundations or crushed stone for bridge foundations (if any).
7. Existing ground.
8. Proposed cross-section of road, railroad, or stream under the structure (give all pertinent dimensions such as sidewalk and roadway widths, track to track centerlines as well as their distances from the proposed or retained substructure elements).
9. Individual span lengths and overall span length, both square and skew (center line to center line of bearings).
10. Tremie seal and sheeting (if applicable, see Subsection 3.2.3 for guidelines).

Elevation of Pier. A scale view, along the length of the pier, showing critical dimensions to be used in its design.

Transverse Section of Superstructure. A cross-section of the superstructure showing:

1. All critical dimensions
2. Roadway cross-slopes
3. Type of railing or barrier
4. Utility locations
5. Spacing, depth, and type of beam
6. Slab thickness and type
7. Type of wearing surface

If stage construction is involved, show the limits of both the existing and proposed structures for all stages of construction. These sections should also show all details and dimensions necessary to determine the adequacy of the proposed staging from both a structural and traffic safety standpoint.

Channel Approach Section. A cross-section of the waterway approaches to the bridge showing:

1. Existing and proposed channel dimensions
2. Treatment of slopes
3. Existing water elevation

4. Design water elevation

Approach Section. A cross-section of the approach to the superstructure showing controlling dimensions and details.

2.7.4 Submission and Approvals

2.7.4.1 Submission of Bridge Sketch Plans. Initial submission of Sketch Plan prints for review is as follows:

MBTA crossing - 3 sets
Other RR crossing - 6 sets
Waterway crossing - 3 sets
Highway crossing - 2 sets

Plus 2 sets for each utility involved.

If the project requires FHWA review and approval, a second submission of 2 sets of prints will be required after all initial review comments are resolved.

2.7.4.2 Review Process. Sketch Plans prints showing review comments shall be returned to the Designer, who will resolve all comments and correct the Sketch Plans as necessary. Corrected prints and all marked-up review prints shall be submitted to the MassHighway where the prints will be back-checked and given initial approval. MassHighway shall forward the initially approved Sketch Plans to FHWA if their approval is required. Should the FHWA comment on the plans, all comments will be resolved and changes made to the Sketch Plans by the Designer.

Final Sketch Plans shall be printed on mylar (plastic drafting film) shall be submitted to MassHighway for approval signatures. Two sets of prints of approved Sketch Plans will be sent to the Designer and are the basis for the preparation of the design. The final mylars become the property of MassHighway.

2.7.4.3 Related Approvals. License plans for permits, if applicable, are to be prepared as outlined in the Federal Register. Federal legislation of 1975 requires the filing of applications with both the U.S. Coast Guard and the U.S. Corps of Engineers.

Permit plans, with letters of application, environmental requirements, water pollution control requirements, and other related material as required, will be processed through MassHighway.

CHAPTER 3
BRIDGE DESIGN GUIDELINES

3.1 DESIGN CRITERIA

3.1.1 Design Specifications

3.1.1.1 All designs for highway bridges shall be performed in accordance with the latest edition of the following specifications and as modified by this Bridge Manual:

1. American Association of State Highway and Transportation Officials (AASHTO), *Standard Specifications for Highway Bridges*.

2. The Commonwealth of Massachusetts, Massachusetts Highway Department, *Standard Specifications for Highways and Bridges*.

3. AASHTO/AWS *Bridge Welding Code* (ANSI/AASHTO/AWS D1.5).

3.1.1.2 All designs for railroad bridges shall be performed in accordance with the latest edition of the American Railway Engineering and Maintenance-of-Way Association (AREMA), *Manual for Railway Engineering*.

3.1.2 Design Methods

Current Bridge Section policy with regards to design methods is as follows:

1. All superstructures shall be designed in accordance with the Service Load Design Method (Allowable Stress Design) of the AASHTO specifications.

2. All substructures shall be designed in accordance with the Strength Design Method (Load Factor Design) of the AASHTO specifications.

3. Culverts, soil-corrugated metal structure interaction systems, 3 sided precast concrete sectional frames, and precast concrete sectional arches shall be designed using the Strength Design Method (Load Factor Design) of the AASHTO specifications.

3.1.3 Live Load

3.1.3.1 The minimum AASHTO design live load for all bridges, culverts, soil-corrugated metal structure interaction systems, and walls shall be HS25. For structures on Federal Aid Interstate Highways, including structures on connectors between Interstate Highways and Interstate Highway on/off ramps, the minimum loading shall be HS25 modified for Military Loading. Design for HS25 loading by multiplying the HS20 wheel or axle loads by 1.25.

3.1.3.2 Existing bridges that are being rehabilitated will be upgraded to meet the minimum design loading of Paragraph 3.1.3.1. Only the Bridge Engineer may grant any exceptions.

3.1.3.3 Historic structures that are being rehabilitated may be exempted from complying with

Paragraph 3.1.3.2 if the structure's inventory rating can be upgraded to meet the anticipated truck traffic loadings. Only the Bridge Engineer may grant any exemptions.

3.1.4 Bridge Railings/Barriers

3.1.4.1 AASHTO has archived the 1989 *Guide Specifications for Bridge Rails* as of the 1998 Interims, and as a result, the document is no longer in force. Designers shall select the appropriate bridge railing/barrier for a project based on the application matrix of Paragraph 3.1.4.2.

3.1.4.2 The standard MassHighway railings/barriers detailed in Chapter 9 of Part II of this Bridge Manual shall be used in accordance with the following matrix:

Railing/Barrier	Test Level	To Be Used	Application Notes
CT-TL2	TL-2 - less than 45 MPH	Non-NHS highways only with design speeds not exceeding 45 MPH	Off system municipally owned bridges w/ or w/out pedestrians; no protective screen
S3-TL4	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	W/ or w/out pedestrians
CP-PL2	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	W/ or w/out pedestrians, mainly urban & RR bridges and all structures over electrified AMTRAK rail lines; must be used with either Type II screen or hand rail
CF-PL2	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	Bridges where pedestrians are prohibited by law; often on undivided state highway bridges
CF-PL3	TL-5	NHS and Non-NHS limited access highways and their ramps	All Interstate and limited access state highway bridges

3.1.4.3 Railings/barriers other than the ones detailed in Chapter 9 of Part II of this Bridge Manual, may be used provided that the use of a non-standard MassHighway railing/barrier can be justified and that they have been crash tested as follows:

Non-NHS highways: Crash tested to meet the requirements of NCHRP 230 or 350, however, every attempt should be made to use a railing crash tested to NCHRP 350.

NHS highways: Federal Highway regulations require that only railings/barriers crash tested to meet the requirements of NCHRP 350 be used on these highways.

Railings/barriers that have not been crash tested will not be used on any MassHighway bridge project.

3.1.4.4 In cases where railings/barriers are mounted on top of U-wingwalls or retaining walls, the wall shall be designed to resist a load of 10 kips acting over a 5 foot length applied at a distance equal to the height of the railing/barrier above the top of the wall. This load shall be distributed down to the footing at a 1:1 slope. This load shall be considered a factored load and the design lateral earth pressure from the retained soil need not be considered to act concurrently with this load.

3.1.5 Other Design Criteria

3.1.5.1 Earth Pressure Computations. Earth pressure coefficient estimates are dependent on the magnitude and direction of wall movement. Unless documented otherwise in the approved Geotechnical Report, the following earth pressure coefficients shall be used in design:

Counterfort, cantilever, gravity walls founded on rock or piles shall use K_o.
Cantilever walls less than 16’-6” in height shall use $0.5(K_o + K_a)$.
Cantilever walls greater than or equal to 16’-6” in height or any spread footing supported wall that does not bear directly on ledge shall use K_a.

Where:
K_o= At-rest earth pressure coefficient;
K_a= Active earth pressure coefficient;

Active pressure coefficients shall be estimated using Coulomb Theory. Passive pressure coefficients shall be estimated using Rankine or Log Spiral Theory, with the exception of passive pressure exerted against integral abutments, which shall be estimated in accordance with Section 3.9 of this chapter. Current MassHighway practice is to use a unit weight for earth of 120 pounds/cubic foot in the calculation of earth pressures where more specific data is not available.

3.1.5.2 Temperature. Thermal stresses and movements shall be calculated in accordance with the AASHTO Specifications for the Cold Climate temperature range. The maximum one way thermal movement, δ_T, for the design of structural components shall be:

$$\delta_T = L\alpha\Delta T$$

Where:
L = Total length of member under consideration from point of assumed zero movement to point where movement is calculated;
α = Coefficient of thermal expansion of member material (0.00000645 for structural steel, 0.0000055 for concrete);
ΔT = 70°F temperature rise and 100°F temperature fall (Structural Steel);
ΔT = 35°F temperature rise and 45°F temperature fall (Concrete).

The thermal movement range for structural steel members was developed by assuming a 50°F ambient construction temperature to determine the temperature rise and a 70°F ambient construction temperature to determine the temperature fall.

3.2 FOUNDATION DESIGN

3.2.1 General

The recommendations made in the Geotechnical Report shall form the basis for the selection and design of the foundation of the bridge structure. In addition to recommending the foundation type, this report also provides the site specific design parameters, such as soil resistance, on which the foundation design will be based. Pertinent information from the Geotechnical Report regarding design and/or construction shall be included on the plans and in the special provisions.

3.2.2 Pile Foundations

3.2.2.1 Pile foundations shall be designed in accordance with the provisions of the AASHTO Specifications. The design of piles shall be based on the Factored Geotechnical Pile Resistance and the Factored Ultimate Structural Resistance.

The factored structural axial resistance is the product of the ultimate structural axial resistance of the pile, the corresponding resistance factor, as indicated in AASHTO, and the eccentricity factor, r. AASHTO does not give values for the eccentricity factor. The following eccentricity factors, excerpted from the NCHRP Report 343 (*Manuals for the Design of Bridge Foundations)*, shall be used:

Pile Type	**Eccentricity Factor**
Precast or Prestressed Concrete, Spiral Reinf.	0.85
Precast or Prestressed Concrete, Tied	0.80
Steel H-Piles	0.78
Steel Pipe	0.87
Timber	0.82

The factored geotechnical pile resistance is the product of the ultimate geotechnical resistance of the pile and the corresponding performance factor, as indicated in AASHTO. The lowest resistance value will be the design controlling resistance and shall be greater than the combined effect of the factored loading for each applicable load combination.

3.2.2.2 The additional following criteria shall be used as required:

1. Maximum batter on any pile shall be 1:3. When concrete piles are driven in clay, the maximum batter shall be 1:4.

2. The Geotechnical Report should recommend values for Lateral Resistance provided by vertical or battered piles. The geotechnical analysis, relating lateral resistance to deflection, should be performed based on unfactored lateral loads.

3. Maximum spacing of piles shall be 10 feet on center, minimum spacing shall be 2.5 times the pile diameter, unless an alternate design is performed by the Designer and has been reviewed and approved by MassHighway.

4. Minimum distance from edge of footing to center of pile shall be 18 inches.

5. The resultant center of loading and the center of gravity of the pile layout shall coincide as nearly as practical.

6. Pile layouts of piers with continuous footings shall show a uniform distribution of piles. Exterior piles on the sides and ends of pier footings may be battered if required by design.

7. Steel pile supported foundation design shall consider that steel piles may be subject to corrosion, particularly in fill soils, low ph soils (acidic) and marine environments. Where warranted, a field electric resistivity survey, or resistivity testing and ph testing of soil and groundwater samples should be used to evaluate the corrosion potential. Steel piles subject to corrosion shall be designed with appropriate thickness deductions from the exposed surfaces of the pile and/or shall be protected with a coating that has good dielectric strength, is resistant to abrasive forces during driving, and has a proven service record in the type of corrosive environment anticipated. Protective coating options include electrostatically applied epoxies, concrete encasement jackets, and metalized zinc and aluminum with a protective top coat.

8. When roadway borrow is more than 10 feet in depth, holes should be pre-augured for all piles except H piles.

9. Pile to footing connections shall be designed to transfer no less than 10% of the pile's ultimate capacity in tension. Weldable reinforcing steel attachments shall be provided on steel piles where necessary to transfer pile tension.

3.2.3 Sheet Piling Design

3.2.3.1 All sheeting that is to be left in place shall be designated as permanent sheeting, shall be fully designed, shall be shown on the plans, and a unit price item shall be provided for permanent sheeting in the estimate. All sheeting that is to be left in place shall be steel sheeting. The Designer shall verify the availability of the steel sheeting sections specified. The design shall include the following:

1. Plan view indicating horizontal limits of sheeting.

2. Cross-section indicating vertical limits of sheeting.

3. Minimum section modulus and nominal strength of steel sheeting.

4. Where a braced sheeting design is indicated, the design of the bracing and wales shall also be provided and shown with full dimensions on the plans.

3.2.3.2 The Designer, in designing the sheeting, shall assume that the bottom of excavation may be lowered by 24 inches. This lowering may be due to over-excavation or removal of unsuitable materials.

3.2.3.3 Sheeting that is used in conjunction with a tremie seal cofferdam shall be left in place. The Designer shall design both the tremie seal and the cofferdam. The Designer shall indicate the depth and thickness for the tremie seal, and the horizontal and vertical limits of the steel sheeting for the cofferdam. In addition the Designer shall indicate on the plans the elevation at which the cofferdam should be flooded in the event that the water rises outside the cofferdam to cause excess hydrostatic pressure.

3.2.3.4 Sheeting that protrudes into the soil that supports the bridge structure shall be left in place. Supporting soil shall be defined as all soil directly below the footing contained within a series of planes that originate at the perimeter of the bottom of the footing and project down and away from the footing at an angle of 45° from the horizontal. Sheeting placed at the heels of abutment and walls may be exempted at the discretion of the Bridge Engineer.

3.2.3.5 All sheeting required for the support of railroads shall be designed as permanent sheeting by the Designer.

3.2.3.6 Whether sheeting is indicated on the plans or not, the Contractor shall be informed by the Special Provisions that any sheeting driven into the supporting soil below the bridge structure, as defined by Paragraph 3.2.3.4, shall be cut off and left in place and no additional payment will be made for this sheeting.

3.2.4 Drilled Shafts

3.2.4.1 Drilled shafts shall be considered where cost and constructability may be favorable compared to spread footing or pile supported structures. Anticipated advantages are the reduction of the quantities and cost of excavation, dewatering, and sheeting. Additionally, the use of drilled shafts may be beneficial in working within critical horizontal restrictions, or in limiting the environmental impact.

3.2.4.2 Design. Drilled shafts shall be designed in accordance with the requirements of the latest AASHTO specifications and the following:

1. The Designer shall consider the intended method of construction (temporary or permanent casing, slurry drilling, etc.) and the resulting impact on the stiffness and resistance of the shaft.

2. If the pier column is an integral extension of the drilled shaft and the design assumes a constant diameter throughout, it is imperative that either the construction of the shaft be consistent with this assumption or that the revised details be fully evaluated prior to construction. Tolerances between the plumbness of the shaft, shaft location, and pier cap dimensions shall be considered relative to the types of subsurface and site conditions encountered for these types of shafts.

3. The lateral resistance and lateral load – deflection behavior of the drilled shaft shall be determined using soil-pile interaction computer solutions or other acceptable methods.

4. When a drilled shaft is constructed with a permanent casing, the skin friction along the permanently cased portion of the shaft should be neglected.

5. Continuous steel reinforcing shall be maintained where possible throughout the length of the shaft. Splices should be avoided in the longitudinal steel where practical. If splices are unavoidable, they shall be made with mechanical reinforcing bar splicers and shall be

staggered a minimum of 24 inches. Splices in the spiral confinement reinforcement shall, where necessary, be made using mechanical reinforcing bar splicers. Detailing for seismic requirements prohibits splices in those regions that may develop plastic hinges. The Designer shall ensure that cover requirements are met over the mechanical reinforcing bar splicers.

6. The maximum coarse aggregate size for the shaft concrete and the spacing of reinforcement shall be coordinated to ensure that the clearance between reinforcing bars is at least 5 times the maximum coarse aggregate size. Concrete mix design and workability shall be consistent for tremie or pump placement. In particular, the concrete slump should be 5 inches ± 1 inch for permanent casing construction or dry uncased construction, 7 inches ± 1 inch for dry temporary casing construction, and 8 inches ± 1 inch for tremie or slurry construction.

3.2.4.3 Special design and detailing is required where the drilled shaft is an extension of a pier column. The drilled shaft reinforcement shall be continuous with that of the pier column. The spiral reinforcing shall extend from the base of the shaft into the pier cap as required by the AASHTO seismic requirements.

3.2.5 Gravel Borrow for Bridge Foundations

3.2.5.1 Gravel Borrow For Bridge Foundations (Item 151.1) shall be assumed to have a soil friction angle (Φ) of 37˚. The ultimate bearing resistance shall be estimated using accepted soil mechanics theories based upon the assumed soil friction angle (Φ) of 37˚ for the Gravel Borrow For Bridge Foundations, the measured soil parameters of the material underlying the Gravel Borrow For Bridge Foundations, the effect produced by load inclination, and the highest anticipated position of the groundwater level at the footing location.

For loads eccentric to the footing centroid a reduced effective bearing area will be assumed to be concentrically loaded for the purpose of calculating the factored bearing pressure. The structural design of the eccentrically loaded footing will assume a triangular or trapezoidal contact pressure distribution based upon factored loads. The average factored bearing pressure shall be compared to the factored ultimate bearing capacity to determine whether the bearing capacity is adequate.

Gravel for this item will be permitted up to a height of 20 feet under the footings and shall be compacted in accordance with the MassHighway *Standard Specifications for Highways and Bridges*. In special cases, this depth may be increased. A study should be made in each case to show that its use will affect an economy in the cost of the structure. Its use is not authorized for river structures or for placement under water.

3.2.6 Crushed Stone for Bridge Foundations

In general, this material is used where water conditions prevent the use of **GRAVEL BORROW FOR BRIDGE FOUNDATIONS**. The pressure on the granular soil below the crushed stone will govern the Ultimate Bearing Resistance of the crushed stone. De-watering the area and using **GRAVEL BORROW FOR BRIDGE FOUNDATIONS** compacted in the dry, or not de-watering and using **CRUSHED STONE FOR BRIDGE FOUNDATIONS** shall be investigated for feasibility and economy.

3.2.7 Foundations on Ledge

3.2.7.1 If the top of ledge is comparatively level and is located at a shallow depth from the proposed bottom of footing, then, for economy, consideration shall be given to lowering the footing so that it will be founded entirely on ledge.

3.2.7.2 If a footing will be located partly on ledge and partly on satisfactory granular material, the ledge should be excavated to a depth of about 18" below the bottom of footing and backfilled with **GRAVEL BORROW FOR BRIDGE FOUNDATIONS**. Consideration should also be given to excavating the material above the ledge and backfilling with 2500 PSI, 1½ ", 425 Cement Concrete to the bottom of proposed footing elevation. In either case, the footing must be founded on the same material throughout its bearing length.

3.2.7.3 All weathered and/or deteriorated ledge shall be removed so that the entire footing will rest on sound rock, unless otherwise designed and approved.

3.2.8 Pre-loaded Areas

3.2.8.1 Pre-loading or pre-loading with surcharge may be required to consolidate compressible soils and minimize long-term settlements under load. If unsuitable material is encountered, it shall be excavated prior to placing the embankment.

3.2.8.2 If the water table is higher than the bottom of excavation of unsuitable material, crushed stone shall be used in the embankment up to the proposed elevation of the bottom footing, followed by the placement of gravel borrow for the embankment. Both of these materials shall be placed during embankment construction. The amount of anticipated settlement should be accounted for in the specified top elevation of the crushed stone beneath the proposed bottom of footing.

3.3 SUBSTRUCTURE DESIGN

3.3.1 General

3.3.1.1 Footings shall be proportioned in accordance with the standard details shown in Part II of this Bridge Manual and shall be designed for factored loads so that the resultant center of pressure shall be located within the middle half of the footing dimension in any direction when it is founded on suitable soil material. The resultant center of pressure shall be located within the middle ¾ of the footing dimension in any direction when it is founded on suitable rock. The passive resistance of the earth in front of a wall shall be neglected in determining wall stability. The stability of the wall during all stages of construction shall be investigated. Reinforced concrete keyways tied into footings shall not be used to aid in the resistance to sliding due to the questionable resistance provided by the subsoil in contact with the keyway that is likely to be disturbed during construction.

3.3.1.2 Factored bearing pressures under the footings shall be calculated in accordance with AASHTO. The weight of the earth in front of a wall shall be considered in computing soil pressure.

3.3.1.3 The non-seismic longitudinal forces for abutment design shall include:

1. The live load longitudinal forces specified in AASHTO Section 3.
2. The horizontal shear force developed by the bearings through either shear deformation

(elastomeric bearings) or friction (sliding plate bearings).

3.3.1.4 Piers and abutments of a bridge over salt water will normally be protected with granite within the tidal range. The granite blocks will be caulked with polysulfide caulking. Piers and abutments over fresh water do not require this protection unless the normal flow of water and seasonal water level variations are anticipated to be large.

3.3.1.5 At a minimum, the reinforcing bars used in the following elements of the substructure require protection and, so, shall be epoxy coated: backwalls, beam seats, pier caps, and the High Performance concrete pour section of U-wingwalls. Also, when abutment faces, piers, wingwall faces, and retaining wall faces are within 30 feet of a traveled way, the reinforcing bars adjacent to those faces shall be epoxy coated. If all of the reinforcing bars in the given concrete pour are to be coated, and the coated bars will never come into contact with or are to be tied to non-coated bars, then galvanized bars may be used instead of epoxy coated bars. In these situations, the plans shall designate these bars as COATED BARS, without specifying the coating type.

3.3.2 Walls: Abutment and Wingwall

3.3.2.1 Gravity walls. Walls of this type are used where low walls are required, generally up to 14' in height. When the wall is founded on sound ledge the footing is omitted. The top of ledge shall be roughened as necessary to provide resistance against sliding. A shear key may be provided, if necessary.

3.3.2.2 Cantilever walls. Generally, this wall type is used in the intermediate height range (14' to 30') applications between gravity and counterfort walls. In those situations where a wall starts in the height range prescribed for cantilevered walls but tapers down into the height range prescribed for gravity walls, the cantilevered wall type will be used throughout instead of changing to a gravity type in mid-wall. Footings for wall segments of variable height shall be designed using a wall height equal to the low end wall height plus 75% of the difference in height between the low end and high end.

When designing the reinforcement in the toe of the footing, the weight of the soil above the toe shall not be used to offset the force of the upward soil pressure. The reinforcement in the heel of the footing shall be designed to carry the entire dead load of all materials above the heel, including the dead load of the heel. The effect of the upward soil pressure or pile reaction will not be used to offset this design load.

3.3.3 Counterfort Walls

A counterfort wall design shall be considered for retaining structures and abutments higher than 30 feet. However, the economics and constructability of a counterfort wall versus a similar height cantilevered wall with a thicker stem shall be investigated.

3.3.4 Piers

3.3.4.1 Piers for most structures are typically of reinforced concrete construction. Piers for grade separation structures are typically open type bents with circular columns. Piers for structures over railroads can be either a solid stem type or an open type bent with a crash wall conforming to AREMA requirements for pier protection, depending on an economic analysis. Piers for structures over water are typically a solid stem type. Piers for trestle type structures are typically pile bents.

3.3.4.2 For open type bents, the bottom of the pier cap is normally level. However, if the height of one end of the pier cap exceeds 1.5 times the height of the cap at the other end, then the bottom of the pier cap may be sloped to stay within these limits.

3.3.4.3 The columns shall be assumed as fully fixed at the footing, and the pier designed as a rigid frame above the footing. Continuous footings founded on granular material or on piles shall be designed as a continuous beam. Individual footings shall be used on ledge.

3.3.4.4 Live loads shall be positioned on the bridge deck so as to produce maximum stresses in the pier bent. To determine the maximum live load reactions on a bent using truck loading, only one truck per lane shall be used. In the case of lane loading, only one concentrated load per lane shall be used in conjunction with the uniform load. Stringer reactions resulting from dead and live loads (plus impact) shall be considered as concentrated loads on the pier cap.

3.3.4.5 The effect of wind on bridges shall be ignored when:

1. Pier height is less than 25 feet as measured from top of footing to top of pier cap.

2. Span lengths are less than 90 feet as measured centerline to centerline of bearings.

3.3.5 Culverts

3.3.5.1 Normally, sidesway of the structure shall be ignored in the design of culverts and other rigid frame structures provided that the fill placed around the structure shall be deposited on both sides to approximately the same elevations at the same time. No hydrostatic effect on the culvert shall be considered in its design.

3.3.5.2 Fillets for box culverts shown in Part II of this Bridge Manual are not to be taken into consideration in the design of the section. However, for culverts where fillets are larger than 12”, the fillets shall be considered as being haunches and the design shall include their effect on the section.

3.3.5.3 Moments, and the moment diagram, shall be calculated using member lengths based on the distances to the geometric centers of the members in accordance with the AASHTO Section 8 article on span lengths. Where critical sections are at the face of supports, the design moment shall be taken as that moment which, according to the moment diagram, occurs at the critical section location and not at the geometric center.

3.3.5.4 Design criteria (live load, impact, etc.) for the roof of a culvert shall also apply for the floor of the culvert. A maximum of one-half of the moment caused by the lateral earth pressure shall be used to reduce the positive moments in top and bottom slabs of culverts in accordance with AASHTO Section 3 for earth pressures for rigid frames.

3.4 SEISMIC DESIGN GUIDELINES

3.4.1 Dynamic Modeling

3.4.1.1 The following discussion is intended to illustrate techniques used to model multiple span bridge structures and determine their dynamic response to ground excitations. Recommendations for modeling soil-structure interaction are given.

3.4.1.2 The current practice is to model the stiffness of bridge structures using a linear elastic "stick model" approach. Superstructures are modeled as a single line of beam elements. The flexural stiffness and mass of the superstructure and substructure may be determined by hand or by using readily available computer programs. These parameters are lumped at discrete locations as referenced in AASHTO. The Designer shall adhere to the following guidelines when performing a seismic analysis:

1. A linear elastic model of the bridge system, with member properties determined assuming gross uncracked sections, shall be used. All multiple span bridges, which do not meet the AASHTO definition of a “regular” bridge, shall require a multi-mode spectral analysis. All other bridges require a single mode spectral analysis. The response spectrum analysis method shall be used to determine the elastic inertial forces. The definition of a regular and an essential bridge is provided in the *Seismic Retrofitting Manual for Highway Bridges (Report No. FHWA-RD-94-052)*. Bridges which require a multi-mode analysis shall use 3 modes of vibration for each span, or more, if necessary, to capture the dynamic characteristics of the bridge system.

2. Uncracked column section properties shall be used. This will result in shorter periods of vibration and higher inertial forces than would be expected should column yielding occur during the design earthquake. Pier cap properties shall be assumed to be rigid to simulate the stiffness of the superstructure. The resulting column moments and shears in multi-column piers should be approximately the same as a result of the assumption of a rigid pier cap.

3. Substructures shall be designed and detailed to ensure that sufficient inelastic capacity is provided. Multiple column piers are typically used due to their inherent redundancy. The process of dividing elastic column demand forces and moments, obtained from the model, by various R factors, assumes that the column detailing is sufficient to allow inelastic behavior to occur. If proper detailing is not present, such as is often the case with existing construction, the R factors must be reduced to account for a lack of ductile capacity. Recommended R factors for existing construction are specified in the section on seismic retrofitting.

3.4.2 Substructure Seismic Performance

3.4.2.1 Abutments may be categorized as one of the following types:

1. Integral
2. Seat type (Gravity, Cantilever, Semi-Integral, etc.)

Integral abutments utilize controlled compacted backfill to absorb seismic energy. AASHTO recommends consideration be given to using integral abutments as a method of minimizing collapse potential for short span bridges. AASHTO further recommends that the integral abutment diaphragm be designed to resist passive earth pressures as a means of minimizing damage when the abutment is relied upon to resist longitudinal seismic forces. When piers are also used to provide longitudinal restraint of the superstructure the distribution of longitudinal forces shall be a function of the relative stiffness of each substructure unit.

Use of seat type abutments is sometimes necessary where skew, span length, geotechnical, and/or constructability issues make integral construction unfeasible. Seat type abutments have the advantage of generally simplifying the analysis, however, their use introduces a potential collapse mechanism into the structure. Bearings at seat type abutments for multiple span bridges should, where possible, allow for longitudinal translation. The use of more flexible and ductile multiple column piers is recommended for providing longitudinal restraint in multiple span bridges, rather than more rigid gravity or cantilever abutments.

Continuous superstructures shall be utilized wherever possible on multiple span bridges. This results in serviceability improvements to the structure and eliminates a potential collapse mechanism. The skew angle and degree of curvature for bridges shall be minimized as much as possible. Skewed supports tend to promote rotation of the superstructure about a vertical axis under seismic loading.

Multiple column piers shall be designed as a rigid frame. The effects of slenderness shall be considered. Shear and confinement reinforcement shall be spirals designed and detailed in accordance with AASHTO criteria. Hammerhead pier stems may feature interlocking spirals or ties designed and detailed in accordance with AASHTO criteria.

3.4.2.2 Seat Widths / Anchor Bolts. Design displacements shall be determined in accordance with AASHTO requirements. The minimum bearing seat length shall be the maximum value from either the elastic analysis or the value from the following formula:

$$N = (8 + 0.02L + 0.08H)(1 + 0.000125S^2) \text{ in.}$$

Where:

L = length, in feet, of the bridge deck to the adjacent expansion joint or to the end of the bridge deck. For single span bridges L equals the length of the bridge deck. For hinges within a span, L is the sum of deck lengths measured from the hinge to the next expansion joint on each side of the hinge.

S = angle of skew in degrees, measured from a line parallel to the centerline of the pier to a line normal to the centerline of the superstructure.

H is given by the following:

For abutments, average height in feet of piers located between abutment in question and the next expansion joint. H is measured from the average bottom of footing to the average top of pier. H equals 0 for single span bridges.

For piers, H is the pier height in feet for the pier in question.

For hinges within a span, H is the average height in feet of the two adjacent piers on either side of the hinge.

CALTRANS recommends that structures that feature intermediate joints or hinges be designed to accommodate the structure's independent movement of different parts. The inelastic time history method of analysis is one method of determining out of phase displacements. This method is fairly rigorous and requires a site-specific assessment of expected ground accelerations. As a compromise, the maximum modal displacements from a multi-mode dynamic analysis for each component part of the structure may be used to determine differential displacements. Concerns over out of phase motions, as well as serviceability concerns, discourage the use of hinges within spans.

3.4.2.3 Connections. Connections are defined as those members that transfer shear or shear and axial loads between one component and another. Generally, they include bearing devices and shear keys, but do not include members that transfer bending moments. Connections for single span bridges shall be designed to resist the tributary weight of the superstructure multiplied by the acceleration coefficient and the site coefficient divided by the connection R factor. For single span bridges where the superstructure is restrained in the longitudinal direction at only one abutment, the weight of the entire superstructure shall be used to determine the connection design force in the longitudinal direction. For single span bridges where the superstructure is restrained in the transverse direction at each abutment, the gravity reaction at each abutment shall be used to determine the connection design force in the transverse direction.

3.4.2.4 Isolation Bearings. Isolation bearings are considered a practical method of reducing inertial forces transferred from the superstructure to the substructure. Typically, elastomeric systems lengthen the period of vibration of the structure producing an isolation effect by deflecting rather than absorbing seismic energy. Sliding isolation systems produce the isolation effect by limiting the amount of force transferred across the sliding interface and absorbing energy through use of a displacement control device.

Isolation bearings are a useful tool in giving the Designer control over the distribution of seismic forces to the various substructures. This can be beneficial in the retrofit of existing bridges that feature inadequate substructure strength and ductility. Isolation design for new construction may also be useful on essential bridges where an elastic response is desirable. Isolation design on new and existing structures considered non-essential must demonstrate cost viability through reduction of foundation costs.

The Bridge Section shall provide appropriate specifications for isolation design where necessary.

3.4.2.5 Cross Bracing at Bearings. Steel cross bracing, bolts and connection plates located between the beams or girders at the bearing locations shall be designed to transfer the seismic forces in the plane of the bracing due to the inertia of the superstructure to the bearings. The Strength Design Method (Load Factor Design) shall be used. K-bracing, using channel diaphragms, with single or double diagonal angles, shall be used at locations that require support of the deck slab. K- or X-bracing with single or double angles may be used at locations where the deck is continuous.

3.4.2.6 Retaining Walls. The Mononobie - Okabe analysis method of estimating earth pressures from horizontal seismic accelerations shall be used in the design of gravity, semi-gravity, and non-gravity walls and wingwalls. The seismic design moment used to design the flexural reinforcement in the stems of reinforced concrete cantilevered retaining walls shall be determined by dividing the elastic seismic moment by the response modification factor 2. No portion of the lap splice of main flexural reinforcement for the stem shall be located in the area where plastic hinging is expected to occur.

3.5 SUPERSTRUCTURE DESIGN REQUIREMENTS

3.5.1 Composite Design

3.5.1.1 All stringer bridges will be designed compositely with the deck. All composite beams shall be designed for composite action without the use of temporary intermediate supports during the placing and curing of the deck concrete. Composite section properties will be calculated based on the following modular ratio formula:

$$n = \frac{E_B}{E_C}$$

where n is the modular ratio, E_B is the Modulus of Elasticity of the beam material, either steel or precast concrete, and E_C is the Modulus of Elasticity of the cast-in-place deck concrete.

3.5.1.2 When calculating any composite section properties, the depth of the standard haunch as detailed in Part II of this Bridge Manual will conservatively be assumed to be zero. This is due to the fact that actual depth of the haunch varies depending on the amount of over-cambering in the beam.

3.5.1.3 For steel beams, the effect of creep will be considered in the design of composite beams which have dead loads acting on the composite section in accordance with the provisions of AASHTO Section 10. For precast prestressed beams, the same composite properties will be used for calculating both superimposed dead load and live load stresses.

3.5.1.4 Continuous steel structures will be designed compositely through the negative moment region by providing negative moment reinforcing steel in accordance with AASHTO Section 10. Moments will be distributed along the beam using the gross deck concrete section properties in the negative moment region. The stresses in the negative moment region will be calculated using section properties based on the steel section and reinforcing steel, i.e., cracked section.

3.5.1.5 Stud shear connectors shall be used for composite steel beams. The pitch of the studs need not be made in multiples of the spacing of transverse steel reinforcement in the deck slab. Stud shear connector spacings will be designed based on fatigue requirements. The total number of studs provided must be adequate for ultimate strength requirements in accordance with AASHTO Section 10.

3.5.1.6 Precast concrete beams designed compositely shall use dowels cast into the beams to transfer the horizontal shear between the beam and deck slab. These dowels shall be detailed as shown in Part II of this Bridge Manual and will be designed in accordance with AASHTO requirements for horizontal shear for composite flexural members.

3.5.2 Deck Slabs

3.5.2.1 Steel reinforcement and slab thickness shall be determined by using the design chart in Part II of this Bridge Manual. If the beam spacing falls outside of the chart limits, the deck slab reinforcement shall be designed in accordance with the AASHTO Specifications of Section 3. All deck reinforcement shall be coated (either epoxy coated or galvanized).

3.5.2.2 Deck slabs with or without a hot mix asphalt wearing surface shall be constructed using high performance cement concrete. Decks to be constructed without membrane waterproofing and hot mix asphalt wearing surface shall be constructed in one single full-depth placement. The top ¾" of such placements shall be considered sacrificial and not contributing to the section properties. Bridges where all portions of the deck have profile grades less than 4% shall be constructed with membrane waterproofing and a hot mix asphalt wearing surface.

3.5.2.3 Removable forms shall be used for deck slab construction. They shall be used for the forming of end diaphragms, bays with longitudinal construction joints, and overhanging portions of the deck slab, as well. The use of stay-in-place (SIP) forms shall not be allowed for bridge deck construction.

3.5.2.4 Top-of-form elevations must be provided in order to set the forms such that, after all dead loads have been applied, the top of roadway will be at the correct profile elevation. Top-of-form elevations will be calculated as follows:

1. Calculate the theoretical top of roadway elevation directly over the beam at the required points along its span as specified in Part II of this Bridge Manual.

2. From this elevation, subtract the thickness of the wearing surface and deck to obtain the in-place bottom of deck elevation. Include ¼" for the thickness of the membrane, if used.

3. To the in-place bottom of deck elevation, add the total dead load deflection of the beam, excluding the deflection due to the beam's self-weight, calculated for the particular point along the beam under consideration. The result is the top-of-form elevation.

3.5.3 Distribution of Loads on Stringer Bridges

3.5.3.1 Deck slab dead load shall be distributed to each beam directly below based on tributary area.

3.5.3.2 Wearing surface/overlay superimposed dead load is to be evenly distributed among all beams.

3.5.3.3 Sidewalk/safety curb/barrier superimposed dead load, including any railing and sidewalk live load is to be distributed 60 percent to the fascia stringer and 40 percent to all the interior stringers. If a sidewalk spans over two or more stringers, the 60 percent shall be equally distributed among these stringers and the 40 percent to the remaining interior stringers.

3.5.3.4 In the case of an excessive overhang, all superimposed loads shall be distributed to the fascia stringer assuming that the deck is hinged at the first interior stringer.

3.5.3.5 All stringers under a raised median shall be designed for full dead load and live load plus impact as for an interior beam.

3.5.4 Utilities on Structures

3.5.4.1 Typical details for utility supports for the various different types of superstructures are shown in the Part II of this Bridge Manual. At the initiation of the project, the Designer shall investigate and identify all utilities (existing or proposed) carried on the structure or crossing its footprint. The Designer shall submit to the MassHighway Utility/Railroad Engineer letter(s) of transmittal that the said utility investigation was performed and resolution of all issues was achieved. All existing and proposed utilities shall be shown on the plans. Railroads may have additional utility placement requirements that the Designer shall incorporate in the design.

3.5.4.2 All utilities on stringer bridges shall be carried in the utility bay or bays of the superstructure and shall be accessible from below. Utilities shall not be embedded within a deck slab or sidewalk slab because their presence there could inhibit future maintenance activities. Utilities on adjacent prestressed concrete beam bridges shall be carried and designed for in accordance with the guidelines for these structures in Subsection 3.8.2.

3.5.4.3 Utilities are normally installed before the deck is placed since it facilitates their installation and alignment both horizontally and vertically. Therefore, the non-composite section shall carry the total dead load of utilities.

3.5.4.4 For stringer bridges, the dead load of utilities is assumed to be carried by the two stringers comprising the utility bay. For structures carrying local roads with no existing utilities in the roadway, it is acceptable to show a utility bay in the superstructure and provide for a future load of 250 pounds/foot (125 pounds per foot per beam) in the design. Provisions shall be made for fiber optic conduit and highway lighting conduit on bridges that carry interstate highways.

3.5.4.5 When the utility is to be installed for a municipality, such as a water pipe, the complete support system shall be included as part of the contract. Other utilities not installed by the Contractor, such as telephone ducts and gas mains, shall be indicated on the plans as to their location in the utility bay or other designated area with the notation: TO BE INSTALLED BY OTHERS. The designer is cautioned to provide utility bays of sufficient size to accommodate the utility installation.

3.5.5 Deflection and Camber

3.5.5.1 The ratio of live load plus impact deflection to span length will not be greater than 1/1000 for all bridges with provisions for pedestrians. For bridges with no provisions for pedestrians, this ratio shall preferably not be greater than 1/1000. However, under no circumstances shall it be greater than 1/800. Deflections of individual beams shall be computed using the same live load distribution factor that was used to calculate stresses, unless the entire structure is modeled in 3 dimensions using finite element analysis software and lesser distribution factors are justified. HS20 live load shall be used to determine live load deflection.

3.5.5.2 Camber for steel beams shall be calculated and specified on the plans as shown in Part II of this Bridge Manual.

3.5.5.3 Camber and profile vertical curvature will be considered when calculating bridge seat elevations for prestressed concrete beam bridges so that the top of roadway will match the design roadway profile. Cambers will not be shown on the plans nor will they be used when calculating under-bridge clearances. The prestressing force produces moments in prestressed concrete beams that result in upward deflections. These deflections are partially offset by the downward deflections due to the beam dead weight, resulting in a net upward deflection of the beam at erection. Observation of actual bridges indicates that once the slab is placed, the prestressed concrete beams tend to behave as if they were locked in position. The net upward camber of these beams shall be calculated using the PCI "at erection" multipliers applied to the deflections from prestressing and self-weight. The bridge seat elevations shall be determined using the methodology contained in Part II of this Bridge Manual.

3.5.6 Elastomeric Bridge Bearing Assemblies (Revised June 2007)

3.5.6.1 General. Elastomeric bearing assemblies shall be used for both precast concrete and steel beam bridges and shall be designed and fabricated in accordance with the requirements of Section 14, Division I and Section 18, Division II of the latest edition of the AASHTO Specifications, and as modified by this section.

Steel reinforced elastomeric bearing assemblies shall consist of alternate layers of steel laminates and elastomer bonded together and, either a beveled or flat sole plate for steel beam bridges, or internal load plate for prestressed concrete beam bridges if required. All internal layers of elastomer shall be of the same thickness. The minimum thickness of the top and bottom cover layers of elastomer shall be ¼". These top and bottom cover layers shall be no thicker than 70% of the individual internal layers. Steel laminates shall have a minimum thickness of 11 gage. Holes in either the elastomer or the steel laminates are not allowed.

3.5.6.2 Elastomer Material Properties. The nominal hardness of elastomer shall be either 50 or 60 durometer for reinforced bearings and 60 for plain (un-reinforced) pads. Hardness over 70 durometer is not allowed. The shear modulus of the elastomer at 73°F shall be used as the basis for design. Unless otherwise required by design, bearings shall be of low temperature, Grade 3, 60-durometer elastomer with the minimum and maximum shear modulus of 130 PSI and 200 PSI, respectively. The shear modulus shall be taken as that value which is most conservative for each part of the design.

3.5.6.3 Reinforcement. Steel laminates in steel reinforced elastomeric bearings shall conform to ASTM A 1011 Grade 36 or higher. Tapered internal load plates shall conform to AASHTO M 270 Grade 36 or higher.

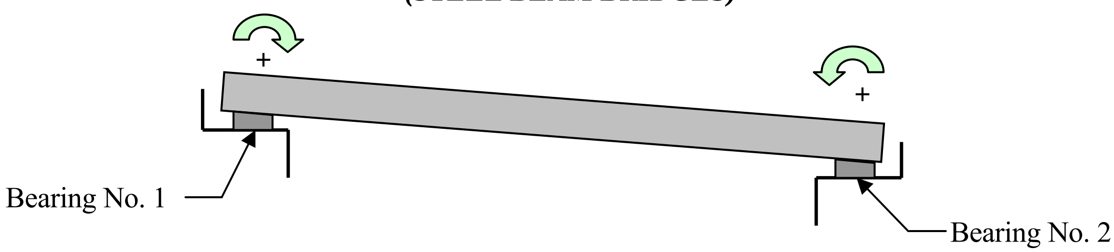
3.5.6.4 Design. All elastomeric bearing assemblies shall be designed for unfactored service loads in accordance with design Method A, as defined in the AASHTO Specifications, Article 14.6.6. Impact shall not be included. The stress increases permitted for certain load combinations by Table 3.22.1A of the AASHTO Specifications shall not apply to the design of bearings.

One of the requirements is to design bearing assemblies for dead and live load rotations, rotation due to profile grade, and an additional rotation of 0.005 radians for the combination of uncertainties and construction tolerances. Careful consideration shall be given to the effect of beveled sole plates (steel beam bridges) or internal beveled load plates (prestressed concrete beam bridges) and girder camber. For prestressed concrete beams, the net upward camber and associated end of beam rotations shall be calculated using the PCI "at erection" multipliers.

Sole plates (steel beam bridges) or internal load plates (prestressed concrete beam bridges) should be beveled to account for the rotations due to profile grade. Ideally, properly beveled sole plates or internal load plates provide a level surface after the application of total dead load and after "at erection" camber (prestressed concrete beam bridges) has developed. If beveled sole plates or internal load plates are used, the design rotation for the elastomer due to profile grade should be neglected. In some cases the bearings require sole plates (steel beam bridges) or internal load plates (prestressed concrete beam bridges) with less than 1% bevels. In these cases the Designer shall add the anticipated rotation (bevel in radians) to the total design rotation while designing the bearing. This will accommodate the anticipated rotation while using a flat sole plate (steel beam bridges) or no internal beveled load plate (prestressed concrete beam bridges).

If the girder is cambered for dead loads (steel beam bridges), the dead load design rotation of the elastomer should be neglected. If the girder is not cambered the Designer shall account for the dead load rotation. In the case where a beveled internal load plate is used (prestressed concrete beam bridges), it shall be designed to accommodate the rotation due to profile grade, the dead load rotation and the beam camber at erection. The following tables demonstrate the effects of girder cambering and a beveled sole plate (steel beam bridges) or internal beveled load plates (prestressed concrete beam bridges) on the rotation design of elastomeric bearings of a simple bridge (please note that the numbers shown are not specific to any bridge):

SAMPLE TABULATION OF BEARING ROTATIONS FOR ELASTOMERIC BEARINGS (STEEL BEAM BRIDGES)



GIRDER WITHOUT BEVELED SOLE PLATES AND WITHOUT GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	+ 0.014 RAD	+ 0.014 RAD
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.035 RAD**	**+ 0.030 RAD**

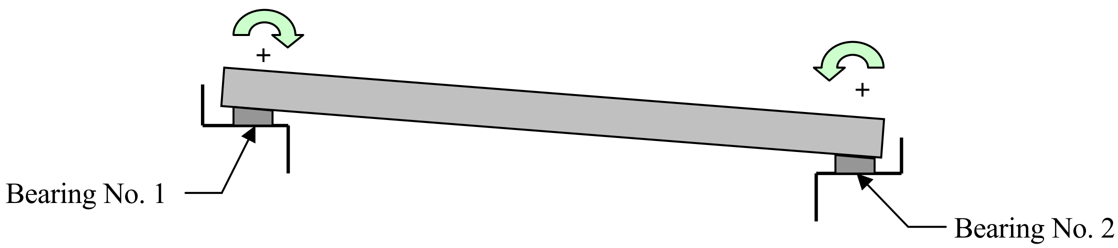
GIRDER WITHOUT BEVELED SOLE PLATES AND WITH GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	NONE (GIRDER CAMBERED)	NONE (GIRDER CAMBERED)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.021 RAD**	**+ 0.011 RAD**

GIRDER WITH BEVELED SOLE PLATES AND WITH GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	NONE (BEVELED SOLE PLATE)	NONE (BEVELED SOLE PLATE)
DEAD LOAD	NONE (GIRDER CAMBERED)	NONE (GIRDER CAMBERED)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.016 RAD**	**+ 0.016 RAD**

SAMPLE TABULATION OF BEARING ROTATIONS FOR ELASTOMERIC BEARINGS (PRESTRESSED CONCRETE BEAM BRIDGES)



GIRDER WITHOUT INTERNAL BEVELED LOAD PLATES

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	+ 0.014 RAD	+ 0.014 RAD
CAMBER (AT ERECTION)	- 0.010 RAD	- 0.010 RAD
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.025 RAD**	**+ 0.015 RAD**

GIRDER WITH INTERNAL BEVELED LOAD PLATES

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
DEAD LOAD	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
CAMBER (AT ERECTION)	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.016 RAD**	**+ 0.016 RAD**

The live load reactions and rotations shall be determined using the standard distribution factors contained in the AASHTO Standard Specifications. Also, when designing a bearing for the exterior beam under the sidewalk, the application of truck loading on the top of sidewalk, in addition to all other pertinent loads, will produce unreasonably large bearings and, due to this fact, shall not be applied.

For a simple span bridge the maximum rotation of the beam end can be calculated using normal stiffness methods. However, many beam design computer programs do not calculate the beam end rotation. An approximate beam end rotation can be determined based on maximum midspan deflection (please note that this is an exact solution only in the case when the beam is prismatic and the beam deflection is parabolic):

- Calculate the maximum live load deflection at midspan Δ;
- Approximate end rotation in radians is equal to $(4*\Delta)$/Span Length.

For continuous span bridges, the composite section properties shall be used for all segments of all girders. This includes the negative moment regions, where the transformed concrete slab should be used in place of the cracked section (beam and slab reinforcement).

The bearings should also be designed for all longitudinal and lateral movements. Longitudinal translation due to dead load girder rotation about the neutral axis may need to be accounted for on beams with large rotations or for deep girders. This translation should be added to the design longitudinal movement. The AASHTO specifications outline requirements for calculation of thermal movement. The following are general guidelines that are intended to supplement the AASHTO specifications:

STANDARD BRIDGES:

In this context a standard bridge is defined as a bridge that has the following geometric conditions:

1. Straight beams;
2. Skew angle ≤ 30 degrees;
3. Span length to width ratio greater than 2;
4. 3 or less travel lanes.

The major contributor to thermal movements is the bridge deck. This portion of the bridge structure is exposed to the highest temperature extremes and is a continuous flat plate. A flat plate will expand and contract in two directions, and will not be significantly affected by the steel framing below. For bridges that meet the general criteria listed above, the calculations for thermal movement can be based on the assumption that the bridge expands along its major axis, which is along the span length.

NON-STANDARD BRIDGES:

The treatment of non-standard bridges requires careful design and planning. A refined analysis may be required for non-standard bridges in order to determine the thermal movements, beam rotations (transverse and longitudinal), as well as the structural behavior of the system. The stiffness of substructure elements may also have an effect on the thermal movement at bearings. The following are general basic guidelines outlining the thermal movement behavior for non-standard bridges:

- Curved Girder Bridges:

It has been well documented that curved girder bridges do not expand and contract along the girder lines. The most often used approach is to design bearing devices to expand along a chord that runs from the point of zero movement (usually a fixed substructure element) to the bearing element under consideration.

- Large Skew Bridges:

The major axis of thermal movement on a highly skewed bridge is along the diagonal from the acute corners. The alignment of bearings and keeper assemblies should be parallel to this axis. The design of the bearings should also be based on thermal movement along this line.

- Bridges with small span-to-width ratios:

Bridges with widths that approach and sometimes exceed their lengths are subject to unusual thermal movements. A square bridge will expand equally in both directions, and bridges that are wider than they are long will expand more in the transverse direction than in the longitudinal direction. The design of bearing devices and keeper assemblies should take into account this movement.

- Wide bridges:

Bridges that are wider than three lanes will experience transverse thermal movements that can become excessive. Care should be taken along lines of bearings as to not to guide or fix all bearings along the line. Guides and keeper assemblies should be limited to the interior portions of the bridge that do not experience large transverse movements.

The Designer should specify on the plans a range of temperatures for setting the bearings based on their design. Provisions should also be included for jacking the structure in order to reset the bearings if this range cannot be met during construction. A recommended temperature range is the average ambient temperature range for the bridge location plus or minus 10 °F. Larger values can be specified provided that the bearing is designed for the additional movement.

In addition to the above design requirements a few other design criteria shall be considered. They are as follows:

Elastomeric bearings shall be designed so that uplift does not occur under any combination of loads and corresponding rotation.

For continuous span bridges, bearings will see both minimum and maximum loads, depending on the location of the truck along the span of the bridge. In this situation, a bearing needs to be designed and detailed for the maximum loading combination. The minimum loading combination shall be ignored in the bearing design.

The potential for slippage of elastomeric bearings on both steel and concrete surfaces shall be checked. If the design shear force due to bearing deformation exceeds one-fifth of the minimum vertical force, the bearing shall be secured against horizontal movement by providing a positive restraint. See Part II of this Bridge Manual for details.

Where anchor bolts are used to resist lateral forces, they shall be located outside the bearing pads and shall be designed for bending as well as shear. The sole plates shall also be checked for shear and bending.

3.5.6.5 Detailing. Steel reinforced elastomeric bearings shall be detailed on the Plans in accordance with Part II of this Bridge Manual. The thickness of steel laminates shall be specified in gage, while the total thickness of the bearing pad shall be shown in inches in ¼" increments.

Tapered layers of elastomer in reinforced bearings are not permitted. If tapering of the bearing is necessary, it shall be accomplished as follows:

- For steel beams, provide an external tapered steel sole plate welded to the bottom flange.

- For concrete beams, use a tapered internal steel load plate and provide a cover layer of elastomer with constant thickness.

The minimum longitudinal slope of the bottom flange beyond which tapering of the bearing is required shall be equal to 1%. Refer to Paragraph 3.5.6.4 of this section regarding situations with less than 1% bevels.

Standard bridge bearing details are shown in Part II of this Bridge Manual. Bearing types not shown must receive prior approval from the Bridge Engineer before being used in the design of a bridge project.

3.5.6.6 Application. For adjacent concrete box and deck beam bridges with a span length of 50 feet or less, use rectangular plain (un-reinforced) elastomeric pads, 1” thick by 5” wide, detailed and placed as shown in Part II of this Bridge Manual.

For all other applications, circular steel reinforced elastomeric bearings shall be used. As an exception, in case of large rotations, primarily about one axis on narrow bridges with skews of 10° or less, the use of rectangular steel reinforced elastomeric bearings arranged to facilitate rotation about the weak axis may be considered. The use of and detailing of rectangular steel reinforced elastomeric bearings must receive prior approval of the Bridge Engineer.

3.5.6.7 Filled and lubricated PTFE (polytetrafluorethylene) sliding bearings shall only be used when a bearing with a low coefficient of friction is needed to minimize horizontal forces, i.e. thermal or seismic, on the substructure. Section 14, Article 14.6.2, Division I of the AASHTO Specifications shall be used to design this type of bearing. They shall be detailed on the Plans as shown in Part II of this Bridge Manual.

3.5.6.8 Marking. Problems have occurred in the field with the installation of bearings with beveled sole plates (steel beam bridges) or beveled internal load plates (prestressed concrete beam bridges). It is not always obvious which orientation a bearing must take on a beam before the dead load rotation has been applied. This is especially true for bearings with minor bevels. To prevent errors, the Designer shall add the following notes to the plans: “All bearings shall be marked prior to shipping. The marks shall include the bearing location on the bridge, and a 1/32” deep direction arrow that points up-station. All marks shall be permanent and be visible after the bearing is installed.”

3.5.7 Scuppers

3.5.7.1 An accurate determination of the need for scuppers on bridges as well as the design of deck drainage systems will be based on the latest edition of the Hydraulic Engineering Circular No. 21: *Design of Bridge Deck Drainage* (Publication No. FHWA SA-92-010).

3.5.7.2 The following may be used as a guide for estimating the need for scuppers and for locating them to properly drain the bridge superstructure:

1. On long bridges, scuppers should be placed about 350 feet on centers.

2. When the bridge is superelevated, scuppers are placed only on the low side.

3. On bridges, scuppers may be required when:

    I. The profile grade is less than 1%.
    II. The profile grade is such that ponding may occur on the roadway surface. An example would be a sag curve on the bridge.

The Designer shall investigate the highway drainage, which may include catch basins at the approaches to the structure.

3.5.7.3 When scuppers are needed, they shall generally be placed near a pier and on the upgrade side of a deck joint. Care shall be taken to ensure that scupper outlets will not result in run-off pouring or spraying onto either the superstructure beams or the piers.

3.5.7.4 Horizontal runs of drainpipes and 90° bends shall not be used. The minimum drainpipe diameter or width shall be 10". The number of drainpipe alignment changes shall be minimized. Multiple alignment changes result in plugged scuppers that defeat the purpose of providing deck drainage. Cleanouts shall be accessible for maintenance purposes and shall be placed, in general, at every change in the alignment of the drainpipes. Typical details for scuppers and downspouts are shown in Part II of this Bridge Manual.

3.6 STEEL SUPERSTRUCTURES

3.6.1. General

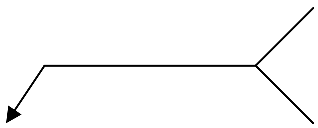
Uncoated weathering steel, AASHTO M 270 Grade 50W, shall be the primary option for all steel bridges constructed by MassHighway. If the Designer determines that the use of uncoated weathering steel is not prudent for a specific location, then the Bridge Engineer must concur with this decision before design begins. Hot Dipped Galvanized steel may be used in locations where the use of uncoated weathering steel is considered inappropriate. Guidelines for the use of weathering steel are contained in the FHWA Technical Advisory T5140.22.

The use of uncoated weathering steel is probably not prudent in the following situations:

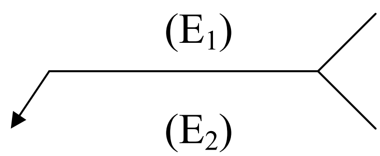
- In acidic or corrosive environments;
- In locations subject to salt water spray or fog;
- In depressed limited access highway sections (tunnel effect with less than 20 feet underclearance) where salt spray and other pollutants may be trapped;
- In low underclearance situations where the steel is 10 feet or less from normal water elevation;
- Where the steel may be continuously wet or may be buried in soil;
- In expansion joints or for stringers or other members under open steel decking;
- In bridge types where salt spray and dirt accumulation may be a concern (e.g., trusses or inclined-leg bridges).

3.6.1.2 For all steel rolled beam and plate girder bridges, the ratio of the length of span to the overall depth of the beam (depth of the beam plus thickness of the design slab) shall preferably not be greater than 21. This ratio may be exceeded where, due to clearance and profile requirements, a shallower structure is required, however under no circumstances will the span to depth ratio be greater than 25. For continuous spans, the span length shall be considered as the distance between dead load points of contraflexure.

3.6.1.3 All welding and fabrication shall be in conformance with the AASHTO/AWS Bridge Welding Code (AASHTO/AWS D1.5). The contract drawings shall clearly show the type of weld required. The drawings shall clearly distinguish between shop and field welds. For complete joint penetration (CJP) and partial penetration (PJP) groove welds, the drawings shall show the location and extent of the welds and, for the PJP welds, the required weld size. PJP groove welds shall not be allowed on main members. These weld symbols shall be shown as follows:



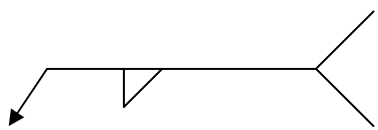
CJP



PJP

E_1 and E_2 represent the effective throat size.

For fillet welds, the drawings shall show the location, size and extent of the weld as shown below.



3.6.1.4 All structural steel shall meet the requirements of AASHTO M 270. Main members only, need to conform to the applicable Charpy V-Notch (CVN) Impact Test requirements of AASHTO M 270. A Main Member is defined as any member making up the primary path that either the dead or live load takes from its point of application to its point of reaction onto the substructure, or in the case of steel bent piers, onto the foundation system. Some examples of main members are plate girders, floor beams, stringers, and diaphragms on curved girder bridges. All other structural steel shall conform to AASHTO M 270, excluding the CVN tests. ASTM A709 is similar to AASHTO M 270 and may be used in lieu of M 270 provided that the applicable CVN requirements for main members are met.

3.6.1.5 Fracture critical members (FCM), or member components, are tension members or tension components of bending members (including those subject to the reversal of stress) whose failure may result in the collapse of the bridge. All FCM members and components shall be clearly designated on the contract drawings. All members and components designated as FCM are subject to the additional requirements of the Fracture Control Plan in the AASHTO/AWS Bridge Welding Code. Members and components not subject to tensile stress under any condition of live load are not fracture critical. In general, secondary members, such as intermediate diaphragms, connection plates of diaphragms, transverse stiffeners, and lateral bracing should not be designated as fracture critical. Fracture critical requirements do not apply to temporary stages in construction. For longitudinal box girder bridges, components of the girders which meet the FCM definition, shall be designated FCM if there are two or less box girders in the bridge cross section. For the case of a single span two box girder bridge cross section, the top flanges shall not be considered fracture critical.

3.6.1.6 The Designer shall locate and detail all field and transition splices. The location of these splices is dependent upon such factors as design criteria, available length of plates and members, ability to transport the members to the site, and erection and site limitations.

3.6.2 Cover Plates

3.6.2.1 The minimum cover plate thickness shall be ½". For economy, it is preferable to use the same thickness cover plate on all similar size beams.

3.6.2.2 Bottom cover plates will be terminated not more than 2'-0" from the centerline of bearings or centerline of integral abutments, however the Designer must still check the fatigue stress range at the termination point.

3.6.2.3 Top cover plates, when used in the negative moment regions of continuous beams, shall extend beyond the theoretical end by at least the terminal distance as defined in AASHTO Section 10, however, the actual termination point will be determined by fatigue considerations.

3.6.2.4 The Designer will design all cover plate to flange welds or will verify the adequacy of the minimum weld sizes.

3.6.3 Welded Plate Girders

3.6.3.1 Minimum sizes for webs, flanges and welds, as well as detailing guidelines for plate girders, are given in Part II of this Bridge Manual.

3.6.3.2 The Designer shall first consider a web design that does not require the use of transverse stiffeners. If the required web thickness is excessive, a stiffened web will be considered, however the spacing of the transverse stiffeners will be as large as possible. Cross frame connection plates can be used as stiffeners if they meet the AASHTO requirements for stiffener plates. For aesthetics, transverse stiffeners shall not be placed on the outside face of the exterior girders.

3.6.3.3 Longitudinal web stiffeners shall be avoided unless required by design to avoid excessively thick, transversely stiffened webs. Typically, longitudinal stiffeners should only be considered for very deep girders. If longitudinal stiffeners are used, they shall be placed on the opposite side of the web from the un-paired transverse stiffeners. Under no circumstances will longitudinal and transverse stiffeners be allowed to intersect. Shop splices of longitudinal web stiffeners shall be full penetration butt welds, and shall be made before attachment to the web.

3.6.3.4 Flanges shall be sized as required by design, however for shipping and erection safety, the ratio of the length to the width of the flanges shall be limited to 100 where practical even at the expense of some additional steel.

3.6.3.5 The flange width may vary over the length of the girder, however constant width flanges are preferred. For longer spans where flange width transitions may be necessary, flange width transitions shall occur at the field splices. Top and bottom flanges need not be of the same width.

3.6.3.6 Due to the cost of making a full penetration welded flange splice, the number of changes to the flange thickness will be kept to a minimum. When a girder flange is butt spliced, the thinner segment shall be not less than one-half the thickness of the adjoining segment.

3.6.4 Welded Box Girders

3.6.4.1 In general, the requirements for Welded Plate Girders contained in Subsection 3.6.3 shall apply to welded box girders.

3.6.4.2 The length of top flange used for the calculation of the length to width ratios for flanges contained in Paragraph 3.6.3.4 shall be based on the distance between internal shop installed cross frames.

3.6.4.3 In general, the provisions for transverse web stiffeners contained in Paragraph 3.6.3.2 shall apply to box girders, except that all transverse stiffeners shall be placed in the interior of the box girder.

3.6.4.4 Longitudinal bottom flange stiffeners shall be avoided unless required by design to avoid excessively thick bottom flanges. Typically, longitudinal bottom flange stiffeners should only be considered for very wide flanges.

3.6.4.5 Box girder cross sections should be of a trapezoidal shape with webs sloped equally out from the bottom flange. Preferably, the minimum web depth shall be 6'-6" to allow for inspection access and maintenance activities inside the box girders. The minimum bottom flange width shall be 4'-0". Shorter web depths and narrower bottom flange widths may be used with the written permission of the Bridge Engineer. In general, box girders placed on superelevated cross sections shall be rotated so that the top and bottom flanges are parallel to the deck cross slope.

3.6.4.6 Girder spacing shall be maximized in order to reduce the number of girders required, thereby reducing the costs of fabrication, shipping, erection, and future maintenance. Spacing of the top flanges in a bridge cross section shall be approximately equal, however, the spacing may be varied in accordance with AASHTO Section 10.39.

3.6.4.7 Utilities shall not be placed inside the box girders. This restriction shall also apply to scupper drain pipes and street lighting conduit.

3.6.4.8 At least 2 access manholes shall be provided in the bottom flange of box girders. Alternatively, access shall be provided in the box girder ends at abutments. These manholes shall be located and detailed such that bridge inspectors can gain access without the need for special equipment.

The manholes shall have rounded corners fitted with a hinged cover that is lightweight and opens inward. If manhole doors are accessible from the ground without ladders or equipment, the doors shall be provided with an appropriate locking system to prevent unauthorized entry. Access holes shall be provided through all solid diaphragms. Stresses resulting from the introduction of access holes in steel members shall be investigated and kept within allowable limits.

3.6.4.9 The interior surfaces of box girders, including all structural steel components within the box girders (such as diaphragms, cross-frames, connection plates, etc.) shall be painted. The color of the interior paint shall be Gloss White (Federal Standard 595B Color Number 17925) in order to facilitate bridge inspection. In order that bridge inspectors can better orient themselves within the box girder, the distance from each box girder's West centerline of bearings, for bridges oriented generally west to east, or from the South centerline of bearings, for bridges oriented generally from south to north, shall be indicated in five (5) foot increments throughout the full length of each box girder. This indication shall consist of a vertical line ½" wide by 6" high with the measured distance given below the line in 5" high numerals painted in black color halfway up on the inside of the left girder web. This distance shall be measured without interruption from the reference end of the box girder to the other end and shall be sequential over intermediate bearings and/or field splices within each box girder but shall not be carried over between separate box girders within the same girder line.

3.6.4.10 Top flange lateral bracing shall be provided to increase the torsional stiffness of individual box girder sections during fabrication, erection, and placement of the deck slab. Permanent internal lateral bracing shall be connected to the top flanges.

Bracing members shall typically consist of equal leg angles or WT sections directly attached to the flange or attached to the flange via gusset plates. Gusset plates shall be bent to accommodate the difference in elevation between connections.

The bracing shall be designed to resist the torsional forces across the top of the section and the forces due to the placement of the deck, satisfying the stress and slenderness requirements. The lateral bracing connections to the top flange shall be designed to transfer bracing forces. Pratt type bracing should be considered because of efficiency. X-bracing patterns should be avoided for economy.

Allowable fatigue stress ranges shall not be exceeded where the gusset plate attaches to the flange.

3.6.4.11 The welds between the web and flanges shall be comprised of double fillet welds except where welding equipment cannot be placed within the box during fabrication. For this case, the backup bars shall be made continuous. Testing of welded splices in backup bars shall be treated similarly to flange splices.

3.6.5 Splices and Connections

3.6.5.1 In general, all field connections shall be made with high strength bolts conforming to the requirements of AASHTO M164. All structural connections shall be designed as Slip-Critical connections. AASHTO M253 bolts shall not be used, except with written permission of the Bridge Engineer.

3.6.5.2 Field splices in beams and girders, when necessary, shall generally be located as follows:

Continuous Spans: Points of Dead Load Contraflexture
Simple Span: Quarter Point

3.6.5.3 Field splices shall generally be made using 7/8" ∅ high strength bolts. For large repetitive connections, the use of larger bolts shall be evaluated if a significant number of bolts could be saved. All bolts used in a splice shall be of the same diameter. Filler plates shall not be less than ⅛" thick. Field splices of flanges and webs shall not be offset.

3.6.5.4 Transverse stiffeners will be located as specified in Part II of this Bridge Manual so that they do not coincide with the splice plates. If stiffeners in the area of a bolted splice are unavoidable, bolted steel angles shall be used as stiffeners instead of plates welded to the splice plates.

3.6.5.5 All shop welded splices shall have flange splices offset 5'-0" from the web splice. As welded flange splices are costly, a savings of approximately 1300 pounds of steel should be realized in order to justify the cost of the flange splice.

3.7 PRESTRESSED CONCRETE SUPERSTRUCTURES

3.7.1 Standard Beam Sections

3.7.1.1 Standard AASHTO - PCI precast concrete deck, box, or New England Bulb Tee (NEBT) beam sections as detailed in Part II of this Bridge Manual will be used to construct precast concrete bridge superstructures. Other sections may be used where the situation precludes the use of standard sections and prior approval has been obtained from the Bridge Engineer, or where so permitted by this Bridge Manual.

3.7.1.2 The standard beam sections were developed in conjunction with PCI New England and meet the fabrication tolerances and practices of most regional precasters. If a particular design requires that major alterations be made to the standard details, such as the placement of strands in locations other than those shown or different reinforcing details, it will be the Designer's responsibility to ensure that the design can be fabricated by a majority of area precasters.

3.7.1.3 In adjacent precast beam superstructures, the beams should be placed to follow the roadway cross slope as much as is practical. On bridges with a Utility Bay under the sidewalk, the sidewalk beam need not be placed to follow the cross slope, unless a deeper sidewalk depth is required over this beam for railing/traffic barrier attachments. For NEBT or spread box beam bridges, the beams will be placed plumb and a deck haunch deep enough to accommodate the drop of deck across the width of the beam flange will be provided.

3.7.2 Materials

3.7.2.1 Concrete Stresses. Standard designs shall be based on a concrete compressive strength (f'_c) of 6500 PSI. If required by design, the use of a concrete compressive strength of 8000 PSI (HPC) may be used with the prior approval of the Bridge Engineer. In general, the concrete compressive strength at release (f'_{ci}) shall be taken as 4000 PSI. Higher concrete release strengths, up to 0.8 f'_c, may be used only if required by design in order to avoid going to a deeper beam. Concrete release strengths greater than 0.8 f'_c shall not be used.

3.7.2.2 Prestressing Strands. MassHighway Specifications call for the use of Low Relaxation strands meeting the requirements of AASHTO M203. Strands shall be 0.6” diameter. Strands shall not be epoxy coated. MassHighway Specifications further require that beams be fabricated with the prestressing strand layout as shown on the plans. The transformed area of the prestressing strands shall not be used to compute section properties.

3.7.2.3 For the reduction of tensile stresses at the ends of box beams and NEBT beams, either draped or de-bonded strands can be used. For deck beams, due to their construction, draped strands cannot be used. Mixing draped and de-bonded strands in a beam is permitted.

3.7.2.4 Where de-bonded strands are used, no more than 25% of the total number of strands may be de-bonded. The spacing between de-bonded strands in a layer shall be 4” minimum. The outermost strands of each layer will not be de-bonded. In general, the length of de-bonded strand from each end of the beam should be limited to approximately 15% of the span length.

3.7.2.5 Where draped strands are used, the total hold down force of all draped strands for each beam should not exceed 75% of the total beam weight.

3.7.2.6 Reinforcing Steel. All non-prestressed reinforcement shall be epoxy coated Grade 60 reinforcing steel. It is the Designer's responsibility to detail the beams so that all reinforcement will be embedded, developed or lapped as required. In the case of deck or box beams, the size of the void can be reduced (or eliminated for deck beams only), as noted in Part II of this Bridge Manual, to permit proper bar development.

3.7.2.7 Utility Supports. The steel for all utility supports shall conform to AASHTO M 270 Grade 36, and shall be galvanized. All inserts for the attachment of utilities will be cast into the beam at the time of its fabrication. Under no circumstances shall expansion type anchors be allowed. Inserts that are being provided for a future utility installation shall be furnished with a plastic plug that is the same color as the concrete. Drilling of holes for attachments will not be permitted once the beam has been cast.

3.7.3 General Design Requirements

3.7.3.1 All prestressed beams will be designed according to the latest AASHTO *Standard Specifications for Highway Bridges*, except where modified or amended by this section. The beams will be designed using the Service Load Method (Allowable Stress Design) for all service loading conditions the beam will be subjected to during its life. The ultimate strength of the beam will be checked for the final service condition by using the Load Factor Method.

3.7.3.2 Beams will be designed to have no more than $3\sqrt{f'_c}$ PSI tension in the precompressed tensile zone under final service conditions after all losses have occurred. If the only way to reduce these tensile stresses is to go to the next larger beam size and the depth of structure is critical, tensile stresses up to a maximum of $6\sqrt{f'_c}$ PSI will be permitted using HS25 live load to avoid going to the next larger beam size.

3.7.3.3 Transverse stirrups shall be designed in accordance with AASHTO requirements for shear in prestressed concrete beams, except that neither the minimum bar sizes nor the maximum spacings, as noted in Part II of this Bridge Manual, shall be violated. For adjacent box beams, the top bars (straight and U shaped) have been pre-designed as slab reinforcement and spaced accordingly; however, the bottom #4 U-bars shall be designed to satisfy shear reinforcement requirements and shall be spaced at a multiple of the top bars. Each bottom U-bar shall be lapped with a top U-bar to form the transverse stirrups.

3.7.3.4 End transverse stirrups and vertical stirrups shall be designed to meet the AASHTO requirements for Anchorage Zones of prestressed concrete beams, Article 9.22. If absolutely necessary, #5 bars may be used, in which case the lap and embedment lengths would have to be adjusted.

3.8 DESIGN PROCEDURES

3.8.1 Design of Adjacent Deck and Box Beam Bridges

The beams shall be designed to be composite with the deck slab, with dowels cast into the beams designed for horizontal shear as specified in AASHTO. The AASHTO live load fraction shall be computed without incorporating the composite deck slab, however, the composite section shall be used to design the beams and check stresses.

If beams of different Moments of Inertia are used together in an adjacent beam superstructure, the distribution of superimposed Dead Loads to each beam shall be in proportion to its Moment of Inertia according to the following formula:

$$L.D.F._{k} = \frac{I_k}{\sum_{i=1}^{n} I_i}$$

Where L.D.F.$_k$ is the load distribution factor for the *k* th beam, I_k is the Moment of Inertia of the *k* th beam, and I_1 ... I_n are the Moments of Inertia of the beams over which the load is distributed. Design each adjacent beam for: the beam's own dead weight, including all solid sections; the portion of the superimposed Dead Loads and sidewalk Live Load carried by the beam, calculated using the above load distribution factor; the portion of the design Live Load plus Impact carried by the beam, calculated using the AASHTO load fraction. Since the AASHTO load fraction is a function of the beam width and Moment of Inertia, no further distribution of the design Live Load using the above load distribution factor is required.

3.8.2 Utilities on Adjacent Deck and Box Beam Bridges

3.8.2.1 General. Utilities shall be located as shown in Section 4.3 of Part II of this Bridge Manual. Preference shall be given to locating the utilities in the utility bay under the sidewalk wherever possible. Under no circumstances will utilities be located inside Deck or Box beams within the void area.

3.8.2.2 The utility supports shown in Part II of this Bridge Manual represent acceptable configurations. Where members and bolts are provided, these supports may be used up to the limits shown without further design. These supports may have to be altered depending on the utility. If an increase in the side clearance of the utility bay is required, the L4x4x½ attached to the side of the beam may be replaced by an attachment using a section of WT. In these cases, the Designer is responsible for the design of the utility supports. In all cases, the utility supports must be adequately detailed on the plans.

3.8.2.3 Sidewalk Utility Bay - Sidewalk Beam Design. The sidewalk beam as defined in Section 4.3 of Part II of this Bridge Manual may be either a standard PCI New England deck or box beam section or a special rectangular solid precast prestressed beam. NEBT beams shall not be used for this application. If the sidewalk is wide enough to accommodate two sidewalk beams, provide longitudinal joints and transverse ties as for normal adjacent beams. If there are two or more sidewalk beams, distribute the superimposed Dead and Live Loads described in the procedure to each sidewalk beam using the load distribution formula of Subsection 3.8.1.

The beam(s) shall be designed to be composite with the sidewalk slab, with dowels cast into the beam(s) designed for horizontal shear as specified in AASHTO. The effective width of the slab shall extend to mid-bay.

STEP 1: Design the beam for the following Dead and Live loads and allowable stresses:

Dead Loads: Beam Dead Load + (one half of the weight of the utilities in the utility bay) + (the weight of any Dead Loads cantilevered from the exterior of the beam) + (sidewalk slab directly above the beam plus one half the slab over the utility bay) + (railing/barrier Dead Load, distributed 60% to the sidewalk beam and 40% to the roadway beam(s)).

Live Load plus Impact: place a truck on the sidewalk with the wheel line 12" from the face of the railing/barrier and distribute as follows: if the wheel line is located anywhere over the sidewalk beam, apply 100% of the wheel line load to the sidewalk beam; if the wheel line is located over the utility bay, distribute the wheel line load assuming the sidewalk slab acts as a simple beam using the clear span of the slab. Depending on the width of the sidewalk, use one or both wheel lines.

Concrete Stresses: the allowable concrete compressive stresses shall be increased 50% and the allowable tensile stress in the precompressed tensile zone shall be taken as: $6\sqrt{f'_c}$. No increase will be allowed in the initial concrete strengths at release.

STEP 2: Check the sidewalk beam(s) as designed in Step 1 in accordance with Subsection 3.7.3, for the following loads:

Dead Loads: same as Step 1 Dead Loads.

Live Load: the AASHTO sidewalk Live Load located on that strip of sidewalk directly over the sidewalk beam(s) that extends from the face of the railing/barrier to the midpoint of the utility bay.

3.8.2.4 Sidewalk Utility Bay - Roadway Beam Design. The adjacent roadway beam(s) under the sidewalk and adjacent to the utility bay shall be designed according to the procedure in Subsection 3.8.1, modified as follows. Dead Loads shall be all sidewalk Dead Loads not assigned to the sidewalk beam(s). The load carrying contribution of the non-adjacent sidewalk beam(s) will be ignored. Assume that the sidewalk slab acts as a simple beam using the slab's clear span for distributing truck Live Loads. If a wheel line is located over the first adjacent roadway beam, then this beam shall be designed for 100% of this wheel line and the computed load fraction from the outside wheel line. This beam shall be designed composite with the sidewalk slab, using the same criteria as for the sidewalk beam. In no case shall this beam have less load carrying capacity than the other adjacent roadway beams.

3.8.2.5 Sidewalk Utility Bay - Sidewalk Slab Design. The sidewalk slab shall be designed for the differential deflection between the adjacent roadway beams and the sidewalk beam(s).

STEP 1: Calculate the deflection of the adjacent roadway beams by placing design trucks in each of the actual travel lanes (not the AASHTO design lanes) and assuming that all adjacent roadway beams are acting together.

STEP 2: Calculate the equivalent uniformly distributed load (per foot of beam) that would cause the same deflection in the sidewalk beam as calculated in Step 1. Use the composite section properties. If there are two or more sidewalk beams, calculate the load that would deflect all sidewalk beams at once.

STEP 3: For design, the sidewalk slab will be considered a cantilevered beam with a length equal to the clear width of the utility bay. The design load shall be the uniform load calculated in Step 2 and applied at the free end of the cantilever. Assume the section to be singly reinforced and use the smallest *d* dimension. The required steel area shall be provided for both top and bottom transverse slab reinforcement. Spacing of these bars should be at a multiple of the sidewalk dowels of the first roadway beam.

STEP 4: If excessive steel areas are required, consideration should be given first to increasing the depth of the sidewalk slab and, second, by providing intermediate diaphragms. The intermediate diaphragms need only be designed for the load in excess of the slab capacity.

3.8.2.6 Exterior Utility Supports. Whenever a utility is attached to the exterior of an adjacent beam bridge, the torsional effect of such an attachment may cause unequal reactions at the bearings. This effect may be compounded by additional eccentric loads, such as either a sidewalk overhang or a safety curb with a railing/barrier and which does not extend over to the second interior beam. To help equalize the reactions at the bearings, consideration will be given to increasing the number of transverse ties and/or the use of a full depth shear key.

3.8.3 Continuity Design for Prestressed Concrete Beam Bridges

3.8.3.1 General. The closure pour for continuity, as detailed in Part II of this Bridge Manual, is also intended to provide the longitudinal and transverse restraint for the bridge for seismic and other design loads. The reinforcing bar hoops placed in the closure pour as well as the hoops in the pier cap adjacent to the shear key will be designed for the longitudinal loads. The transverse shear requirement will also be checked. If the continuity bars alone are insufficient as shear dowels, additional shear dowels projecting into the closure pour may be cast into the end of the beam.

3.8.3.2 The Designer is advised to consider the effect of creep, shrinkage and long term Dead Load deflections in the design of bridges made continuous over two or more spans, especially if continuity is being made between un-equal spans.

3.8.3.3 Prestressed concrete beam bridges made continuous will be designed according to the procedure outlined below. The full effect of continuity will not be used to reduce the positive superimposed Dead Load and Live Load moments. All design of the reinforcement within the closure pour will be per prestressed beam and based on its width. NCHRP Report 322, *Design of Precast Prestressed Bridge Girders Made Continuous*, is recommended as a reference for the design of continuous prestressed girders.

STEP 1: Design all beams as a simple span for positive moment prestressing.

STEP 2: Calculate the negative superimposed Dead Load and Live Load plus moment envelopes assuming that the beam is fully continuous.

STEP 3: The actual continuity steel provided shall be the smaller of either Case A or B:

Case A: Using the Strength Design Method, calculate the steel area required for the maximum negative moment at the pier from Step 2. The design concrete compressive strength shall be that of the prestressed beam. The compressive stress in the ends of the beams at the piers from the combined effect of prestressing and negative Live Load/superimposed Dead Load moments shall not exceed $0.6\ f'_c$.

Case B: Using Strength Design criteria calculate ρ_b for the section. The maximum steel area to be provided shall not exceed $0.5\ \rho_b$. The design concrete compressive strength shall be that of the prestressed beam.

STEP 4: Using the negative moment envelope, determine the cut-off point for the continuity reinforcement. Spread and adjacent beam bridges shall be designed compositely with the deck slab with the continuity reinforcement placed in the deck slab. The deck slab continuity reinforcement cut-off point shall be where the negative moment steel reinforcement area provided in the deck slab is sufficient for the negative moment plus the splice length of the smaller bars.

Although it is not intended to fully restrain the rotation of the beam end at the closure pour due to creep induced camber growth, provisions have been made to resist the positive restraint moment that may develop by extending the bottom row of prestressing strands into the closure pour at piers.

3.8.3.4 Adjacent Deck and Box Beam Bridges With Sidewalk Utility Bay. Follow the same procedure as above. The continuity reinforcement may be placed in the slab.

3.8.4 Design of New England Bulb Tee Beams

3.8.4.1 The design of vertical stirrups for shear shall be performed in accordance with AASHTO 9.20. In addition to these requirements, the Designer shall verify that sufficient reinforcement is provided near the support by employing the Strut and Tie Analysis as specified in AASHTO 9.21.4

3.8.4.2 The Strut and Tie Analysis shall be performed in accordance with the following guidelines:

1. The Strut and Tie method is an upper bound analysis, and therefore, all loads shall be factored. Prestressing shall be considered an exterior load with a load factor of 1.2.

2. An acceptable stirrup arrangement near the bearing will be one that is capable of distributing the bearing reaction, prestressing and live load point loads through the development of a fully plastic truss configuration. The assumed truss shall be comprised of various compression cords (discrete concrete struts) and tension cords (vertical steel reinforcement ties). The distribution shall be considered successful if all compressive struts acting on the node at the bearing fit within the contact area of the bearing.

3. Reinforcement at the end of the beam and extending to the front face of the bearing shall be considered inactive in the assumed truss model.

4. The end reaction to be distributed out into the truss shall not include the weight of the approach slab and end diaphragm. These forces shall not be considered to act on the truss model extending away from the bearing. Instead, these forces shall be considered to transmit into the bearing directly, and therefore, not affect the strut and tie model.

5. The Strut and Tie Analysis is an iterative trial and error method involving mathematical and graphic techniques to reach a solution. In lieu of this rigorous analysis, the following simplified approach shall be considered an acceptable alternative to the Strut and Tie Analysis:

   For values of L' as follows:

   NEBT 1000 L' = 4.18'
   NEBT 1200 L' = 3.98'
   NEBT 1400 L' = 3.77'
   NEBT 1600 L' = 3.57'
   NEBT 1800 L' = 3.36'

   If: $Vu \leq nF_yA_s + V_{(LL + I)DF} + (w_{DL +SDL})$ L', then the requirements of the Strut and Tie Analysis can be waived.

   Where:

   Vu = Total factored beam reaction (kips) from dead load, superimposed dead load, and live load plus impact, but excluding dead load resulting from end diaphragms and approach slabs.

   n = The number of vertical stirrups contained in the zone extending from the front face of the bearing to the limits of L'.

   L' = The effective length of beam (feet) capable of developing plastic truss action in the strut and tie method. L' is measured from the end of the beam inward towards the center of the span.

   Fy = 60 KSI.

   As = Cross sectional area of a stirrup pair (in^2), usually a # 4 or #5 bar.

   $V_{(LL + I)DF}$ = 1.3(1.67)(20 $kips_{HS25\ Wheel}$)(Impact)(Dist. Factor) kips = 43.42(I)(DF) kips

   $w_{DL +SDL}$ = Factored dead and superimposed dead load in kips per linear foot of beam.

3.9 INTEGRAL ABUTMENT BRIDGES

3.9.1 General

Integral bridges are single span or multiple span continuous deck type structures with each abutment monolithically connected to the superstructure and supported by a single row of flexible vertical piles. The primary purpose of monolithic construction is to eliminate the need for deck movement joints and bearings at abutments.

Integral abutment bridges differ from traditional rigid frame bridges in the manner which movement is accommodated. Rigid frame bridges resist the effects of temperature change, creep and shrinkage with full height abutment walls that are fixed or pinned at the footing level. The effects produced by longitudinal forces in integral abutment bridges are accommodated by designing the abutments to move with less induced strain, thus permitting the use of smaller and lighter abutments.

Integral abutment bridges have a demonstrated history of initial cost savings due to economy of material usage and lifecycle cost savings through reduced maintenance. Integral abutment construction shall be considered as a first option for all slab and slab on stringer bridges.

3.9.2 Guidelines

Construction of integral abutment structures shall be subject to the following guidelines. For bridges that do not fall within these guidelines, integral abutment design will be allowed with the prior approval of the Bridge Engineer. These guidelines apply only to slab and slab-on-stringer bridges:

1. Skew angles should preferably be limited to 30°.

2. Total bridge lengths should preferably be limited to 350 feet for steel bridges and 600 feet for concrete bridges.

3. Curvature should preferably be limited to a 5° subtended central angle.

4. The difference in the profile grade elevation at each of the abutments should preferably not exceed 5% of the bridge length.

5. Abutment heights, measured from the deck surface to the bottom of the cap, should preferably not exceed 15 feet.

3.9.3 Loads

3.9.3.1 Integral abutment bridges shall be designed to resist all of the vertical and lateral loads acting on them. The combined load effects on the structure at various stages of construction must be considered in the design. The stages of construction are of primary importance, they typically require the stringer ends to be simply supported initially, then to be made integral with the abutments after the deck is cast, and then the abutment is backfilled. The vertical loads shall include dead loads, superimposed dead loads, buoyancy, and live loads including impact. Horizontal loads shall include braking forces, soil pressures, seismic forces, and loads induced from temperature changes, shrinkage, and creep.

3.9.4 General Design Requirements

3.9.4.1 Single span integral abutment bridges with spans less than or equal to 100' and skews less than or equal to 30° have had their reinforced concrete abutments and piles pre-engineered and detailed subject to the limitations stipulated in Chapter 12 of Part II of this Bridge Manual. The following methodologies shall be used in the design of integral abutment structures without pre-engineered elements:

Superstructure Elements: Service Load Design Method (Allowable Stress Design)
Substructure Elements: Strength Design Method (Load Factor Design)

3.9.4.2 The thermal movements shall be calculated in accordance with Paragraph 3.1.5.2.

3.9.4.3 The connection between the beams and the abutment shall be assumed to be simply supported for superstructure design and analysis. It is recognized that, in some cases, it may be desirable to take advantage of the frame action in the superstructure design by assuming some degree of fixity. This, however, requires careful engineering judgment. Due to the uncertainty in the degree of fixity, frame action shall not be utilized to reduce design moments in the beams. However, the superstructure design shall include a check for the adverse effects of fixity at the abutments.

For the design of the abutment and piles, the superstructure shall be assumed to transfer moment, and vertical and horizontal forces due to superimposed dead load, live load plus impact, earth pressure, temperature, shrinkage, creep and seismic loads which are applied after the rigid connection with the abutment is achieved. The connection between the abutment and superstructure shall be detailed to resist all applied loads.

3.9.4.4 For integral abutment bridges, a primary requirement is the need to support the abutments on relatively flexible piles. Therefore, where rock or glacial till is very close to the surface (within 25'), or where the use of short piles less than the required minimum length to obtain pile fixity, L_f (Table 3.1), is necessary, the site is not considered suitable for pile supported integral abutments. This limitation may be waived if the design and/or the pile installation procedures can be modified accordingly.

3.9.4.5 The abutment shall be supported on a single row of vertical HP-piles with the webs oriented parallel to the centerline of the abutment. The top of the piles shall be embedded into the abutment, and the abutment shall be adequately detailed and reinforced to transfer the forces from the superstructure.

3.9.4.6 The abutment should be kept as short as possible to reduce the magnitude of soil pressure developed; however, a minimum cover over the bottom of the abutment of 3'-0" is desirable. It is recommended to have abutments of equal height. A difference in abutment heights causes unbalanced lateral load resulting in sidesway. Abutments of unequal height shall be designed by balancing the earth pressure consistent with the direction of sidesway.

3.9.4.7 The magnitude of lateral earth pressure developed by the backfill is dependent on the relative wall displacement, δ_T/H, and may be considered to develop between full passive and at-rest earth pressure. The backfill force shall be determined based on the movement dependent coefficient of earth pressure (K). Results from full scale wall tests performed by UMASS[1] show reasonable agreement between the predicted average passive earth pressure response of MassHighway's standard compacted gravel borrow and the curves of K versus δ/H for dense sand found in design manuals DM-7[2] and NCHRP[3]. For the design of integral abutments, the coefficient of horizontal earth pressure when using compacted gravel borrow backfill shall be estimated using the equation:

$$K = 0.43 + 5.7[1 - e^{-190(\delta_T/H)}]$$

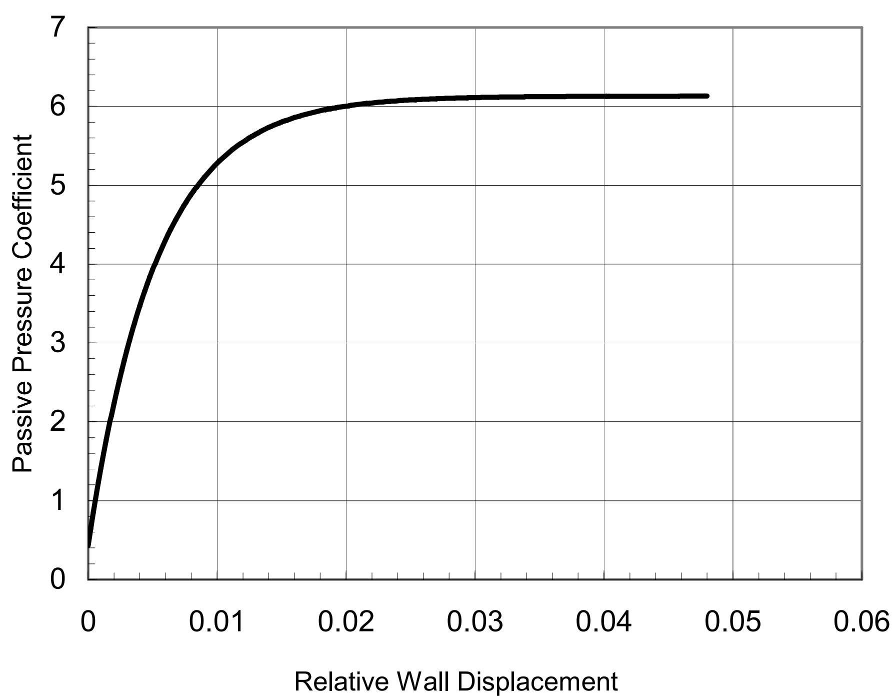


Figure 3.6: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

3.9.4.8 Pre-drilled holes, 8 feet deep and filled with loose crushed stone, shall be provided to reduce resistance to pile lateral movement. To achieve loose conditions, the pre-drilled holes shall be filled with crushed stone after the piles are driven. The minimum diameter of the crushed stone filled pre-drilled holes shall be 2'-0". To accommodate increased movements in the loose crushed stone and minimize influence from the surrounding natural soils, larger hole diameters shall be specified as the expected movements increase. The diameter of the crushed stone filled holes shall be rounded to the nearest 6" increment up to a maximum diameter of 4 feet based upon the following formula with all units in inches:

$$\varnothing_{hole} = 24 + 10(\delta_T)$$

3.9.4.9 Approach slabs shall be used for all integral abutment bridges. The approach slab shall be detailed to remain stationary by constructing a key away from the abutment and shall be detailed to allow sliding at the end supported by the abutment.

3.9.4.10 U - shaped integral wingwalls, with a minimum length of 2 feet shall be used between the abutment and the Highway Guardrail Transition. The integral wingwall length shall be as required by site and bridge geometry, with a maximum length of 10 feet. When a wingwall length longer than 10 feet is required a combination of integral and independent wingwalls shall be utilized.

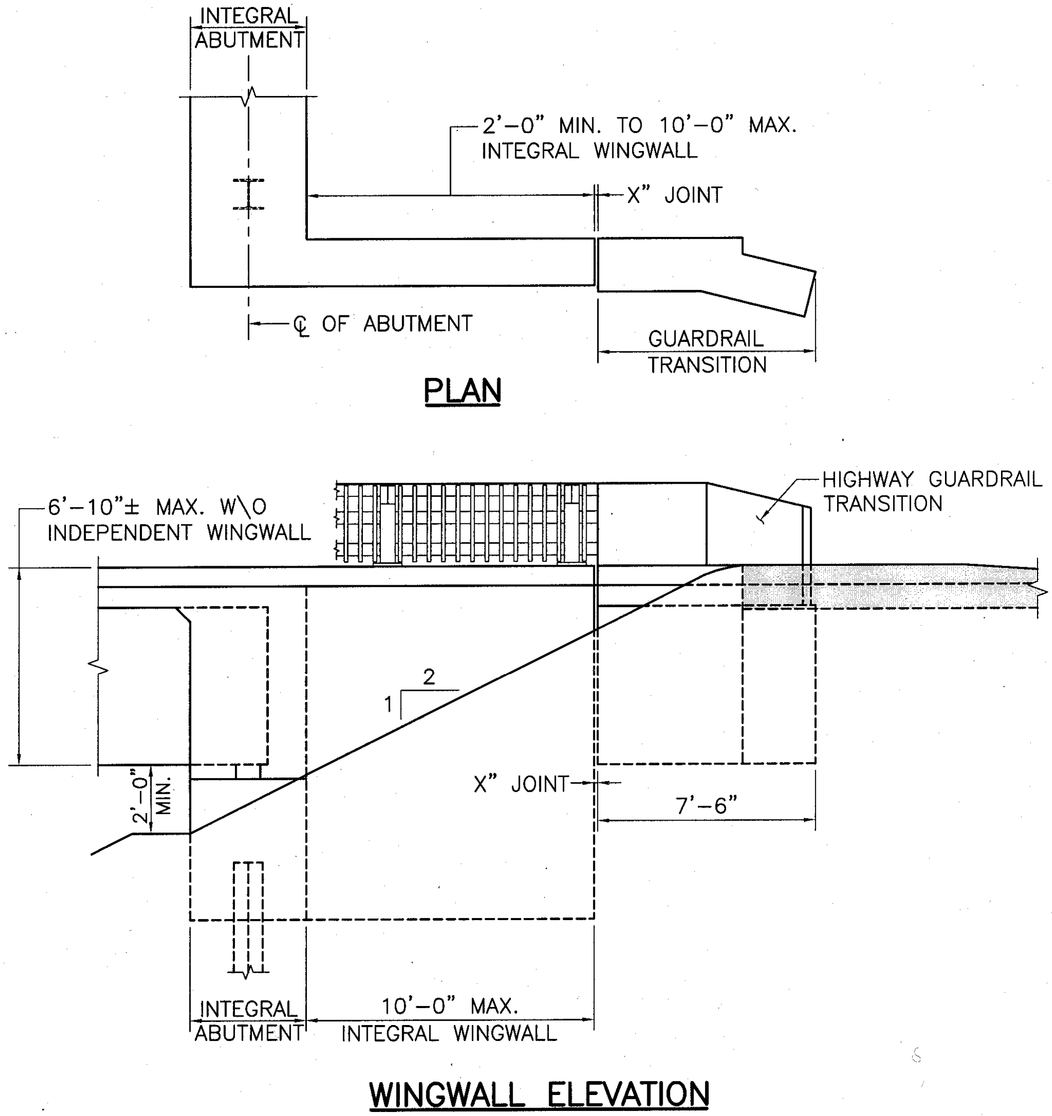


Figure 3.7: Wingwall Geometry.

3.9.5 Pile Design Methodology

3.9.5.1 The methodology for the design of integral abutment piles incorporates the provisions contained in the AASHTO Standard Specifications For Highway Bridges, 17th Edition, Section 10.48. Integral abutment piles are considered to be sufficiently braced to prevent lateral torsional buckling and gross Euler buckling. A review of the literature [3,5,6] suggests that gross buckling is unlikely to occur in piles except in extreme cases of long piles through very soft soils such as peat.

Consideration shall be given to selection of an HP-pile section for adequate resistance to local flange buckling. Local buckling of the webs for HP-piles is not a concern as they are compact.

3.9.5.2 The basic design equation for the capacity of a pile as a structural member is obtained from AASHTO Section 10.54.2 - Combined Axial Load and Bending.

1. The basic equations have been modified to account for pile slenderness. For piles surrounded by the types of soil typically found beneath approach embankments, Euler buckling is not a concern and need not be checked. Weak axis bending is considered the primary mode of bending. The possibility of flange local buckling is addressed by the selection of pile section.
2. Bi-axial bending shall be evaluated.
3. Slender sections are not permitted to be used in integral abutment bridges because of the inability of these pile sections to reach yield in bending prior to flange local buckling (AISC[7], Section C-B5).

3.9.5.3 The initial choice of pile section shall be based upon the recommendations contained in the Geotechnical Report. The preliminary design axial loads shall be based upon AASHTO LFD Group I Loading. Use a minimum of 1 pile per beam line at each abutment.

3.9.5.4 Use live load impact in the design of integral abutment piles.

3.9.5.5 The permissible total length of integral abutment bridges is sensitive to the relative slenderness of the pile section. Compact sections are capable of developing a fully plastic stress distribution and have an inelastic rotational capacity of 3 before the onset of flange local buckling. The final design procedure for compact pile sections incorporates an inelastic rotational capacity factor of 1.75 to account for the pile's ability to undergo inelastic rotation and the associated increase in pile head translation. Non-compact sections are capable of reaching yield, but flange local buckling will precede the development of a fully plastic stress distribution. Therefore, an inelastic rotational capacity factor of 1.0 shall be used for non-compact sections.

1. Acceptable pile sections (F_y = 36 ksi):
   A. Compact: HP10X57; HP12X74; HP12X84; HP14X102; HP14X117.
   B. Non-Compact: None.
2. Acceptable pile sections (F_y = 50 ksi):
   A. Compact: HP10X57; HP12X84.
   B. Non-Compact: HP14X117.
3. Criteria for pile selection:
   A. If bridge skew is 0^o to 20^o, either compact or non-compact sections may be used.
   B. If bridge skew is greater than 20^o, use compact sections only.

3.9.5.6 The Geotechnical Report shall contain a statement indicating whether the lateral support of the piles provided by the soil is sufficient enough to assume that the pile is fully braced against Euler buckling. In cases where the piles extend through regions of very soft soils, such as peat, the piles shall be assumed to behave like unbraced columns, and the applicable AASHTO design requirements shall be followed.

3.9.6 Modeling - General

3.9.6.1 All integral abutment bridges (excluding the pre-engineered ones) shall be modeled as 3D space frames that includes, as a minimum, a "stick" model of the superstructure, abutments, wingwalls, piers (if any), piles, soils springs, and shall be representative of the geometry, including skew (Figure 3.8).

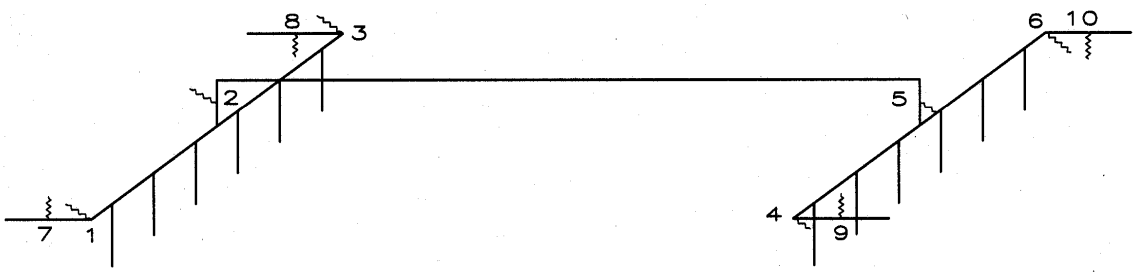


Figure 3.8: "Stick" Model Geometry

The soil behind the abutments shall be modeled with at least 3 horizontal springs that are oriented perpendicular to the wall face, one at mid-height and mid-length of the abutment wall (see nodes 2 and 5 above), and one at the bottom of each end of the abutment (see nodes 1, 3, 4, and 6 above). The soil spring stiffness behind each abutment shall be distributed based on the tributary area for the middle portion (50%) and end quarters (25%) at each abutment end. The non-linear soil spring stiffness shall be based on K values determined in accordance with Paragraph 3.9.4.7 for assumed incremental displacements. The soil springs shall not carry tension forces. The same K values shall be used for both static and dynamic loads. Similarly, the soil behind the integral wingwalls shall be modeled as a horizontal soil spring located at the one-third point from the wingwall end (see nodes 7, 8, 9, and 10 above) with a stiffness calculated as stated above.

3.9.6.2 HP-Piles shall be modeled as beam elements. The length of pile from the base of the abutment to the point of fixity shall be the equivalent length, L_e , defined as the theoretical equivalent length of a free standing column with fixed/fixed support conditions translated through a pile head horizontal displacement δ_T. The equivalent length for each pile, L_e, shall be determined from the following multivariable regression equation:

$$L_e=A(EI/d)+B(\delta_T)+C$$

This equation correlates L_e with the pile head horizontal displacement, δ_T, and the ratio of the pile's flexural rigidity to the pile section's depth in the plane of bending, EI/d. The calculation of L_e shall be made using the average of the temperature rise and temperature fall. The equation coefficients were derived from a parametric[10] study using various assumed soil profiles.

Due to similar results for the dry crushed stone overlying the different sand conditions, those cases were condensed into one equation. Similarly, loose and dense sand underlying wet crushed stone were grouped together, resulting in the six equations outlined below. The Designer shall interpolate equivalent length between soft (c = 575 psf) and stiff (c = 2600 psf) clays. Additionally, if the water table is located intermediate to the cases presented, the Designer shall linearly interpolate between the equation coefficients presented here.

IDEALIZED SOIL CONDITIONS	EQUATION COEFFICIENTS FOR L_E			FIXITY RATIO
$L_e = A(EI/d)+B(\delta_T)+C$	A	B	C	L_f / L_e
	inch/(inch-kip)	inch/inch	inch	
Dry crushed stone over wet or dry sand	3.28E-05	11.9	89.1	2.2
Wet crushed stone over wet sand	3.59E-05	13.9	98.8	2.2
Dry crushed stone over wet stiff clay	3.06E-05	15.4	81.9	1.8
Dry crushed stone over wet soft clay	4.80E-05	21.1	76.4	2.5
Wet crushed stone over wet stiff clay	2.99E-05	18.1	87.9	1.8
Wet crushed stone over wet soft clay	5.26E-05	25.8	86	2.2

Table 3.1: Equation Coefficients to Determine Equivalent Pile Length.

Due to the inherent uncertainty involved in obtaining soil properties, the above equations should be adequate for most cases encountered. If more accurate site specific soil properties are available, or if variable stratified soil conditions exist in the upper 15 feet of soil, a separate lateral pile analysis using a computer program such as COM624P should be performed and presented in the Geotechnical Report.

3.9.6.3 In order to obtain the pile behavior associated with the calculated equivalent lengths, the piles must be installed to a point of fixity or deeper. The practical depth to pile fixity is defined as the depth along the pile to the second point of zero lateral deflection. The required length of fixity, L_f, is normalized to the equivalent length, L_e, and the resulting ratios are summarized in Table 3.1. If piles are installed by driving, they must be embedded to the length of fixity, L_f , or greater, as calculated based upon Table 3.1. Additionally, driven piles must derive their axial capacity at a point below the bottom of the pre-drilled hole. If this depth is not feasible, then the piles shall be predrilled and socketed into rock or dense till, and the socket shall be filled with concrete up to the bottom of the crushed stone. In this case, the equivalent length shall be taken as the depth from the bottom of the integral abutment to the top of the concrete filled socket.

3.9.7 Final Pile Design

3.9.7.1 Perform the analyses for all appropriate factored Load Groups. Determine the pile head design loads from analysis. For Load Groups containing thermal loads, add in P-Δ moments (Axial Load x Deflection). The number or size of piles required to support integral abutments shall not be determined by seismic loading [11].

3.9.7.2 Determine the structural adequacy of the preliminary pile section selected from the Geotechnical Report using the following strength criteria:

$$\frac{P_u}{0.85\ A_s\ F_y} + \frac{M_y}{\theta_l\ M_{uy}} + \frac{M_x}{M_{ux}} \leq 1.0$$

Where:

P_u = Applied axial load determined from analysis;
A_s = Cross sectional area;
M_y ; M_x = Applied moment determined from analysis & P-Δ moment;
M_{uy} ; M_{ux} = Maximum moment strength based on the slenderness criteria;
θ_i = Coefficient of inelastic rotational capacity defined herein;
F_y = Yield Stress.

For compact sections the maximum moment capacity shall be:
$M_{uy} = Z_y F_y$ and $M_{ux} = Z_x F_y$
θ_i = 1.75 (to account for inelastic rotational capacity for weak axis bending only).

Where:
Z_y ; Z_x - Plastic section modulus for respective axis;
$Z \leq 1.5$ S (AISC[7], Section F1.1)
S = Section modulus for respective axis;

For non-compact sections the maximum moment capacity shall be determined in accordance with AASHTO Subsection 10.48.2.

If the analysis results indicate that the piles are inadequate, the Designer shall increase the pile size and/or add additional piles and re-analyze until an adequate pile size and spacing is determined.

3.9.8 Integral Wingwall Design

Integral wingwall reinforcement shall be designed for all loading combinations and detailed as shown in Part II of this Bridge Manual. For single spans less than or equal to 100' span lengths, calculate the soil pressures behind the wingwall based upon a coefficient of earth pressure K = 1.0. For multiple span bridges, design the wingwall reinforcement based upon the soil spring forces from the 3D model.

3.9.9 References

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3.10 REHABILITATION OF STRUCTURES

3.10.1 General Requirements

Every bridge rehabilitation project shall ensure a bridge structure that meets current code and load capacity provisions. Where feasible, structures shall be made jointless.

3.10.2 Options for Increasing Carrying Capacity

3.10.2.1 General. The following are traditional options for increasing the load carrying capacity of existing main load carrying members. They can be used independently or in combination to achieve the desired effect. Not every structure can be upgraded using these options, therefore sound engineering judgement should be employed when evaluating them.

1. Where the existing beams are of non-composite construction, redesigning the beams for composite action and providing for the addition of shear connector studs may be sufficient to increase the carrying capacity.

2. Using a full depth HP Cement Concrete deck with a ¾” thick integral wearing surface may be used in lieu of a regular deck with a bituminous concrete wearing surface to reduce the added dead load. Thin HP Cement Concrete overlays shall not be considered due to the potential for constructability problems.

3. Using lightweight concrete for the deck instead of regular weight concrete. When using lightweight concrete, the Designer must take into account the reduced Modulus of Elasticity in the calculation of composite section properties as well as the increase in the development and lap lengths for reinforcing bars, as specified in AASHTO.

4. On rolled steel beam sections, adding cover plates. On bridges with existing cover plates, consideration can be given to adding additional cover plates on the top of the bottom flange. This is usually accomplished by adding two small plates to the top of the bottom flange, placed symmetrically either side of the web plate. Addition of any cover plates to an existing structure changes the stress distribution in the beam which must be accounted for in design, e.g. the bottom flange carries dead load stresses while the added cover plate is unstressed.

5. Where existing members have cover plates on the bottom flange, it is usually not economically feasible to remove them, especially if the bridge is over a road that has a high ADT.

6. Construct continuity retrofit of simply supported main members over the pier(s) in order to reduce live load stresses in positive moment region(s).

3.10.2.2 Where an excessive haunch depth occurs due to changes in bridge cross slope or changes in vertical profile, the haunch depth in excess of the standard haunch can be utilized in calculating composite section properties. For example, the standard 1½” haunch is not used in calculating composite section properties. If the profile change results in a 6” haunch, the excess 4½” may be used in calculating section properties.

3.10.3 Fatigue Retrofits

3.10.3.1 All fatigue susceptible details shall be fully investigated in bridge rehabilitation projects. Of particular concern are the ends of cover plates where a fatigue category E or E′ exists. In most cases, older cover plated beams will not meet current fatigue requirements for allowable stress ranges.

3.10.3.2 Reference is made to the AASHTO *Guide Specifications for Fatigue Evaluation of Existing Steel Bridges*, for evaluating the remaining fatigue life of existing steel beams that are not adequate based on the standard design requirements for fatigue.

3.10.3.3 If fatigue life is inadequate or if cracks are found at the cover plate ends during a structural inspection, the beams will be retrofitted by installing splice plates on the bottom flange which will span over the cover plate end. These splices will be designed for the maximum force in the cover plate based on the cross sectional area and the allowable stress of the cover plate. The splices will be designed as bolted slip-critical connections.

3.10.3.4 By itself, installing bolts through the existing cover plate termination is not acceptable as a retrofit for the following reasons:

1. This detail will not address a crack at the end of the cover plate that was invisible at the time of the inspection and may subsequently grow.

2. This type of retrofit cannot be made slip-critical, since the use of oils during the drilling operation will contaminate the beam flange/cover plate interface that cannot be cleaned as required to make it a slip-critical connection.

3. Since this connection is not slip-critical, there will be some live load stress flow through the end weld that could continue to contribute to the formation and/or growth of a fatigue crack.

3.11 ANCILLARY STRUCTURES

3.11.1 Pedestrian Bridges

Bridges whose primary function is to carry pedestrian and/or bicycle traffic shall be designed in accordance with the AASHTO *Guide Specifications for Design of Pedestrian Bridges*. Pedestrian bridges shall be designed to comply with the Americans with Disabilities Act (ADA) law.

3.11.2 Temporary Bridges

Pre-Engineered Temporary Panelized Bridges are to be used wherever feasible to maintain traffic flow during bridge reconstruction projects. The design of Pre-Engineered Temporary Panelized Bridge superstructures shall be performed by the supplier and shall be reviewed and approved by the Designer. Where the use of Pre-Engineered Temporary Panelized Bridge superstructures is not feasible, all elements of the temporary bridge structure shall be designed by the Designer. The design of all temporary bridge substructures that are to be used by the public during a bridge project shall be the responsibility of the Designer. Temporary bridge substructures that support Pre-Engineered Temporary Panelized Bridges shall be designed for assumed loads from the superstructure. The temporary bridge substructures shall be located and detailed on the bridge plans. The assumed vertical and horizontal geometry of the Pre-Engineered Temporary Panelized Bridge and the assumed design loads for the substructure shall be specified on the bridge plans. All temporary bridge structures shall be designed as if the structure was intended to be a permanent installation. Provisions for seismic design may be waived with the approval of the Bridge Engineer.

3.11.3 Sign Attachments to Bridges and Walls (Revised June 2007)

3.11.3.1 All sign attachments, their connections and their appurtenances shall be designed in accordance with the latest version, including current interims, of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. The effect of loads from the sign structure on the bridge structure in conjunction with the bridge dead and live loads will be considered during design.

3.11.3.2 In the design of sign supports, the wind velocity to be used shall be in accordance with the basic wind speed figure contained in the latest version, including current interims, of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.*

3.11.3.3 When considering whether to attach a sign to an existing bridge structure, the following recommendations shall be observed:

1. Avoid attaching large signs to existing bridges (signs whose height is greater than 1.5 times the depth of the bridge beam plus coping height.
2. Avoid attaching signs to bridges where the angle between the sign face and the bridge fascia would exceed 30°.
3. Do not attach changeable message signs to existing bridge structures under any circumstances. These shall always be mounted on independent full span structures.
4. Even if it still seems more efficient to mount a sign on an existing bridge, the bridge must still be checked to verify that the beams can carry all of the sign loads (dead load, eccentric torsional load, out of plane bending, etc.) without global or local overstress. If members are overstressed then a retrofit design must be provided. Also, the condition of both the beam and the coping concrete must be investigated to verify that it is competent to be attached to.
5. Signs shall not be attached to bridges with prestressed concrete beams that would require field drilling for the sign attachments. Field drilling into prestressed beams is prohibited since the prestressing strands are embedded in the beams and careless drilling can sever the strands and reduce the load carrying capacity of the beam.

3.11.3.4 Sign supports shall be fabricated from steel conforming to AASHTO M 270 Grade 36 and shall be galvanized in accordance with AASHTO M 111. All steel hardware shall be galvanized in accordance with AASHTO M 232.

3.11.3.5 The minimum size of angles to be used shall be L3x3x5/16. The minimum size weld to be used shall be ¼”. Expansion bolts embedded into existing copings shall have a minimum diameter of ¾”.

3.11.3.6 The distance between sign support panels shall be selected so that the maximum positive and maximum negative moments in the panels shall be approximately equal. The bottom of the sign panel shall be a minimum of 6” above the bottom of the stringer.

3.12 BRIDGE INSPECTION

3.12.1 Requirements for Bridge Inspection Access

3.12.1.1 The main purpose of a bridge inspection is to assure the safety of a bridge for the travelling public by uncovering deficiencies that can affect its structural integrity. The results of a bridge inspection are used to initiate maintenance activities and/or a load rating. In order to comply with these requirements, all structural components of a bridge must be accessible for a hands-on inspection.

The standard MassHighway bridge, as detailed in Part II of this Bridge Manual, allows inspectors to access all structural members through the use of ladders, bucket trucks or the Bridgemaster (Inspector 50) truck. However, this equipment does have limitations, outlined below, that may prevent full access in some locations. Also, non-standard bridges may require special considerations for inspection access and maintenance. In these cases, inspection access must be secured through the use of rigging, platforms, walkways, scaffolding, barges, and in some cases, special travelling gantries.

The Designer is obligated to properly plan for safe inspection access as part of the design process and to provide accommodation for inspection access equipment in the construction plans. This will insure that the bridge will be thoroughly inspected in the future. Otherwise, bridge inspectors may be faced with an impossible task of trying to properly inspect an inaccessible structure.

3.12.1.2 Ladders. Typically, the maximum safe reach for a ladder is about 25 feet. In addition, ladders must be set on firm and level ground. If the topography of the ground under a bridge is sloping, unstable, too rough or if the bridge is directly over water, ladders probably cannot be used.

3.12.1.3 Bucket trucks. Bucket trucks can be used to access the underside of a bridge from below. The maximum safe vertical reach for a bucket truck is about 25 feet. In order to use a bucket truck, there must be a road directly under the bridge. If there is no road, a bucket truck cannot be used. Bucket trucks also cannot be used on sloping ground.

3.12.1.4 Bridgemaster (Inspector 50) Truck. The Bridgemaster is a versatile inspection truck that allows access to the underside of a bridge from the bridge deck. The vehicle has a maneuverable boom with a bucket that can reach over the side of the bridge and move around underneath. The Bridgemaster, however, does have the following limitations:

- The maximum width of sidewalk that the Bridgemaster can reach over from the curb is 6 feet.
- The Bridgemaster cannot be operated with one set of wheels on the sidewalk and the other on the roadway.
- If the sidewalk can support the truck’s weight, the minimum width of sidewalk that the Bridgemaster requires for driving on is 10 feet and there must be a ramp type access to the sidewalk.

- The Bridgemaster bucket can be deployed over a railing or fence with a maximum height of 6 feet. If the fence extends beyond that up to a height of 8 feet, the Bridgemaster boom can only drive along the fence with the bucket already deployed. The bucket must be deployed before or after the start of the 8 foot high fence and there can be no obstructions, such as light poles, in the travel path of the boom. The Bridgemaster cannot reach over fences greater than 8 feet in height.

- The minimum safe vertical underclearance for operating the bucket is 10 feet.

- The maximum roadway cross slope that the Bridgemaster can operate on is 7%.

- The bucket and boom must stay a minimum of 10 feet away from power lines.

- Underneath, the maximum reach under favorable conditions is 50 feet, which is reduced to 25 feet on bridges with problematic access.

- The Bridgemaster bucket cannot reach up around deep girders to allow access to the deck or upper parts of the girder.

- The Bridgemaster cannot be used to access a bridge from below.

3.12.1.5 Bridges with confined spaces in which inspectors must work require special considerations in order to ensure that they will be safe for inspection personnel. OSHA's definition of a confined space is a space large enough and so configured that an employee can bodily enter and perform assigned work but has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. Examples of such confined spaces on a bridge include the inside of steel box girders, hollow abutments, etc. The Designer is obligated to insure that there is sufficient room inside the confined space for a reasonably sized individual to move and turn around, that there is sufficient means of egress in an emergency or access by emergency personnel to rescue a stricken or incapacitated inspector.

3.12.1.5 In all cases of non-standard bridges or bridges with difficult access, the MassHighway Bridge Inspection Unit will review the bridge plans and make recommendations for providing adequate and safe access for bridge inspection.

3.12.2 Fracture Critical Bridge Inspection Procedures

3.12.2.1 If a bridge is designed with fracture critical members, the Designer must prepare and submit a Fracture Critical Inspection Procedure as part of the design process in addition to the contract documents. This procedure will be used to properly inspect these structures in accordance with federal regulations, 23 CFR Part 650, Subpart C, §650.303 (e)(1).

3.12.2.2 The Fracture Critical Inspection Procedure shall be prepared on standard MassHighway forms as supplied by the Bridge Inspection Unit and shall consist of the following parts:

1. Index

2. Identification of Fracture Critical Members

Identify all Fracture Critical members or Fracture Critical portions of members (such as tension zones of non-redundant plate girders or floorbeams) both by text and visually by using key plans, diagrams and elevation views of members. This list will be used by the inspectors to identify and inspect all Fracture Critical members on the bridge. The required inspection frequency shall also be noted.

3. Identification of Fatigue Sensitive Details
Identify all Fatigue Sensitive details on the Fracture Critical members both by text and through the use of the standard Fatigue Sensitive category diagrams. This list will be used by inspectors to identify and inspect all Fatigue Sensitive details on the Fracture Critical members. The required inspection frequency shall also be noted.

4. Inspection Procedure for Inspection of Fracture Critical Members
Outline the procedure the inspectors are to follow when inspecting Fracture Critical members. The required inspection frequency shall also be noted.

5. Inspection Procedure for Inspection of Fatigue Sensitive Details
Outline the procedure the inspectors are to follow when inspecting Fatigue Sensitive details. The required inspection frequency shall also be noted.

6. Photographs
Provide inventory photographs of the bridge structure and photographs of the typical Fracture Critical members and Fatigue Sensitive details for identification purposes.

The Federal Highway Administration Report No. FHWA-IP-86-26 “Inspection of Fracture Critical Bridge Members”, dated September 1986, can be used as a reference and guide in preparing the inspection procedures of parts 3 and 4.

3.12.2.3 Since a Fracture Critical Inspection requires a very detailed, close visual “hands-on” inspection as a means of detecting cracks, the Designer shall make sure that all Fracture Critical members of the bridge can be accessed in accordance with Subsection 3.12.1.

3.12.3 Bridges Requiring Special Inspection and Maintenance Procedures

3.12.3.1 For all structures having unique or special features whose condition cannot be fully assessed through a standard visual inspection, or which require additional attention during an inspection to insure the safety of such bridges, the Designer will prepare a Special Inspection Procedure and will submit it along with the contract documents as a design deliverable. The Special Inspection Procedure will outline the procedures and methods required to properly inspect their condition and could include the use of Non-Destructive Testing equipment, periodic measurements at identified locations, and elevation surveys to properly assess the condition of such features.

Examples of such special and unique features are:

Cable stayed bridges: cable stays, their anchorage to the bridge and the tower, structural tower inspection.

Segmental concrete bridges: post tensioning cables and their anchorages, sagging of the structure due to strand relaxation or deterioration.

Bridge with settling substructures: periodic survey of elevations at piers to monitor settlement rates.

Since it is impossible to outline every potential type of unique or special feature, it is incumbent upon the Designer to consider future inspection needs if the design calls for details which are not part of the MassHighway standards as detailed in Part II of this Bridge Manual. If the Designer is not certain if a Special Inspection Procedure is required, the MassHighway Bridge Inspection Unit should be consulted as early as possible in the design process.

3.12.3.2 For those structures that have unique or special features which require special periodic maintenance to insure their satisfactory and safe operation, the Designer will prepare a Special Maintenance Procedure Manual and submit it along with the contract documents as a design deliverable. This manual will outline the maintenance work that is required, the frequency of the required maintenance, and any special procedures required to perform the work.

Previous versions of the MassHighway Bridge Manual provided guidance for the design of highway structures in Massachusetts in accordance with the methods contained in the American Association of State Highway and Transportation Officials (AASHTO), *Standard Specifications for Highway Bridges.* This draft version of the Bridge Manual contains significant changes. It presents MassHighway's design practices in conformance with a new design methodology, Load and Resistance Factor Design (LRFD).

Use of this manual does not relieve the design engineer of responsibility for the design of a bridge or structural component. Although MassHighway's policy is presented here for numerous situations, content of the manual is still being developed and is not complete at this time. Therefore, use of this manual must be tempered with sound engineering judgment.

CHAPTER 3
LRFD BRIDGE DESIGN GUIDELINES

3.1 DESIGN CRITERIA

3.1.1 Design Specifications

3.1.1.1 All designs for highway bridges shall be performed in accordance with the following specifications, with current interims as of the date of the design, and as modified by this Bridge Manual.

1. American Association of State Highway and Transportation Officials (AASHTO), *LRFD Bridge Design Specifications, 4th Edition*.

2. The Commonwealth of Massachusetts, Massachusetts Highway Department, *Standard Specifications for Highways and Bridges*.

3. AASHTO/AWS *Bridge Welding Code* (ANSI/AASHTO/AWS D1.5).

4. American Association of State Highway and Transportation Officials (AASHTO), *LRFD Bridge Construction Specifications, 2nd Edition*

3.1.1.2 All designs for railroad bridges shall be performed in accordance with the latest edition of the American Railway Engineering and Maintenance-of-Way Association (AREMA), *Manual for Railway Engineering*.

3.1.2 Design Methods

All new and replacement bridge structures shall be designed using the Load and Resistance Factor (LRFD) Design method.

3.1.3 Design Software

As stated in Chapter 7 of Part I of this Bridge Manual, MassHighway currently uses: AASHTOWare™ Virtis version 5.5.0 as the standard software for rating most common bridge structure types and the latest version of Brass™ from the Wyoming Department of Transportation for rating culverts and post-tensioned concrete multiple girder bridges. Since the input file that is submitted with the rating will be used in the future to re-rate the bridge or to design repairs in the event of an emergency, it is vital that the results obtained from the software used by the Designer to design the bridge be consistent with the results obtained from this standard rating software. To ensure this, the Designer shall rate the bridge using the standard MassHighway rating software during the design process so that any discrepancies between the design and rating software may be resolved prior to the completion of the design phase and not after the bridge has been constructed. These rating calculations may be incorporated into the rating report that will be submitted after the bridge is constructed, provided that no changes have been made to the design of the bridge members that require rating during construction.

3.1.4 Live Load

3.1.4.1 The minimum AASHTO design live load for all highway bridges, culverts, soil-corrugated metal structure interaction systems, and walls shall be HL-93.

3.1.4.2 Existing highway bridges that are being rehabilitated will be upgraded to meet the minimum design loading of Paragraph 3.1.4.1. Only the Director of Bridges and Structures may grant any exceptions.

3.1.4.3 Historic structures that are being rehabilitated may be exempted from complying with Paragraph 3.1.4.2 if the structure's inventory rating can be upgraded to meet the anticipated truck traffic loadings. Only the Director of Bridges and Structures may grant any exemptions.

3.1.5 Bridge Railings/Barriers

3.1.5.1 The standard MassHighway railings/barriers detailed in Chapter 9 of Part II of this Bridge Manual shall be used in accordance with the following matrix:

Railing/Barrier	Test Level	To Be Used	Application Notes
CT-TL2	TL-2 - less than 45 MPH	Non-NHS highways only with design speeds not exceeding 45 MPH	Off system municipally owned bridges w/ or w/out pedestrians; no protective screen
S3-TL4	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	W/ or w/out pedestrians
CP-PL2	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	W/ or w/out pedestrians, mainly urban & RR bridges and all structures over electrified AMTRAK rail lines; must be used with either Type II screen or hand rail
CF-PL2	TL-4	NHS and Non-NHS highways, except limited access highways and their ramps	Bridges where pedestrians are prohibited by law; often on undivided state highway bridges
CF-PL3	TL-5	NHS and Non-NHS limited access highways and their ramps	All Interstate and limited access state highway bridges

3.1.5.2 Railings/barriers other than the ones detailed in Chapter 9 of Part II of this Bridge Manual, may be used provided that the use of a non-standard MassHighway railing/barrier can be justified and that they have been crash tested and accepted in accordance with the requirements of NCHRP 350.

Railings/barriers that have not been crash tested shall not be used on any MassHighway bridge project. If the deck slab overhang exceeds the limits specified in Chapter 9 of Part II of this manual, the Designer shall design the deck reinforcement in accordance with Chapter 13 of the *AASHTO LRFD Bridge Design Specifications* for the given test level of the railing/barrier system.

3.1.5.3 In cases where railings/barriers are mounted on top of U-wingwalls or retaining walls, the wall shall be designed to resist a load of 10 kips acting over a 5 foot length applied at a distance equal to the height of the railing/barrier above the top of the wall. This load shall be distributed down to the footing at a 1:1 slope. This load shall be applied with a load factor of 1.0 and the design lateral earth pressure from the retained soil need not be considered to act concurrently with this load.

3.1.6 Other Design Criteria

3.1.6.1 Earth Pressure Computations. Earth pressure coefficient estimates are dependent on the magnitude and direction of wall movement. Unless documented otherwise in the approved Geotechnical Report, the following earth pressure coefficients shall be used in design:

1. Counterfort walls, cantilever walls of any height, or gravity walls that are founded on rock or piles shall use K_o.
2. Cantilever walls not founded on rock or piles that are less than 16' in height shall use $0.5(K_o + K_a)$.
3. Cantilever walls not founded on rock or piles that are greater than or equal to 16' in height or any spread footing-supported gravity wall shall use K_a.

Where:
K_o= At-rest earth pressure coefficient;
K_a= Active earth pressure coefficient;

Active pressure coefficients shall be estimated using Coulomb Theory. Passive pressure coefficients shall be estimated using Rankine or Log Spiral Theory, with the exception of passive pressure exerted against integral abutments, which shall be estimated in accordance with Section 3.9 of this chapter. Current MassHighway practice is to use a unit weight for earth of 120 pounds/cubic foot in the calculation of earth pressures where more specific data is not available.

3.1.6.2 Temperature. Stresses and movements due to uniform thermal changes shall be calculated in accordance with the *AASHTO LRFD Bridge Design Specifications* for the Cold Climate temperature range using Procedure A as revised here. MassHighway bridge design standards use the "floating" bridge concept, where there is no defined fixed bearing. Thus for those bridges designed in accordance with these standards, the point of assumed zero movement shall be taken as the midpoint of the bridge beam, even when it is continuous over a pier. However, if the design requires that a defined fixed bearing be provided, then that bearing will be used as the point of zero movement. Continuous beam bridges with multiple fixed bearings along the length of the beam will require an equilibrium analysis to determine the thermal forces and displacements at each substructure unit. Since bridge members can be set at different ambient temperatures, the assumed ambient temperature for a temperature rise is different from that used for the temperature fall in order to envelope the range of one way thermal movements to be used in design.

The maximum one way thermal movement, δ_T, for the design of structural components shall be:

$$\delta_T = L\alpha\Delta T$$

Where:

L = The length of member from the point of assumed zero movement to the point where movement is to be calculated

α = Coefficient of thermal expansion of member material (0.00000645 for structural steel, 0.0000055 for concrete)

ΔT = For Structural Steel Members:
70°F temperature rise from an assumed ambient temperature of 50°F
100°F temperature fall from an assumed ambient temperature of 70°F

ΔT = For Concrete Members:
30°F temperature rise from an assumed ambient temperature of 50°F
70°F temperature fall from an assumed ambient temperature of 70°F

Procedure B shall not be used for determining stresses and movements due to uniform thermal changes.

The effects of a thermal gradient shall not be investigated for steel or concrete girder bridges with concrete or timber decks, for timber bridges or for solid slab and deck beam bridges.

3.2 FOUNDATION DESIGN

3.2.1 General

The recommendations made in the Geotechnical Report shall form the basis for the selection and design of the foundations of the bridge structure. In addition to recommending the foundation type, this report also provides the site specific design parameters, such as soil resistance, on which the foundation design will be based. Pertinent recommendations from the Geotechnical Report regarding design and/or construction shall be included on the Construction Drawings and in the Special Provisions.

3.2.2 Pile Foundations

3.2.2.1 Pile foundations shall be designed in accordance with the provisions of the *AASHTO LRFD Bridge Design Specifications*. The design factored resistance of piles shall be the lesser of the Factored Geotechnical Pile Resistance and the Factored Structural Resistance.

The factored structural axial resistance is the product of the nominal structural axial resistance of the pile and the corresponding resistance factor, as indicated in AASHTO. The factored geotechnical pile resistance is the product of the nominal geotechnical resistance of the pile and the corresponding performance factor, as indicated in AASHTO. The lowest resistance value will be the design controlling resistance and shall be greater than the combined effect of the factored loading for each applicable load combination.

3.2.2.2 The use of a resistance factor of 0.65 for axial compression of driven piles using dynamic load testing requires that a minimum number of dynamic tests be conducted per site based upon the site variability. The site variability shall be classified as either low, medium, or high using the coefficient of variation for the average measured property value (SPT, q_c, etc.) for the stratum(s) of significance at each boring location.

3.2.2.3 The additional following criteria shall be used as required:

1. Maximum batter on any pile shall be 1:3. When concrete piles are driven in clay, the maximum batter shall be 1:4.

2. The Geotechnical Report should recommend values for Lateral Resistance provided by vertical or battered piles. The geotechnical analysis, relating lateral resistance to deflection, should be performed based on unfactored lateral loads.

3. Maximum spacing of piles shall be 10 feet on center, minimum spacing shall be 2.5 times the pile diameter, unless an alternate design is performed by the Designer and has been reviewed and approved by MassHighway.

4. Minimum distance from edge of footing to center of pile shall be 18 inches.

5. The center of gravity of the pile layout shall coincide as nearly as practical with the resultant center of load for the critical cases of loading.

6. Pile layouts of piers with continuous footings shall show a uniform distribution of piles.

Exterior piles on the sides and ends of pier footings may be battered if required by design.

7. Steel pile-supported foundation design shall consider that steel piles may be subject to corrosion, particularly in fill soils, low pH soils (acidic) and marine environments. Where warranted, a field electric resistivity survey, or resistivity testing and pH testing of soil and groundwater samples should be used to evaluate the corrosion potential. Steel piles subject to corrosion shall be designed with appropriate thickness deductions from the exposed surfaces of the pile and/or shall be protected with a coating that has good dielectric strength, is resistant to abrasive forces during driving, and has a proven service record in the type of corrosive environment anticipated. Protective coating options include electrostatically applied epoxies, concrete encasement jackets, and metalized zinc and aluminum with a protective top coat.

8. When roadway embankment borrow is more than 10 feet in depth, holes should be pre-augured for all piles except H piles.

9. Pile to footing connections shall be designed to transfer no less than 10% of the pile's unfactored resistance in tension. Weldable reinforcing steel attachments shall be provided on steel piles where necessary to transfer pile tension.

3.2.3 Sheet Piling Design

3.2.3.1 All sheeting that is to be left in place shall be designated as permanent sheeting, shall be fully designed, shall be shown on the Construction Drawings, and a unit price item shall be provided for permanent sheeting in the estimate. All sheeting that is to be left in place shall be steel sheeting. The Designer shall verify the availability of the steel sheeting sections specified. The design shall include the following:

1. Plan view indicating horizontal limits of sheeting.

2. Cross-section indicating vertical limits of sheeting.

3. Minimum section modulus and minimum nominal yield strength of steel sheeting.

4. Where a braced sheeting design is indicated, the design of the bracing and wales shall also be provided and shown with full dimensions on the Construction Drawings.

3.2.3.2 The Designer, in designing the sheeting, shall assume that the bottom of excavation may be lowered by 24 inches. This lowering may be due to over-excavation or removal of unsuitable materials.

3.2.3.3 Sheeting that is used in conjunction with a tremie seal cofferdam shall be left in place. The Designer shall design both the tremie seal and the cofferdam. The Designer shall indicate the depth and thickness for the tremie seal, and the horizontal and vertical limits of the steel sheeting for the cofferdam. In addition the Designer shall indicate on the Construction Drawings the elevation at which the cofferdam should be flooded in the event that the water rises outside the cofferdam to cause excess hydrostatic pressure.

3.2.3.4 Sheeting that protrudes into the soil that supports the bridge structure shall be left in place.

Supporting soil shall be defined as all soil directly below the footing contained within a series of planes that originate at the perimeter of the bottom of the footing and project down and away from the footing at an angle of 45° from the horizontal. Sheeting placed at the heels of abutment and walls may be exempted at the discretion of the Director of Bridges and Structures.

3.2.3.5 All sheeting required for the support of railroads shall be designed as permanent sheeting by the Designer.

3.2.3.6 Whether sheeting is indicated on the Construction Drawings or not, the Contractor shall be informed by the Special Provisions that any sheeting driven into the supporting soil below the bridge structure, as defined by Paragraph 3.2.3.4, shall be cut off and left in place and no additional payment will be made for this sheeting.

3.2.4 Drilled Shafts

3.2.4.1 Drilled shafts shall be considered where cost and constructability may be favorable compared to spread footing or pile supported structures. Anticipated advantages are the reduction of the quantities and cost of excavation, dewatering, and sheeting. Additionally, the use of drilled shafts may be beneficial in working within critical horizontal restrictions, or in limiting the environmental impact.

3.2.4.2 Design. Drilled shafts shall be designed in accordance with the requirements of the *AASHTO LRFD Bridge Design Specifications* and the following:

1. The Designer shall consider the intended method of construction (temporary or permanent casing, slurry drilling, etc.) and the resulting impact on the stiffness and resistance of the shaft.

2. If the pier column is an integral extension of the drilled shaft and the design assumes a constant diameter throughout, it is imperative that either the construction of the shaft be consistent with this assumption or that the revised details be fully evaluated prior to construction. Tolerances between the plumbness of the shaft, shaft location, and pier cap dimensions shall be considered relative to the types of subsurface and site conditions encountered for these types of shafts.

3. The lateral resistance and lateral load – deflection behavior of the drilled shaft shall be determined using soil-pile interaction computer solutions or other acceptable methods.

4. When a drilled shaft is constructed with a permanent casing, the skin friction along the permanently cased portion of the shaft should be neglected.

5. Continuous steel reinforcing shall be maintained where possible throughout the length of the shaft. Splices should be avoided in the longitudinal steel where practical. If splices are unavoidable, the splices between adjacent bars shall be staggered and they shall be made with mechanical reinforcing bar splicers. Splices in the spiral confinement reinforcement shall, where necessary, be made using mechanical reinforcing bar splicers. Detailing for seismic requirements prohibits splices in those regions that may develop plastic hinges. The Designer shall ensure that cover requirements are met over the mechanical reinforcing bar splicers.

6. The maximum coarse aggregate size for the shaft concrete and the spacing of reinforcement shall be coordinated to ensure that the clearance between reinforcing bars is at least 10 times the maximum coarse aggregate size. Concrete mix design and workability shall be consistent for tremie or pump placement. In particular, the concrete slump should be 8 inches ± 1 inch for tremie or slurry construction and 7 inches ± 1 inch for all other conditions.

7. When checking the spiral size and spacing using the formula:

$$\rho_s \geq 0.45\left(\frac{A_g}{A_c}-1\right)\frac{f'_c}{f_{yh}}$$

The A_g value used in the formula shall assume 3" of concrete cover is provided over the spiral instead of the 5" minimum actual cover provided. This 2" of additional cover provided is not required for structural confinement of the shaft core, it is provided to improve concrete flow during placement. The ratio of clear spacing to maximum aggregate size for the spiral shall be a minimum of 10, thus allowing for better concrete consolidation during placement with far less likelihood of void inclusions.

3.2.4.3 Special design and detailing is required where the drilled shaft is an extension of a pier column. The drilled shaft reinforcement shall be continuous with that of the pier column. The spiral reinforcing shall extend from the base of the shaft into the pier cap as required by the AASHTO seismic requirements.

3.2.5 Gravel Borrow for Bridge Foundations

3.2.5.1 Gravel Borrow For Bridge Foundation (Item 151.1) shall be assumed to have a soil friction angle (Φ) of 37˚. The nominal bearing resistance shall be estimated using accepted soil mechanics theories based upon the assumed soil friction angle (Φ) of 37˚ for the Gravel Borrow For Bridge Foundations, the measured soil parameters of the material underlying the Gravel Borrow For Bridge Foundations, the effect produced by load inclination, and the highest anticipated position of the groundwater level at the footing location.

For loads eccentric to the footing centroid, a reduced effective bearing area will be assumed in accordance with Article 10.6.1.3 of the *AASHTO LRFD Bridge Design Specifications*. The effective area shall be assumed to be concentrically loaded for the purpose of calculating the factored bearing pressure. The structural design of the eccentrically loaded footing will assume a triangular or trapezoidal contact pressure distribution based upon factored loads. The average factored bearing pressure shall be compared to the factored bearing resistance to determine whether the bearing resistance is adequate.

Gravel for this item will be permitted up to a height of 20 feet under the footings and shall be compacted in accordance with the MassHighway *Standard Specifications for Highways and Bridges*. In special cases, this depth may be increased. A study should be made in each case to show that its use will result in a more economical structure. Its use is not authorized for river structures or for placement under water.

3.2.6 Crushed Stone for Bridge Foundations

In general, this material is used where water conditions prevent the use of **GRAVEL BORROW FOR BRIDGE FOUNDATIONS**. The pressure on the granular soil below the crushed stone will govern the Bearing Resistance of the crushed stone. De-watering the area and using **GRAVEL BORROW FOR BRIDGE FOUNDATIONS** compacted in the dry, or not de-watering and using **CRUSHED STONE FOR BRIDGE FOUNDATIONS** shall be investigated for feasibility and economy.

3.2.7 Foundations on Ledge

3.2.7.1 If the top of ledge is comparatively level and is located at a shallow depth from the proposed bottom of footing, then, for economy, consideration shall be given to lowering the footing so that it will be founded entirely on ledge.

3.2.7.2 If a footing will be located partly on ledge and partly on satisfactory granular material, the ledge should be excavated to a depth of about 18" below the bottom of footing and backfilled with **GRAVEL BORROW FOR BRIDGE FOUNDATION**. Consideration should also be given to excavating the material above the ledge and backfilling with 2500 PSI, 1½ IN, 425 Cement Concrete to the bottom of proposed footing elevation. In either case, the footing must be founded on the same material throughout its bearing area.

3.2.7.3 All weathered and/or deteriorated ledge shall be removed so that the entire footing will rest on sound rock, unless otherwise designed and approved.

3.2.8 Pre-loaded Areas

3.2.8.1 Pre-loading or pre-loading with surcharge may be required to consolidate compressible soils and minimize long-term settlements under load. If unsuitable material is encountered, it shall be excavated prior to placing the embankment.

3.2.8.2 If the water table is higher than the bottom of excavation of unsuitable material, crushed stone shall be used in the embankment up to the proposed elevation of the bottom of footing, followed by the placement of gravel borrow for the embankment. Both of these materials shall be placed during embankment construction. The amount of anticipated settlement should be accounted for in the specified top elevation of the crushed stone beneath the proposed bottom of footing. The effect of the anticipated settlement shall be considered in the design of the superstructure.

3.3 SUBSTRUCTURE DESIGN

3.3.1 General

3.3.1.1 Footings shall be proportioned in accordance with the standard details shown in Part II of this Bridge Manual and shall be designed for factored loads so that the resultant center of pressure shall be located within the middle half of the footing dimension in any direction when it is founded on suitable soil material. The resultant center of pressure shall be located within the middle ¾ of the footing dimension in any direction when it is founded on suitable rock. The passive resistance of the earth in front of a wall shall be neglected in determining wall stability. The stability of the wall during all stages of construction shall be investigated. Reinforced concrete keyways tied into footings shall not be used to aid in the resistance to sliding due to the questionable resistance provided by the subsoil in contact with the keyway that is likely to be disturbed during construction.

3.3.1.2 Factored bearing pressures under the footings shall be calculated in accordance with the *AASHTO LRFD Bridge Design Specifications*. The weight of the earth in front of a wall shall be considered in computing soil pressure.

3.3.1.3 The non-seismic longitudinal forces for abutment design shall include:

1. The live load braking forces specified in the *AASHTO LRFD Bridge Design Specifications*.
2. The horizontal shear force developed by the bearings through either shear deformation (elastomeric bearings) or friction (sliding plate bearings).

3.3.1.4 Piers and abutments of a bridge over salt water will normally be protected with granite within the tidal range. The granite blocks will be caulked with polysulfide caulking. Piers and abutments over fresh water do not require this protection unless the normal flow of water and seasonal water level variations are anticipated to be large.

3.3.1.5 At a minimum, the reinforcing bars used in the following elements of the substructure require protection and, so, shall be epoxy coated: backwalls, beam seats, pier caps, and the High Performance concrete pour section of U-wingwalls. Also, when abutment faces, piers, wingwall faces, and retaining wall faces are within 30 feet of a traveled way, the reinforcing bars adjacent to those faces shall be epoxy coated. If all of the reinforcing bars in the given concrete pour are to be coated, and the coated bars will never come into contact with or are to be tied to non-coated bars, then galvanized bars may be used instead of epoxy coated bars. In these situations, the Construction Drawings shall designate these bars as COATED BARS, without specifying the coating type.

3.3.2 Walls: Abutment and Wingwall

3.3.2.1 Gravity walls. Walls of this type are used where low walls are required, generally up to 14’ in height. When the wall is founded on sound ledge the footing is omitted. The top of ledge shall be roughened as necessary to provide resistance against sliding. A shear key may be provided, if necessary.

3.3.2.2 Cantilever walls. Generally, this wall type is used in the intermediate height range (14’ to 30’) applications between gravity and counterfort walls. In those situations where a wall starts in the height range prescribed for cantilevered walls but tapers down into the height range prescribed for gravity walls, the cantilevered wall type will be used throughout instead of changing to a gravity type in mid-wall. Footings for wall segments of variable height shall be designed using a wall height equal to the low end wall height plus 75% of the difference in height between the low end and high end.

When designing the reinforcement in the toe of the footing, the weight of the soil above the toe shall not be used to offset the force of the upward soil pressure. The reinforcement in the heel of the footing shall be designed to carry the entire dead load of all materials above the heel, including the dead load of the heel. The effect of the upward soil pressure or pile reaction will not be used to offset this design load.

3.3.3 Counterfort Walls

A counterfort wall design shall be considered for retaining structures and abutments higher than 30 feet. However, the economics and constructability of a counterfort wall versus a similar height cantilevered wall with a thicker stem shall be investigated.

3.3.4 Piers

3.3.4.1 Piers for most structures are typically of reinforced concrete construction. Piers for grade separation structures are typically open type bents with circular columns. Piers for structures over railroads can be either a solid stem type or an open type bent with a crash wall conforming to AREMA requirements for pier protection, depending on an economic analysis. Piers for structures over water are typically a solid stem type. Piers for trestle type structures are typically pile bents.

3.3.4.2 For open type bents, the bottom of the pier cap is normally level. However, if the height of one end of the pier cap exceeds 1.5 times the height of the cap at the other end, then the bottom of the pier cap may be sloped to stay within these limits.

3.3.4.3 The columns shall be assumed as fully fixed at the footing, and the pier designed as a rigid frame above the footing. Continuous footings founded on granular material or on piles shall be designed as a continuous beam. Individual footings shall be used on ledge.

3.3.4.4 Live loads shall be positioned on the bridge deck so as to produce maximum stresses in the pier. To determine the maximum live load reactions on a pier, the live load will be as prescribed in *AASHTO LRFD Bridge Design Specifications* Article 3.6.1.3.1. The multiple presence factors and the dynamic load allowance of *AASHTO LRFD Bridge Design Specifications* Articles 3.6.1.1.2 and 3.6.2.1, respectively, shall apply. Stringer reactions resulting from dead and live loads (plus dynamic load allowance) shall be considered as concentrated loads on the pier cap.

3.3.5 Culverts

3.3.5.1 Normally, sidesway of the structure shall be ignored in the design of culverts and other rigid frame structures provided that the fill placed around the structure shall be deposited on both sides to approximately the same elevations at the same time. No hydrostatic effect on the culvert shall be considered in its design.

3.3.5.2 Fillets for box culverts shown in Part II of this Bridge Manual are not to be taken into consideration in the design of the section. However, for culverts where fillets are larger than 12”, the fillets shall be considered as being haunches and the design shall include their effect on the section.

3.3.5.3 Moments, and the moment diagram, shall be calculated using member lengths based on the distances to the geometric centers of the members in accordance with the *AASHTO LRFD Bridge Design Specifications* Article 4.6.1.2.6. Where critical sections are at the face of supports, the design moment shall be taken as that moment which, according to the moment diagram, occurs at the critical section location and not at the geometric center.

3.3.5.4 The earth pressure shall be based on a minimum equivalent fluid pressure of 0.030 kcf and on a maximum equivalent fluid pressure of 0.060 kcf.

3.3.5.5 The dynamic load allowance (IM) for culverts and other buried structures shall account for the depth of fill over the culvert. The dynamic load allowance shall be considered for fill heights of up to 8'-0".

3.3.5.6 The approximate strip method shall be used for the design with the 1'-0" wide design strip oriented parallel to the direction of traffic (longitudinal direction). The design live loads shall include the HL-93 truck, lane and tandem loads. For both the strength and service limit states, consider the following three load cases:

1. Maximum vertical load on the roof and maximum outward load on the walls: DCmax + EVmax + EHmin+(LL+IM)max + WAmax

2. Minimum vertical load on the roof and maximum inward load on the walls: DCmin + EVmin + EHmax

3. Maximum vertical load on the roof and maximum inward load on the walls: DCmax + EVmax + EHmax + (LL + IM)max

3.3.5.7 The vertical loads applied to the culvert (earth, water, live load) are assumed to be carried with uniformly distributed reactions applied to the bottom of the bottom slab. Box culverts supported on stiff or rigid subgrades (rock) require additional investigation.

3.4 SEISMIC GUIDELINES

3.4.1 General

3.4.1.1 The 1000 year return period (7 percent probability of exceedance in 75 years) horizontal spectral response map of the United States of 1.0 second period indicates that the acceleration coefficients for Massachusetts vary between approximately 2.7 and 4.1 percent of g for Site Class B. As a result, all of Massachusetts is in Seismic Zone 1 for Site Class A through E and no seismic analysis is required unless the bridge is deemed critical.

3.4.2 Analysis

3.4.2.1 A site-specific geotechnical evaluation and dynamic site response analysis shall be performed for all sites in Site Class F.

3.4.2.2 Connections. The *AASHTO LRFD Bridge Design Specifications* require that Seismic Zone 1 structures satisfy detailing requirements. These requirements pertain to the length of bearing seats supporting superstructure elements and the capacity of a force path for superstructure dead loads to be transferred to substructure elements. Connections are defined as those members that transfer shear or shear and axial loads between one component and another. Generally, they include bearing devices and shear keys, but do not include members that transfer bending moments.

3.4.2.3 Retaining Walls. The Mononobe - Okabe analysis method of estimating equivalent static forces due to horizontal seismic accelerations shall be used in the design of gravity, semi-gravity (including cantilever), and non-gravity walls and wingwalls. The seismic design forces shall also include wall inertia. For flexible cantilevered walls the forces resulting from wall inertia may be ignored.

3.5 SUPERSTRUCTURE DESIGN REQUIREMENTS

3.5.1 Composite Design

3.5.1.1 All stringer bridges will be designed compositely with the deck. All composite beams shall be designed for composite action without the use of temporary intermediate supports during the placing and curing of the deck concrete. Composite section properties shall be calculated based on the short-term modular ratio or long-term modular ratio formula:

$$n = \frac{E_B}{E_C}$$

where n is the short-term modular ratio, E_B is the Modulus of Elasticity of the beam material, either steel or precast concrete, and E_C is the Modulus of Elasticity of the cast-in-place deck concrete.

3.5.1.2 When calculating any composite section properties, the depth of the standard haunch as detailed in Part II of this Bridge Manual will conservatively be assumed to be zero. This is due to the fact that actual depth of the haunch varies depending on the amount of over-cambering in the beam.

3.5.1.3 For steel beams, when calculating stresses due to dead loads acting on the composite section, the effect of creep will be considered by using the long-term modular ratio as specified in *AASHTO LRFD Bridge Design Specifications* Article 6.10.1.1.1b. For precast prestressed beams, the same composite properties will be used for calculating both superimposed dead load and live load stresses.

3.5.1.4 Continuous steel structures will be designed compositely through the negative moment region by providing negative moment reinforcing steel in accordance with *AASHTO LRFD Bridge Design Specifications* Article 5.14.1.4.8 . Moments will be distributed along the beam using the gross deck concrete section properties in the negative moment region. The stresses in the negative moment region will be calculated using section properties based on the steel section and reinforcing steel, i.e., cracked section.

3.5.1.5 Stud shear connectors shall be used for composite steel beams. The pitch of the studs need not be made in multiples of the spacing of transverse steel reinforcement in the deck slab. The pitch of the stud shear connectors will be designed based on fatigue requirements. The total number of studs provided must be adequate for the strength limit state requirements in accordance with *AASHTO LRFD Bridge Design Specifications* Article 6.10.10.4.1.

3.5.1.6 Precast concrete beams designed compositely shall use dowels cast into the beams to transfer the horizontal shear between the beam and deck slab. These dowels shall be detailed as shown in Part II of this Bridge Manual and will be designed in accordance with *AASHTO LRFD Bridge Design Specifications* requirements for shear-friction for composite flexural members (Article 5.8.4.2).

3.5.2 Deck Slabs

3.5.2.1 Steel reinforcement and slab thickness shall be determined by using the design tables in Part II of this Bridge Manual. If the beam spacing falls outside of the table limits, the deck slab reinforcement shall be designed using the traditional approximate method of analysis identified in *AASHTO LRFD Bridge Design Specifications* Article 9.7.3, not the empirical deck design method shown in Article 9.7.2. The deck shall be treated as a continuous beam. Moments as provided in *AASHTO LRFD Bridge Design Specifications* Table A4-1 are to be applied at the design sections shown in Figure 9.2.1. All deck reinforcement shall be coated (either epoxy coated or galvanized).

3.5.2.2 Deck slabs with or without a hot mix asphalt wearing surface shall be constructed using high performance cement concrete. Decks to be constructed without membrane waterproofing and hot mix asphalt wearing surface shall be constructed in one single full-depth placement. The top ¾” of such placements shall be considered sacrificial and not contributing to the section properties. Bridges where all portions of the deck have profile grades of 4% or less shall be constructed with membrane waterproofing and a hot mix asphalt wearing surface.

3.5.2.3 Stay-in-place (SIP) forms shall be used for deck construction over rivers, active railroad tracks and roadways that will remain open to the public during construction. SIP forms will be used as detailed in Part II of this Bridge Manual. Removable forms shall be used for the forming of end diaphragms, bays with longitudinal construction joints, and overhanging portions of the deck slab.

3.5.2.4 Top-of-form elevations must be provided in order to set the forms such that, after all dead loads have been applied, the top of roadway will be at the correct profile elevation. Top-of-form elevations will be calculated as follows:

1. Calculate the theoretical top of roadway elevation directly over the beam at the required points along its span as specified in Part II of this Bridge Manual.

2. From this elevation, subtract the thickness of the wearing surface and deck to obtain the in-place bottom of deck elevation. Include ¼” for the thickness of the membrane, if used.

3. To the in-place bottom of deck elevation, add the total dead load deflection of the beam, excluding the deflection due to the beam's self-weight, calculated for the particular point along the beam under consideration. The result is the top-of-form elevation.

3.5.3 Distribution of Loads on Stringer Bridges

3.5.3.1 Deck slab dead load shall be distributed to each beam directly below based on tributary area. Wearing surface and overlay superimposed dead loads shall be distributed equally to all beams.

3.5.3.2 When designing interior beams, all superimposed dead loads shall be evenly distributed among all beams.

3.5.3.3 When designing exterior beams, three load cases shall be used to determine the distribution of sidewalk/safety curb/barrier superimposed dead load, vehicular live load, and sidewalk live load to exterior beams:

1. Apply 60% of the sidewalk, safety curb, and barrier superimposed dead load and the entire HL93 design load with a live load distribution factor determined using the lever rule and with the HL-93 truck outer wheel line applied 2'-0" from the curb line and include pedestrian live load applied to the sidewalk.
2. Apply equal distribution of all forms of superimposed dead load and pedestrian live load, and the live load distribution factor shall be determined using the rigid superstructure (pile analogy).
3. Apply equal distribution of all forms of superimposed dead load and the live load distribution factor shall be determined using the lever rule with the HL-93 truck without lane load on the sidewalk with the outer wheel line 12” from the face of the railing/barrier and no pedestrian live load. Depending on the width of the sidewalk, use one or both wheel lines.

Deflection limits shall not apply to Case 3. Case 3 will be checked using the Strength II limit state.

3.5.3.4 In the case of an excessive overhang, all superimposed loads on the overhang shall be distributed to the fascia stringer assuming that the deck is hinged at the first interior stringer. The loads on the first interior girder shall not be reduced to account for the additional load on the exterior girder.

3.5.3.5 All stringers under a raised median shall be designed for full dead load and live load plus dynamic load allowance as for an interior beam. If there is a longitudinal joint in the median, then the beams adjacent to this joint shall be designed as exterior beams.

3.5.4 Utilities on Structures

3.5.4.1 Typical details for utility supports for the various different types of superstructures are shown in the Part II of this Bridge Manual. At the initiation of the project, the Designer shall investigate and identify all utilities (existing or proposed) carried on the structure or crossing its footprint. The Designer shall submit to the MassHighway Utility/Railroad Engineer letter(s) of transmittal that the said utility investigation was performed and resolution of all issues was achieved. All existing and proposed utilities shall be shown on the Construction Drawings. Railroads may have additional utility placement requirements that the Designer shall incorporate in the design.

3.5.4.2 All utilities on stringer bridges shall be carried in the utility bay or bays of the superstructure and shall be accessible from below. Utilities shall not be embedded within a deck slab or sidewalk slab because their presence there could inhibit future maintenance activities. Utilities on adjacent deck and box beam bridges shall be carried and designed for in accordance with the guidelines for these structures in Subsection 3.8.2.

3.5.4.3 Utilities are normally installed before the deck is placed since it facilitates their installation and alignment both horizontally and vertically. Therefore, the non-composite section shall carry the total dead load of utilities.

3.5.4.4 For stringer bridges, the dead load of utilities is assumed to be carried by the two stringers comprising the utility bay. For structures carrying local roads with no existing utilities in the roadway, a utility bay shall be provided and shall be designed for a future load of 250 pounds/foot (125 pounds per foot per beam). Provisions shall be made for fiber optic conduit and highway lighting conduit on bridges that carry interstate highways.

3.5.4.5 When the utility is to be installed for a municipality, such as a water pipe, the complete support system shall be included as part of the contract. Other utilities not installed by the Contractor, such as telephone ducts and gas mains, shall be indicated on the Construction Drawings as to their location in the utility bay or other designated area with the notation: TO BE INSTALLED BY OTHERS. The designer is cautioned to provide utility bays of sufficient size to accommodate the utility installation.

3.5.5 Deflection and Camber

3.5.5.1 The ratio of live load plus dynamic load allowance deflection to span length will not be greater than 1/1000 for all bridges with sidewalks. For bridges with no sidewalks, this ratio shall preferably not be greater than 1/1000. However, under no circumstances shall it be greater than 1/800. Deflections of individual beams shall be computed by multiplying the number of lanes by the multiple presence factor and dividing by the total number of beams.

3.5.5.2 Camber for steel beams shall be calculated and specified on the Construction Drawings as shown in Part II of this Bridge Manual.

3.5.5.3 Camber and profile vertical curvature will be considered when calculating bridge seat elevations for prestressed concrete beam bridges so that the top of roadway will match the design roadway profile. Cambers will not be shown on the Construction Drawings nor will they be used when calculating under-bridge clearances. The prestressing force produces moments in prestressed concrete beams that result in upward deflections. These deflections are partially offset by the downward deflections due to the beam dead weight, resulting in a net upward deflection of the beam at erection. Observation of actual bridges indicates that once the slab is placed, the prestressed concrete beams tend to behave as if they were locked in position. The net upward camber of these beams shall be calculated using the PCI "at erection" multipliers applied to the deflections from prestressing and self-weight. The bridge seat elevations shall be determined using the methodology contained in Part II of this Bridge Manual.

3.5.6 Elastomeric Bridge Bearing Assemblies

3.5.6.1 General. Elastomeric bearing assemblies shall be used for both precast concrete and steel beam bridges and shall be designed and fabricated in accordance with the requirements of Section 14 of the *AASHTO LRFD Bridge Design Specifications* and Section 18 of the *AASHTO LRFD Bridge Construction Specifications*, and as modified by this section.

Steel reinforced elastomeric bearing assemblies shall consist of alternate layers of steel laminates and elastomer bonded together and, either a beveled or flat sole plate for steel beam bridges, or internal load plate for prestressed concrete beam bridges if required. The minimum thickness of the top and bottom cover layers of elastomer shall be ¼". These top and bottom cover layers shall be no thicker than 70% of the individual internal layers. Steel laminates shall have a minimum thickness of 11 gage. Holes in either the elastomer or the steel laminates are not allowed.

3.5.6.2 Elastomer Material Properties. The nominal hardness of elastomer shall be either 50 or 60 durometer for reinforced bearings and 60 for plain (un-reinforced) pads. The shear modulus of the elastomer at 73°F shall be used as the basis for design. Unless otherwise required by design, bearings shall be of low temperature, Grade 3, 60-durometer elastomer with the minimum and maximum shear modulus of 130 PSI and 200 PSI, respectively. The shear modulus shall be taken as that value which is most conservative for each part of the design.

3.5.6.3 Reinforcement. Steel laminates in steel reinforced elastomeric bearings shall conform to ASTM A 1011 Grade 36 or higher. Tapered internal load plates shall conform to AASHTO M 270 Grade 36 or higher.

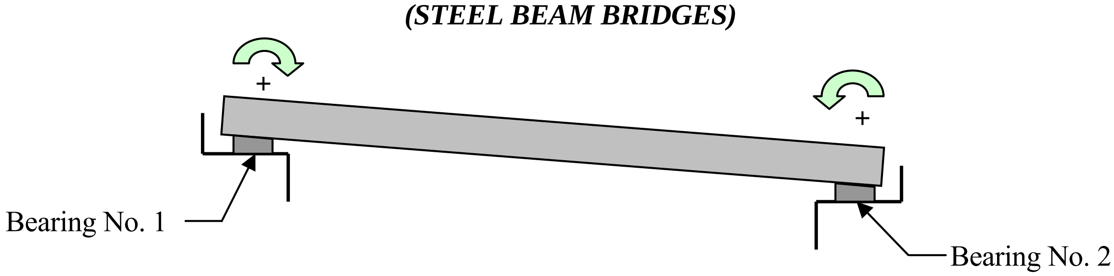
3.5.6.4 Design. All elastomeric bearing assemblies shall be designed for Service I Limit State in accordance with design Method A, as defined in the *AASHTO LRFD Bridge Design Specifications*, Article 14.7.6. Dynamic load allowance shall not be included.

The design rotation of bearing assemblies shall account for dead and live load rotations, rotation due to profile grade, and an additional rotation of 0.005 radians to account for uncertainties and construction tolerances. Careful consideration shall be given to the effect of beveled sole plates (steel beam bridges) or internal beveled load plates (prestressed concrete beam bridges) and girder camber. For prestressed concrete beams, the net upward camber and associated end of beam rotations shall be calculated using the PCI “at erection” multipliers.

Sole plates (steel beam bridges) or internal load plates (prestressed concrete beam bridges) should be beveled to account for the rotations due to profile grade. Refer to Paragraph 3.5.6.5 of this section for other bevel plates requirements. Ideally, properly beveled sole plates or internal load plates provide a level surface after the application of total dead load and after “at erection” camber (prestressed concrete beam bridges) has developed. If beveled sole plates or internal load plates are used, the design rotation for the elastomer due to profile grade should be neglected. When the required bevel of sole plates (steel beam bridges) or internal load plates (prestressed concrete beam bridges) is less than 1%, the required bevel (in radians) shall be included in the bearing design rotation and a flat sole plate (steel beam bridges) or a flat internal load plates (prestressed concrete beam bridges) shall be used.

If the girder is cambered for dead loads (steel beam bridges), the dead load design rotation of the elastomer should be neglected. If the girder is not cambered the Designer shall account for the dead load rotation. In the case where a beveled internal load plate is used (prestressed concrete beam bridges), it shall be designed to accommodate the rotation due to profile grade, the dead load rotation and the beam camber at erection. The following tables demonstrate the effects of girder cambering and a beveled sole plate (steel beam bridges) or internal beveled load plates (prestressed concrete beam bridges) on the rotation design of elastomeric bearings of a simple bridge (please note that the numbers shown are not specific to any bridge):

SAMPLE TABULATION OF BEARING ROTATIONS FOR ELASTOMERIC BEARINGS (STEEL BEAM BRIDGES)



GIRDER WITHOUT BEVELED SOLE PLATES AND WITHOUT GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	+ 0.014 RAD	+ 0.014 RAD
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.035 RAD**	**+ 0.030 RAD**

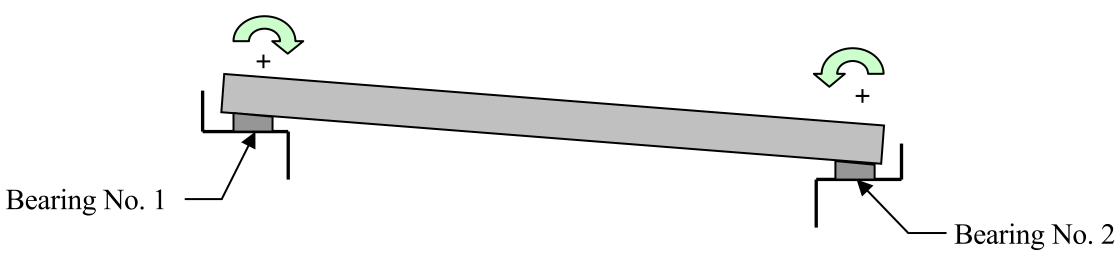
GIRDER WITHOUT BEVELED SOLE PLATES AND WITH GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	NONE (GIRDER CAMBERED)	NONE (GIRDER CAMBERED)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.021 RAD**	**+ 0.011 RAD**

GIRDER WITH BEVELED SOLE PLATES AND WITH GIRDER CAMBER

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	NONE (BEVELED SOLE PLATE)	NONE (BEVELED SOLE PLATE)
DEAD LOAD	NONE (GIRDER CAMBERED)	NONE (GIRDER CAMBERED)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.016 RAD**	**+ 0.016 RAD**

SAMPLE TABULATION OF BEARING ROTATIONS FOR ELASTOMERIC BEARINGS (PRESTRESSED CONCRETE BEAM BRIDGES)



GIRDER WITHOUT INTERNAL BEVELED LOAD PLATES

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	+ 0.005 RAD	- 0.005 RAD
DEAD LOAD	+ 0.014 RAD	+ 0.014 RAD
CAMBER (AT ERECTION)	- 0.010 RAD	- 0.010 RAD
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.025 RAD**	**+ 0.015 RAD**

GIRDER WITH INTERNAL BEVELED LOAD PLATES

	BEARING NO. 1	BEARING NO. 2
PROFILE GRADE	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
DEAD LOAD	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
CAMBER (AT ERECTION)	NONE (BEVELED LOAD PLATE)	NONE (BEVELED LOAD PLATE)
LIVE LOAD	+ 0.011 RAD	+ 0.011 RAD
UNCERT. & TOLERANCES	+ 0.005 RAD	+ 0.005 RAD
TOTAL DESIGN ROTATION	**+ 0.016 RAD**	**+ 0.016 RAD**

The live load reactions and rotations for interior beam bearings shall be determined using the standard distribution factors contained in the *AASHTO LRFD Bridge Design Specifications.* When designing a bearing for an exterior beam, the provisions of Article 3.5.3.3 shall be used to determine superimposed dead load, vehicular live load, and pedestrian live load combinations.

For a simple span bridge the maximum rotation of the beam end can be calculated using normal stiffness methods. However, many beam design computer programs do not calculate the beam end rotation. An approximate beam end rotation can be determined based on maximum midspan deflection (please note that this is an exact solution only in the case when the beam is prismatic and the beam deflection is parabolic):

- Calculate the maximum live load deflection at midspan Δ;
- Approximate end rotation in radians is equal to $(4*\Delta)$/Span Length.

When determining the deflections and end rotations of continuous span bridges, the composite section properties shall be used for all segments of all girders. This includes the negative moment regions, where the transformed concrete slab should be used in place of the cracked section (beam and slab reinforcement).

The bearings should also be designed for all longitudinal and lateral movements. Longitudinal translation due to dead load girder rotation about the neutral axis may need to be accounted for on beams with large rotations or for deep girders. This translation should be added to the design longitudinal movement. The *AASHTO LRFD Bridge Design Specifications* outline requirements for calculation of thermal movement. The following are general guidelines that are intended to supplement the AASHTO specifications:

STANDARD BRIDGES:

In this context a standard bridge is defined as a bridge that has the following geometric conditions:

1. Straight beams;
2. Skew angle $\leq$ 30 degrees;
3. Span length to width ratio greater than 2;
4. The bridge has 3 or less travel lanes.

The major contributor to thermal movements is the bridge deck. This portion of the bridge structure is exposed to the highest temperature extremes and is a continuous flat plate. A flat plate will expand and contract in two directions, and will not be significantly affected by other components of the superstructure below, i.e. girders, diaphragms and cross frames. For bridges that meet the general criteria listed above, the calculations for thermal movement can be based on the assumption that the bridge expands along its major axis, which is along the span length.

NON-STANDARD BRIDGES:

The treatment of non-standard bridges requires careful design and planning. A refined analysis may be required for non-standard bridges in order to determine the thermal movements, beam rotations (transverse and longitudinal), as well as the structural behavior of the system. The stiffness of substructure elements may also have an effect on the thermal movement at bearings. The following are general basic guidelines outlining the thermal movement behavior for non-standard bridges:

- Curved Girder Bridges:

It has been well documented that curved girder bridges do not expand and contract along the girder lines. The most often used approach is to design bearing devices to expand along a chord that runs from the point of zero movement (usually a fixed substructure element) to the bearing element under consideration.

- Large Skew Bridges:

The major axis of thermal movement on a highly skewed bridge is along the diagonal connecting the acute corners. The alignment of bearings and keeper assemblies should be parallel to this axis. The design of the bearings should also be based on thermal movement along this line.

- Bridges with small span-to-width ratios:

Bridges with widths that approach and sometimes exceed their lengths are subject to unusual thermal movements. A square bridge will expand equally in both directions, and bridges that are wider than they are long will expand more in the transverse direction than in the longitudinal direction. The design of bearing devices and keeper assemblies should take into account this movement.

- Wide bridges:

Bridges that are wider than three lanes will experience transverse thermal movements that can become excessive. Care should be taken along lines of bearings as to not to guide or fix all bearings along the line. Guides and keeper assemblies should be limited to the interior portions of the bridge that do not experience large transverse movements.

The Designer should specify on the Construction Drawings a range of temperatures for setting the bearings based on their design. Provisions should also be included for jacking the structure in order to reset the bearings if this range cannot be met during construction. A recommended temperature range is the average ambient temperature range for the bridge location plus or minus 10 °F. Larger values can be specified provided that the bearing is designed for the additional movement.

In addition to the above design requirements a few other design criteria shall be considered. They are as follows:

Elastomeric bearings shall be designed so that uplift does not occur under any combination of loads and corresponding rotation.

For continuous span bridges, bearings will see both minimum and maximum loads, depending on the location of the truck along the span of the bridge. In these situations, a bearing shall be designed and detailed for the maximum loading combination. The minimum loading combination shall be ignored in the bearing design.

The potential for slippage of elastomeric bearings on both steel and concrete surfaces shall be checked. If the design shear force due to bearing deformation exceeds one-fifth of the minimum vertical force, the bearing shall be secured against horizontal movement by providing a positive restraint. See Part II of this Bridge Manual for details.

Where anchor bolts are used to resist lateral forces, they shall be located outside the bearing pads and shall be designed for bending as well as shear. The sole plates shall also be checked for shear and bending.

3.5.6.5 Detailing. Steel reinforced elastomeric bearings shall be detailed on the Construction Drawings in accordance with Part II of this Bridge Manual. The thickness of steel laminates shall be specified in gage, while the total thickness of the bearing pad shall be shown in inches in ¼” increments.

Tapered layers of elastomer in reinforced bearings are not permitted. If tapering of the bearing is necessary, it shall be accomplished as follows:

- For steel beams, provide an external tapered steel sole plate welded to the bottom flange.
- For concrete beams, use a tapered internal steel load plate and provide a cover layer of elastomer with constant thickness.

The minimum longitudinal slope of the bottom flange beyond which tapering of the bearing is required shall be equal to 1%. Refer to Article 3.5.6.4 of this section regarding situations with less than 1% bevels.

Standard bridge bearing details are shown in Part II of this Bridge Manual. Bearing types not shown must receive prior approval from the Director of Bridges and Structures before being used in the design of a bridge project.

3.5.6.6 Application. For adjacent concrete box and deck beam bridges with a span length of 50 feet or less, use rectangular plain (un-reinforced) elastomeric pads, 1” thick by 5” wide, detailed and placed as shown in Part II of this Bridge Manual.

For all other applications, circular steel reinforced elastomeric bearings shall be used. As an exception, in case of large rotations, primarily about one axis on narrow bridges with skews of 10° or less, the use of rectangular steel reinforced elastomeric bearings arranged to facilitate rotation about the weak axis may be considered. The use of and detailing of rectangular steel reinforced elastomeric bearings must receive prior approval of the Director of Bridges and Structures.

3.5.6.7 Unfilled and lubricated PTFE (polytetrafluorethylene) sliding bearings shall only be used when a bearing with a low coefficient of friction is needed to minimize horizontal forces, i.e. thermal or seismic, on the substructure. Section 14, Article 14.7.2, of the *AASHTO LRFD Bridge Design Specifications* shall be used to design this type of bearing. They shall be detailed on the Construction Drawings as shown in Part II of this Bridge Manual.

3.5.6.8 Marking. Problems have occurred in the field with the installation of bearings with beveled sole plates (steel beam bridges) or beveled internal load plates (prestressed concrete beam bridges). It is not always obvious which orientation a bearing must take on a beam before the dead load rotation has been applied. This is especially true for bearings with minor bevels. To prevent errors, the Designer shall add the following notes to the Construction Drawings: “*All bearings shall be marked prior to shipping. The marks shall include the bearing location on the bridge, and a 1/32” deep direction arrow that points up-station. All marks shall be permanent and be visible after the bearing is installed.*”

3.5.7 Scuppers

3.5.7.1 An accurate determination of the need for scuppers on bridges as well as the design of deck drainage systems will be based on the latest edition of the Hydraulic Engineering Circular No. 21: *Design of Bridge Deck Drainage* (Publication No. FHWA SA-92-010).

3.5.7.2 The following may be used as a guide for estimating the need for scuppers and for locating them to properly drain the bridge superstructure:

1. On long bridges, scuppers should be placed about 350 feet on centers.

2. When the bridge is superelevated, scuppers are placed only on the low side.

3. On bridges, scuppers may be required when:

   I. The profile grade is less than 1%.
   II. The profile grade is such that ponding may occur on the roadway surface. An example would be a sag curve on the bridge.

The Designer shall investigate the highway drainage, which may include catch basins at the approaches to the structure.

3.5.7.3 When scuppers are needed, they shall generally be placed near a pier and on the upgrade side of a deck joint. Care shall be taken to ensure that scupper outlets will not result in run-off pouring or spraying onto either the superstructure beams or the piers.

3.5.7.4 Horizontal runs of drainpipes and 90° bends shall not be used. The minimum drainpipe diameter or width shall be 10”. The number of drainpipe alignment changes shall be minimized. Multiple alignment changes result in plugged scuppers that defeat the purpose of providing deck drainage. Cleanouts shall be accessible for maintenance purposes and shall be placed, in general, at every change in the alignment of the drainpipes. Typical details for scuppers and downspouts are shown in Part II of this Bridge Manual.

3.6 STEEL SUPERSTRUCTURES

3.6.1. General

Uncoated weathering steel, AASHTO M 270 Grade 50W, shall be the primary option for all steel bridges constructed by MassHighway. If the Designer determines that the use of uncoated weathering steel is not prudent for a specific location, then the Director of Bridges and Structures must concur with this decision before design begins. Hot Dip Galvanized steel may be used in locations where the use of uncoated weathering steel is considered inappropriate. Guidelines for the use of weathering steel are contained in the FHWA Technical Advisory T5140.22.

The use of uncoated weathering steel is probably not prudent in the following situations:

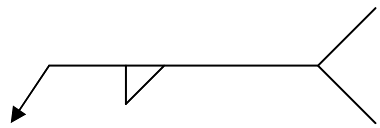
- In acidic or corrosive environments;
- In locations subject to salt water spray or fog;
- In depressed limited access highway sections (tunnel effect with less than 20 feet underclearance) where salt spray and other pollutants may be trapped;
- In low underclearance situations where the steel is 10 feet or less from normal water elevation;
- Where the steel may be continuously wet or may be buried in soil;
- In expansion joints or for stringers or other members under open steel decking;
- In bridge types where salt spray and dirt accumulation may be a concern (e.g., trusses or inclined-leg bridges).

3.6.1.2 For all steel rolled beam and plate girder bridges, the ratio of the length of span to the overall depth of the beam (depth of the beam plus thickness of the design slab) shall preferably not be greater than 21. This ratio may be exceeded where, due to clearance and profile requirements, a shallower structure is required, however under no circumstances will the span to depth ratio be greater than 25. For continuous spans, the span length used in calculating this ratio shall be taken as the distance between dead load points of contraflexure.

3.6.1.3 All welding and fabrication shall be in conformance with the AASHTO/AWS Bridge Welding Code (AASHTO/AWS D1.5). The contract drawings shall clearly show the type of weld required. The drawings shall clearly distinguish between shop and field welds. For complete joint penetration (CJP) and partial penetration (PJP) groove welds, the drawings shall show the location and extent of the welds and, for the PJP welds, the required weld size. PJP groove welds shall not be allowed on main members. These weld symbols shall be shown as follows:

E_1 and E_2 represent the effective throat size.

For fillet welds, the drawings shall show the location, size and extent of the weld as shown below.



3.6.1.4 All structural steel shall meet the requirements of AASHTO M 270. Main members only, need to conform to the applicable Charpy V-Notch (CVN) Impact Test requirements of AASHTO M 270. A Main Member is defined as any member making up the primary path that either the dead or live load takes from its point of application to its point of reaction onto the substructure, or in the case of steel bent piers, onto the foundation system. Some examples of main members are plate girders, floor beams, stringers, and diaphragms or cross frames on curved girder bridges. All other structural steel shall conform to AASHTO M 270, excluding the CVN tests. ASTM A709 is similar to AASHTO M 270 and may be used in lieu of M 270 provided that the applicable CVN requirements for main members are met.

3.6.1.5 Fracture critical members (FCM), or member components, are tension members or tension components of bending members (including those subject to the reversal of stress) whose failure may result in the collapse of the bridge. All FCM members and components shall be clearly designated on the contract drawings. All members and components designated as FCM are subject to the additional requirements of the Fracture Control Plan in the AASHTO/AWS Bridge Welding Code. Members and components not subject to tensile stress under any condition of live load are not fracture critical. In general, secondary members, such as intermediate diaphragms on straight girder bridges, connection plates of diaphragms, transverse stiffeners, and lateral bracing should not be designated as fracture critical. Fracture critical requirements do not apply to temporary stages in construction. For longitudinal box girder bridges, components of the girders which meet the FCM definition, shall be designated FCM if there are two or less box girders in the bridge cross section. For the case of a single span two box girder bridge cross section, the top flanges shall not be considered fracture critical.

3.6.1.6 The Designer shall locate and detail all field and transition splices. The location of these splices is dependent upon such factors as design criteria, available length of plates and members, ability to transport the members to the site, and erection and site limitations.

3.6.2 Cover Plates

3.6.2.1 The minimum cover plate thickness shall be ½". For economy, it is preferable to use the same thickness cover plate on all similar size beams.

3.6.2.2 Bottom cover plates will be terminated not more than 2'-0" from the centerline of bearings or centerline of integral abutments, however the Designer must still check the fatigue stress range at the termination point.

3.6.2.3 Top cover plates, when used in the negative moment regions of continuous beams, shall extend beyond the theoretical end by at least the terminal distance as defined in *AASHTO LRFD Bridge Design Specifications* Article 6.10.12.2, however, the actual termination point will be determined by fatigue considerations.

3.6.2.4 The Designer will design all cover plate to flange welds or will verify the adequacy of the minimum weld sizes.

3.6.3 Welded Plate Girders

3.6.3.1 Minimum sizes for webs, flanges and welds, as well as detailing guidelines for plate girders, are given in Part II of this Bridge Manual.

3.6.3.2 The Designer shall first consider a web design that does not require the use of transverse stiffeners. If the required web thickness is excessive, a stiffened web will be considered, however the spacing of the transverse stiffeners will be as large as possible. Cross frame connection plates can be used as stiffeners if they meet the *AASHTO LRFD Bridge Design Specifications* requirements for stiffener plates. For aesthetics, transverse stiffeners shall not be placed on the outside face of the exterior girders.

3.6.3.3 Longitudinal web stiffeners shall be avoided unless required by design to avoid excessively thick, transversely stiffened webs. Typically, longitudinal stiffeners should only be considered for very deep girders. If longitudinal stiffeners are used, they shall be placed on the opposite side of the web from the un-paired transverse stiffeners. Under no circumstances will longitudinal and transverse stiffeners be allowed to intersect. Shop splices of longitudinal web stiffeners shall be full penetration butt welds, and shall be made before attachment to the web.

3.6.3.4 Flanges shall be sized as required by design, however for shipping and erection safety, the ratio of the shipping length to the width of the flanges shall be limited to 85 where practical even at the expense of some additional steel.

3.6.3.5 The flange width may vary over the length of the girder, however constant width flanges are preferred. For longer spans where flange width transitions may be necessary, flange width transitions shall occur at the field splices. Top and bottom flanges need not be of the same width.

3.6.3.6 Due to the cost of making a full penetration welded flange splice, the number of changes to the flange thickness will be kept to a minimum. When a girder flange is butt spliced, the thinner segment shall be not less than one-half the thickness of the adjoining segment.

3.6.4 Welded Box Girders

3.6.4.1 In general, the requirements for Welded Plate Girders contained in Subsection 3.6.3 shall apply to welded box girders.

3.6.4.2 The length of top flange used for the calculation of the length to width ratios for flanges contained in Paragraph 3.6.3.4 shall be based on the distance between internal shop-installed cross frames.

3.6.4.3 In general, the provisions for transverse web stiffeners contained in Paragraph 3.6.3.2 shall apply to box girders, except that all transverse stiffeners shall be placed in the interior of the box girder.

3.6.4.4 Longitudinal bottom flange stiffeners shall be avoided unless required by design to avoid excessively thick bottom flanges. Typically, longitudinal bottom flange stiffeners should only be considered for very wide flanges.

3.6.4.5 Box girder cross sections should be of a trapezoidal shape with webs sloped equally out from the bottom flange. Preferably, the minimum web depth shall be 6'-6" to allow for inspection access and maintenance activities inside the box girders. The minimum bottom flange width shall be 4'-0". Shorter web depths and narrower bottom flange widths may be used with the written permission of the Director of Bridges and Structures. In general, box girders placed on superelevated cross sections shall be rotated so that the top and bottom flanges are parallel to the deck cross slope.

3.6.4.6 Girder spacing shall be maximized in order to reduce the number of girders required, thereby reducing the costs of fabrication, shipping, erection, and future maintenance. Spacing of the top flanges in a bridge cross section shall be approximately equal, however, the spacing may be varied in accordance with *AASHTO LRFD Bridge Design Specifications* Article 6.11.2.3.

3.6.4.7 Utilities shall not be placed inside the box girders. This restriction shall also apply to scupper drain pipes and street lighting conduit.

3.6.4.8 At least 2 access manholes shall be provided in the bottom flange of box girders. Alternatively, access shall be provided in the box girder ends at abutments. These manholes shall be located and detailed such that bridge inspectors can gain access without the need for special equipment.

The manholes shall have rounded corners fitted with a hinged cover that is lightweight and opens inward. If manhole doors are accessible from the ground without ladders or equipment, the doors shall be provided with an appropriate locking system to prevent unauthorized entry. Access holes shall be provided through all solid diaphragms. Stresses resulting from the introduction of access holes in steel members shall be investigated and kept within allowable limits.

3.6.4.9 The interior surfaces of box girders, including all structural steel components within the box girders (such as diaphragms, cross-frames, connection plates, etc.) shall be painted. The color of the interior paint shall be Gloss White (Federal Standard 595B Color Number 17925) in order to facilitate bridge inspection. In order that bridge inspectors can better orient themselves within the box girder, the distance from each box girder's West centerline of bearings, for bridges oriented generally west to east, or from the South centerline of bearings, for bridges oriented generally from south to north, shall be indicated in five (5) foot increments throughout the full length of each box girder. This indication shall consist of a vertical line ½" wide by 6" high with the measured distance given below the line in 5" high numerals painted in black color halfway up on the inside of the left girder web. This distance shall be measured without interruption from the reference end of the box girder to the other end and shall be sequential over intermediate bearings and/or field splices within each box girder but shall not be carried over between separate box girders within the same girder line.

3.6.4.10 Top flange lateral bracing shall be provided to increase the torsional stiffness of individual box girder sections during fabrication, erection, and placement of the deck slab. Permanent internal lateral bracing shall be connected to the top flanges.

Bracing members shall typically consist of equal leg angles or WT sections directly attached to the flange or attached to the flange via gusset plates. Gusset plates shall be bent to accommodate the difference in elevation between connections.

The bracing shall be designed to resist the torsional forces across the top of the section and the forces due to the placement of the deck, satisfying the stress and slenderness requirements. The lateral bracing connections to the top flange shall be designed to transfer bracing forces. Pratt type bracing should be considered because of efficiency. X-bracing patterns should be avoided for economy. Forces due to any loads applied after the deck is cured shall not be considered in the connection of the bracing members or their connections.

Allowable fatigue stress ranges shall not be exceeded where the gusset plates are connected to the flange.

3.6.4.11 The welds between the web and flanges shall be comprised of double fillet welds except where welding equipment cannot be placed within the box during fabrication. For this case, fillet welds shall consist of a single line applied on the outer side of the web. Backup bars shall be used inside the box and shall be made continuous. Testing of welded splices in backup bars shall be treated similarly to flange splices.

3.6.5 Splices and Connections

3.6.5.1 In general, all field connections shall be made with high strength bolts conforming to the requirements of AASHTO M164. All structural connections shall be designed as Slip-Critical connections. AASHTO M253 bolts shall not be used, except with written permission of the Director of Bridges and Structures.

3.6.5.2 Field splices in beams and girders, when necessary, shall generally be located as follows:

Continuous Spans: Points of Dead Load Contraflexture
Simple Span: Quarter Point

3.6.5.3 Field splices shall generally be made using 7/8” ∅ high strength bolts. For large repetitive connections, the use of larger bolts shall be evaluated if a significant number of bolts could be saved. All bolts used in a splice shall be of the same diameter. Filler plates shall not be less than ⅛” thick. Field splices of flanges and webs shall not be offset.

3.6.5.4 Transverse stiffeners will be located as specified in Part II of this Bridge Manual so that they do not coincide with the splice plates. If stiffeners in the area of a bolted splice are unavoidable, bolted steel angles shall be used as stiffeners instead of plates welded to the splice plates.

3.6.5.5 All shop welded splices shall have flange splices offset 5’-0” from the web splice. As welded flange splices are costly, a savings of approximately 1300 pounds of steel should be realized in order to justify the cost of the flange splice.

3.7 PRESTRESSED CONCRETE SUPERSTRUCTURES

3.7.1 Standard Beam Sections

3.7.1.1 Standard AASHTO - PCI precast concrete deck, box, or New England Bulb Tee (NEBT) beam sections as detailed in Part II of this Bridge Manual will be used to construct precast concrete bridge superstructures. Other sections may be used where the situation precludes the use of standard sections and prior written approval has been obtained from the Director of Bridges and Structures, or where so permitted by this Bridge Manual.

3.7.1.2 The standard beam sections were developed in conjunction with PCI New England and meet the fabrication tolerances and practices of most regional precasters. If a particular design requires that major alterations be made to the standard details, such as the placement of strands in locations other than those shown or different reinforcing details, it will be the Designer's responsibility to ensure that the design can be fabricated by a majority of area precasters.

3.7.1.3 In adjacent precast beam superstructures, the beams should be placed to follow the roadway cross slope as much as is practical. On bridges with a Utility Bay under the sidewalk, the sidewalk beam need not be placed to follow the cross slope, unless a deeper sidewalk depth is required over this beam for railing/traffic barrier attachments. For NEBT or spread box beam bridges, the beams will be placed plumb and a deck haunch deep enough to accommodate the drop of deck across the width of the beam flange will be provided.

3.7.2 Materials

3.7.2.1 Concrete Stresses. Standard designs shall be based on a concrete compressive strength (f'_c) of 6500 PSI. If required by design, the use of a concrete compressive strength of 8000 PSI (HPC) may be used with the prior approval of the Director of Bridges and Structures. In general, the concrete compressive strength at release (f'_{ci}) shall be taken as 4000 PSI. Higher concrete release strengths, up to $0.8\ f'_c$, may be used only if required by design in order to avoid going to a deeper beam. Concrete release strengths greater than $0.8\ f'_c$ shall not be used.

3.7.2.2 Prestressing Strands. Only Low Relaxation strands meeting the requirements of AASHTO M203 shall be used as required by MassHighway Specifications. Strands shall be 0.6" diameter. Strands shall not be epoxy coated. Beams shall be fabricated with the prestressing strand layout as shown on the Construction Drawings. The concrete gross section shall be used to compute section properties (the transformed area of the prestressing strands shall not be used to compute section properties).

3.7.2.3 For ease of fabrication, the use of straight, de-bonded strands is preferred over the use of draped strands in order to reduce the tensile stresses at the ends of box beams and NEBT beams. The traping of strands shall be used only if de-bonding alone, due to the limitations imposed on de-bonding in Article 3.7.2.4, will still result in unacceptably high tensile stresses. In this situation, mixing draped and de-bonded strands in a beam will be permitted. For deck beams, due to their construction, draped strands cannot be used.

3.7.2.4 Where de-bonded strands are used, no more than 25% of the total number of strands may be de-bonded and no more than 40% of the strands in each row shall be debonded. The spacing between de-bonded strands in a layer shall be 4" minimum. The outermost strands of each layer will not be de-bonded. In general, the length of de-bonded strand from each end of the beam should be limited to approximately 15% of the span length.

3.7.2.5 Where draped strands are used, the total hold down force of all draped strands for each beam should not exceed 75% of the total beam weight.

3.7.2.6 Reinforcing Steel. All non-prestressed reinforcement shall be epoxy coated Grade 60 reinforcing steel. It is the Designer's responsibility to detail the beams so that all reinforcement will be embedded, developed or lapped as required. In the case of deck or box beams, the size of the void can be reduced (or eliminated for deck beams only), as noted in Part II of this Bridge Manual, to permit proper bar development.

3.7.2.7 Utility Supports. The steel for all utility supports shall conform to AASHTO M 270 Grade 36, and shall be galvanized. All inserts for the attachment of utilities will be cast into the beam at the time of its fabrication. Under no circumstances shall expansion type anchors be allowed. Inserts that are being provided for a future utility installation shall be furnished with a plastic plug that is the same color as the concrete. Drilling of holes for attachments will not be permitted once the beam has been cast.

3.7.3 General Design Requirements

3.7.3.1 All prestressed beams will be designed according to the *AASHTO LRFD Bridge Design Specifications* except where modified or amended by this section. The beams will be designed for all applicable limit states and for all loading conditions the beam will be subjected to during its life.

3.7.3.2 Beams will be designed to have no more than $0.0948\sqrt{f'_c}$ ksi tension in the precompressed tensile zone under Service III limit state after all losses have occurred. If the only way to reduce these tensile stresses is to go to the next larger beam size and the depth of structure is critical, tensile stresses up to a maximum of $0.19\sqrt{f'_c}$ ksi will be permitted using a live load factor of 1.0 in the Service III Load Combination to avoid going to the next larger beam size.

3.7.3.3 Transverse stirrups shall be designed in accordance with *AASHTO LRFD Bridge Design Specifications* requirements for shear in concrete components, except that neither the minimum bar sizes nor the maximum spacings, as noted in Part II of this Bridge Manual, shall be violated. For adjacent box beams, the top bars (straight and U shaped) have been pre-designed as slab reinforcement and spaced accordingly; however, the bottom #4 U-bars shall be designed to satisfy shear reinforcement requirements and shall be spaced at a multiple of the top bars. Each bottom U-bar shall be lapped with a top U-bar to form the transverse stirrups.

3.7.3.4 End transverse stirrups and vertical stirrups shall be designed to meet the *AASHTO LRFD Bridge Design Specifications* requirements for Anchorage Zones of prestensioned concrete components, Article 5.10.10. These bars should be placed within a distance d/4 from the end of the beams and should be #4 bars or smaller. If absolutely necessary to accommodate the design force while placing the bars within the specified distance from the end of the beams, #5 bars may be used, in which case the lap and embedment lengths shall be adjusted.

3.8 DESIGN PROCEDURES

3.8.1 Design of Adjacent Deck and Box Beam Bridges

The beams shall be designed to be composite with the deck slab, with dowels cast into the beams designed for horizontal shear as specified in *AASHTO LRFD Bridge Design Specifications* Article 5.8.4. The AASHTO-LRFD live load distribution factor shall be computed assuming noncomposite beams, however, the composite section shall be used to design the beams and check stresses.

If beams of different Moments of Inertia are used together in an adjacent beam superstructure, the distribution of superimposed Dead Loads to each beam shall be in proportion to its Moment of Inertia according to the following formula:

$$L.D.F._{k} = \frac{I_k}{\sum_{i=1}^{n} I_i}$$

Where $L.D.F._k$ is the load distribution factor for the *k* th beam, I_k is the Moment of Inertia of the *k* th beam, and I_1 ... I_n are the Moments of Inertia of the beams over which the load is distributed. Design each adjacent beam for: the beam's own dead weight, including all solid sections; the portion of the superimposed Dead Loads and sidewalk Live Load carried by the beam, calculated using the above load distribution factor; the portion of the design Live Load plus dynamic load allowance carried by the beam, calculated using the AASHTO-LRFD live load distribution factor. Since the AASHTO-LRFD live load distribution factor is a function of the beam width and Moment of Inertia, no further distribution of the design Live Load using the above load distribution factor is required.

3.8.2 Utilities on Adjacent Deck and Box Beam Bridges

3.8.2.1 General. Utilities shall be located as shown in Section 4.3 of Part II of this Bridge Manual. Preference shall be given to locating the utilities in the utility bay under the sidewalk wherever possible. Under no circumstances will utilities be located inside Deck or Box beams within the void area.

3.8.2.2 The utility supports shown in Part II of this Bridge Manual represent acceptable configurations. Where members and bolts are provided, these supports may be used up to the limits shown without further design. These supports may have to be altered depending on the utility. If an increase in the side clearance of the utility bay is required, the L4x4x½ attached to the side of the beam may be replaced by an attachment using a section of WT. In these cases, the Designer is responsible for the design of the utility supports. In all cases, the utility supports must be adequately detailed on the Construction Drawings.

3.8.2.3 Sidewalk Utility Bay - Sidewalk Beam Design. The sidewalk beam as defined in Section 4.3 of Part II of this Bridge Manual may be either a standard PCI New England deck or box beam section or a special rectangular solid precast prestressed beam. NEBT beams shall not be used for this application. If the sidewalk is wide enough to accommodate two sidewalk beams, provide longitudinal joints and transverse ties as for normal adjacent beams. If there are two or more sidewalk beams, distribute the superimposed Dead and Live Loads described in the procedure to each sidewalk beam using the load distribution formula of Subsection 3.8.1.

The beam(s) shall be designed to be composite with the sidewalk slab, with dowels cast into the beam(s) designed for horizontal shear as specified in *AASHTO LRFD Bridge Design Specifications* Article 5.8.4. The effective width of the slab shall extend to mid-bay.

STEP 1: Design the beam for the following Dead and Live loads and allowable stresses:

Dead Loads: Beam Dead Load + (one half of the weight of the utilities in the utility bay) + (the weight of any Dead Loads cantilevered from the exterior of the beam) + (sidewalk slab directly above the beam plus one half the slab over the utility bay) + (railing/barrier Dead Load, distributed 60% to the sidewalk beam and 40% to the roadway beam(s)).

Live Load plus dynamic load allowance: place HL-93 truck on the sidewalk with the wheel line 12" from the face of the railing/barrier and distribute as follows: if the wheel line is located anywhere over the sidewalk beam, apply 100% of the wheel line load to the sidewalk beam; if the wheel line is located over the utility bay, distribute the wheel line load assuming the sidewalk slab acts as a simple beam using the clear span of the slab. Depending on the width of the sidewalk, use one or both wheel lines.

Concrete Stresses: the allowable concrete compressive stresses at the service limit state shall be increased 50% and the allowable tensile stress in the precompressed tensile zone shall be taken as: $0.19\sqrt{f'_c}$ ksi. No increase will be allowed in the initial concrete strengths at release.

STEP 2: Check the sidewalk beam(s) as designed in Step 1 in accordance with Subsection 3.7.3, for the following loads:

Dead Loads: same as Step 1 Dead Loads.

Live Load: the AASHTO-LRFD sidewalk Live Load located on that strip of sidewalk directly over the sidewalk beam(s) that extends from the face of the railing/barrier to the midpoint of the utility bay.

3.8.2.4 Sidewalk Utility Bay - Roadway Beam Design. The adjacent roadway beam(s) under the sidewalk and adjacent to the utility bay shall be designed according to the procedure in Subsection 3.8.1, modified as follows. Dead Loads shall be all sidewalk Dead Loads not assigned to the sidewalk beam(s). The load carrying contribution of the non-adjacent sidewalk beam(s) will be ignored. Assume that the sidewalk slab acts as a simple beam using the slab's clear span for distributing truck Live Loads. If a wheel line is located over the first adjacent roadway beam, then this beam shall be designed for 100% of this wheel line and the computed load fraction from the outside wheel line. This beam shall be designed composite with the sidewalk slab, using the same criteria as for the sidewalk beam. In no case shall this beam have less load carrying capacity than the other adjacent roadway beams.

3.8.2.5 Sidewalk Utility Bay - Sidewalk Slab Design. The sidewalk slab shall be designed for the differential deflection between the adjacent roadway beams and the sidewalk beam(s).

STEP 1: Calculate the deflection of the adjacent roadway beams by placing design trucks in each of the actual travel lanes (not the AASHTO design lanes) and assuming that all adjacent roadway beams are acting together, i.e. live load is distributed equally to all roadway beams.

STEP 2: Calculate the equivalent uniformly distributed load (per foot of beam) that would cause the same deflection in the sidewalk beam as calculated in Step 1. Use the composite section properties. If there are two or more sidewalk beams, calculate the load that would deflect all sidewalk beams at once.

STEP 3: For design, the sidewalk slab will be considered a cantilevered beam with a length equal to the clear width of the utility bay. The design load shall be the uniform load calculated in Step 2 and applied at the free end of the cantilever. Assume the section to be singly reinforced and use the smallest *d* dimension. The required steel area shall be provided for both top and bottom transverse slab reinforcement. Spacing of these bars should be at a multiple of the sidewalk dowels of the first roadway beam.

STEP 4: If excessive sidewalk slab reinforcement is required, consideration should be given first to increasing the thickness of the sidewalk slab and, second, by providing intermediate diaphragms. The intermediate diaphragms need only be designed for the load in excess of the slab capacity.

3.8.2.6 Exterior Utility Supports. Whenever a utility is attached to the exterior of an adjacent beam bridge, the torsional effect of such an attachment may cause unequal reactions at the bearings. This effect may be compounded by additional eccentric loads, such as either a sidewalk overhang or a safety curb with a railing/barrier and which does not extend over to the second interior beam. To help equalize the reactions at the bearings, consideration will be given to increasing the number of transverse ties and/or the use of a full depth shear key.

3.8.3 Continuity Design for Prestressed Concrete Beam Bridges

3.8.3.1 General. The closure pour for continuity, as detailed in Part II of this Bridge Manual, is also intended to provide the longitudinal and transverse restraint for the bridge for seismic and other design loads. The reinforcing bar hoops placed in the closure pour as well as the hoops in the pier cap adjacent to the shear key will be designed for the longitudinal loads. The transverse shear requirement will also be checked. If the continuity bars alone are insufficient as shear dowels, additional shear dowels projecting into the closure pour may be cast into the end of the beam.

3.8.3.2 The Designer is advised to consider the effect of creep, shrinkage and long term Dead Load deflections in the design of bridges made continuous over two or more spans, especially if continuity is being made between un-equal spans.

3.8.3.3 Prestressed concrete beam bridges made continuous will be designed according to the procedure outlined below. The full effect of continuity will not be used to reduce the positive superimposed Dead Load and Live Load moments. All design of the reinforcement within the closure pour will be per prestressed beam and based on its width. NCHRP Report 322, *Design of Precast Prestressed Bridge Girders Made Continuous*, is recommended as a reference for the design of continuous prestressed girders.

STEP 1: Design all beams as a simple span for positive moment prestressing.

STEP 2: Calculate the negative superimposed Dead Load and Live Load plus moment envelopes assuming that the beam is fully continuous.

STEP 3: The actual continuity steel provided shall be the smaller of either Case A or B:

Case A: Using the Strength limit state, calculate the steel area required for the maximum negative moment at the pier from Step 2. The design concrete compressive strength shall be that of the prestressed beam. The compressive stress in the ends of the beams at the piers from the combined effect of prestressing and negative Live Load/superimposed Dead Load moments calculated using Service I limit state shall not exceed 0.6 f'_c.

Case B: Calculate the reinforcement required in order to provide a tension-controlled section, where the net tensile strain in the extreme tension steel equals or exceeds 0.005 just as the concrete in compression reaches its assumed strain limit of 0.003. The steel area to be provided shall not exceed 2/3 of the reinforcement required to provide a tension-controlled section.

STEP 4: Using the negative moment envelope, determine the cut-off point for the continuity reinforcement. Spread and adjacent beam bridges shall be designed compositely with the deck slab with the continuity reinforcement placed in the deck slab. The deck slab continuity reinforcement cut-off point shall be where the negative moment steel reinforcement area provided in the deck slab is sufficient for the negative moment plus the splice length of the smaller bars.

Although it is not intended to fully restrain the rotation of the beam end at the closure pour due to creep induced camber growth, provisions have been made in the details in Part II of this Bridge Manual to resist the positive restraint moment that may develop by extending the bottom row of prestressing strands into the closure pour at piers.

3.8.3.4 Adjacent Deck and Box Beam Bridges With Sidewalk Utility Bay. Follow the same procedure as above. The continuity reinforcement may be placed in the slab.

3.8.4 Design of New England Bulb Tee Beams

3.8.4.1 The design of vertical stirrups for shear shall be performed in accordance with *AASHTO LRFD Bridge Design Specifications* Article 5.8.

3.9 INTEGRAL ABUTMENT BRIDGES *(UNDER DEVELOPMENT)*

3.9.1 General

Integral bridges are single span or multiple span continuous deck type structures with each abutment monolithically connected to the superstructure and supported by a single row of flexible vertical piles. The primary purpose of monolithic construction is to eliminate the need for deck movement joints and bearings at abutments.

Integral abutment bridges differ from traditional rigid frame bridges in the manner which movement is accommodated. Rigid frame bridges resist the effects of temperature change, creep and shrinkage with full height abutment walls that are fixed or pinned at the footing level. The effects produced by longitudinal forces in integral abutment bridges are accommodated by designing the abutments to move with less induced strain, thus permitting the use of smaller and lighter abutments.

Integral abutment bridges have a demonstrated history of initial cost savings due to economy of material usage and lifecycle cost savings through reduced maintenance. Integral abutment construction shall be considered as a first option for all slab and slab on stringer bridges.

3.9.2 Guidelines

Construction of integral abutment structures shall be subject to the following guidelines. For bridges that do not fall within these guidelines, integral abutment design will be allowed with the prior approval of the Director of Bridges and Structures. These guidelines apply only to slab and slab-on-stringer bridges:

1. Skew angles should preferably be limited to 20°.

2. Total bridge lengths should preferably be limited to 400 feet for steel bridges and 600 feet for concrete bridges.

3. Curvature should preferably be limited to a 5° subtended central angle.

4. The difference in the profile grade elevation at each of the abutments should preferably not exceed 5% of the bridge length.

5. Abutment heights, measured from the deck surface to the bottom of the cap, should preferably not exceed 15 feet.

6. Maximum individual span lengths should be limited to 145 feet.

3.9.3 Loads

3.9.3.1 Integral abutment bridges shall be designed to resist all of the vertical and lateral loads acting on them. The combined load effects on the structure at various stages of construction must be considered in the design. The stages of construction are of primary importance, they typically require the stringer ends to be simply supported initially, then to be made integral with the abutments after the deck is cast, and then the abutment is backfilled. The vertical loads shall include dead loads, superimposed dead loads, buoyancy, and live loads including dynamic load allowance. Horizontal loads shall include braking forces, soil pressures, seismic forces, and loads induced from temperature changes, shrinkage, and creep.

3.9.4 General Design Requirements

3.9.4.1 Single span integral abutment bridges with spans less than or equal to 100’ and skews less than or equal to 30° will have their reinforced concrete abutments and piles pre-engineered and detailed subject to the limitations stipulated in Chapter 12 of Part II of this Bridge Manual.

3.9.4.2 The thermal movements shall be calculated in accordance with Paragraph 3.1.5.2.

3.9.4.3 The creep and shrinkage movement should be addressed mostly in designs of cast-in-place or prestressed concrete superstructures. Reference is made to the 6th Edition of the *PCI Design Handbook*, Section 4.7 for more information on how to calculate this displacement.

3.9.4.4 The connection between the beams and the abutment shall be assumed to be simply supported for superstructure design and analysis. It is recognized that, in some cases, it may be desirable to take advantage of the frame action in the superstructure design by assuming some degree of fixity. This, however, requires careful engineering judgment. Due to the uncertainty in the degree of fixity, frame action shall not be utilized to reduce design moments in the beams. However, the superstructure design shall include a check for the adverse effects of fixity at the abutments.

For the design of the abutment and piles, the superstructure shall be assumed to transfer moment, and vertical and horizontal forces due to superimposed dead load, live load plus dynamic load allowance, earth pressure, temperature, shrinkage, creep and seismic loads which are applied after the rigid connection with the abutment is achieved. The connection between the abutment and superstructure shall be detailed to resist all applied loads.

3.9.4.5 For integral abutment bridges, a primary requirement is the need to support the abutments on relatively flexible piles. Therefore, where rock or glacial till is very close to the surface (within 25’), or where the use of short piles less than the required minimum length to obtain pile fixity is necessary, the site may still be suitable for pile supported integral abutments provided that the design accounts for the reduced equivalent length of pile.

3.9.4.6 The abutment shall be supported on a single row of vertical HP-piles with the webs oriented parallel to the centerline of the abutment. The top of the piles shall be embedded into the abutment, and the abutment shall be adequately detailed and reinforced to transfer the forces from the superstructure.

3.9.4.7 The abutment should be kept as short as possible to reduce the magnitude of soil pressure developed; however, a minimum fill cover over the bottom of the abutment of 3’-0” is desirable. It is recommended to have abutments of equal height. A difference in abutment heights causes more movements to take place at the shorter abutment. Abutments of unequal height shall be designed by balancing the earth pressure consistent with the magnitude of the displacement at each abutment.

3.9.4.8 The magnitude of lateral earth pressure developed by the backfill is dependent on the relative wall displacement, δ_T/H, and may be considered to develop between full passive and at-rest earth pressure. The backfill force shall be determined based on the movement-dependent coefficient of earth pressure (K). Results from full scale wall tests performed by UMASS[1] show reasonable agreement between the predicted average passive earth pressure response of MassHighway's standard compacted gravel borrow and the curves of K versus δ/H for dense sand found in design manuals DM-7[2] and NCHRP[3]. For the design of integral abutments, the coefficient of horizontal earth pressure when using compacted gravel borrow backfill shall be estimated using the equation:

$$K = 0.43 + 5.7[1 - e^{-190(\delta_T/H)}]$$

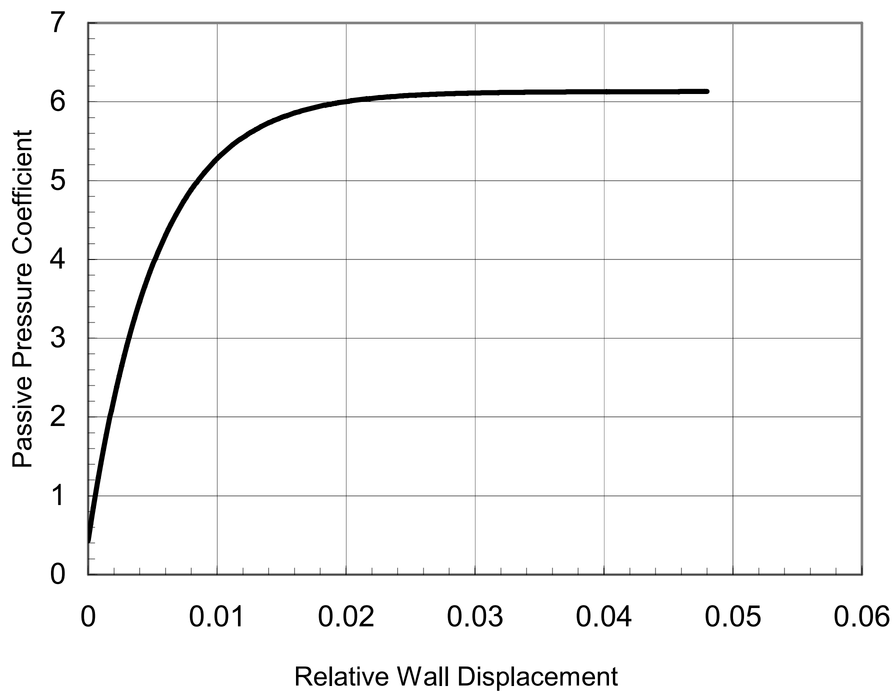


Figure 3.1: Plot of Passive Pressure Coefficient, K, vs. Relative Wall Displacement, δ_T/H.

3.9.4.9 Pre-drilled holes, 8 feet deep and filled with loose crushed stone, shall be provided to reduce resistance to pile lateral movement. To achieve loose conditions, the pre-drilled holes shall be filled with crushed stone after the piles are driven. The minimum diameter of the crushed stone-filled pre-drilled holes shall be 2'-0". To accommodate increased movements in the loose crushed stone and minimize influence from the surrounding natural soils, larger hole diameters shall be specified as the expected movements increase. The diameter of the crushed stone filled holes shall be rounded to the nearest 6" increment up to a maximum diameter of 4 feet based upon the following formula with all units in inches:

$$\varnothing_{hole} = 24 + 10(\delta_T)$$

3.9.4.10 Approach slabs shall be used for all integral abutment bridges. The approach slab shall be detailed to remain stationary by constructing a key away from the abutment and shall be detailed to allow sliding at the end supported by the abutment.

3.9.4.11 U - shaped integral wingwalls, with a minimum length of 2 feet shall be used between the abutment and the Highway Guardrail Transition. The integral wingwall length shall be as required by site and bridge geometry, with a maximum length of 10 feet. When a wingwall length longer than 10 feet is required a combination of integral and independent wingwalls shall be utilized.

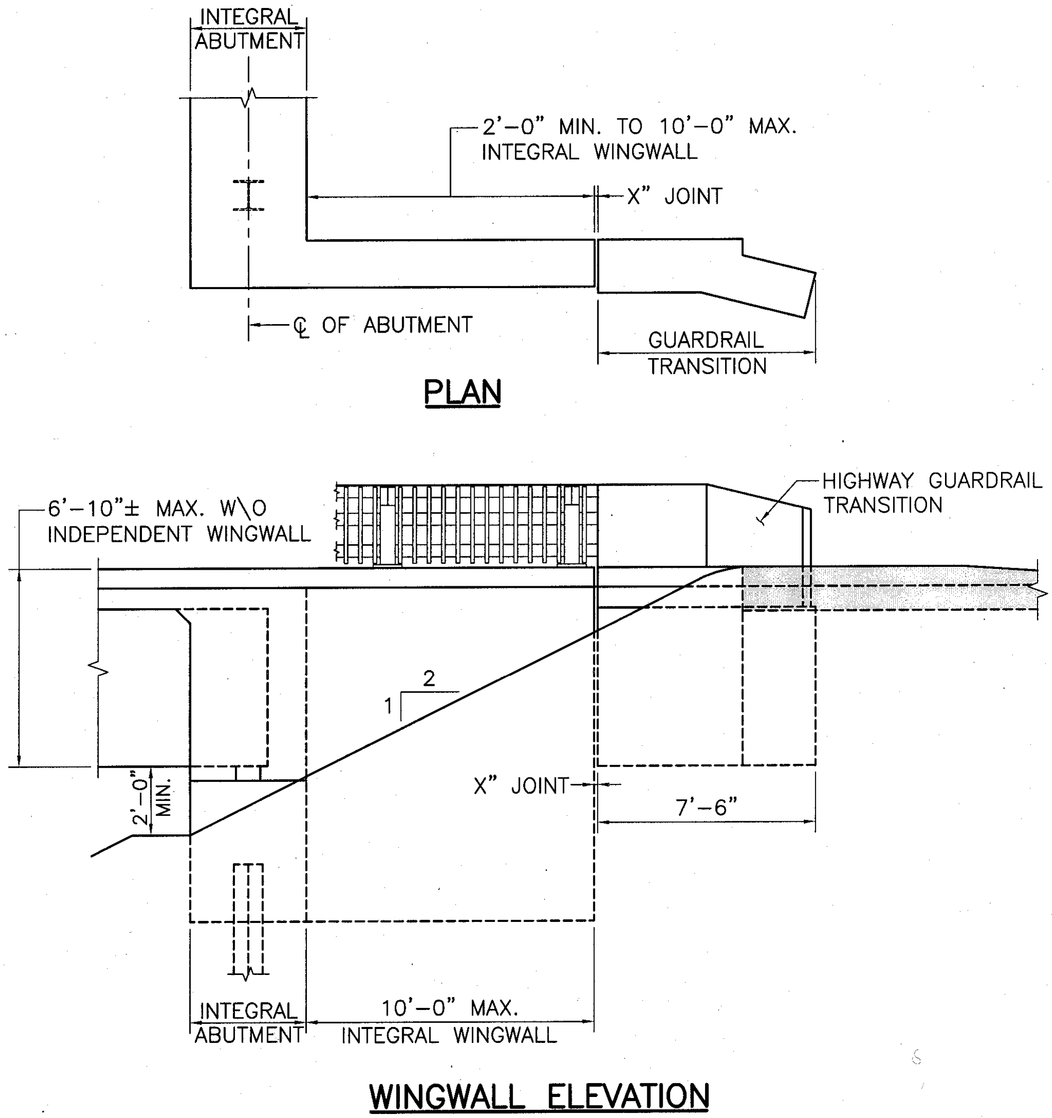


Figure 3.2: Wingwall Geometry.

3.9.5 Pile Design Methodology

3.9.5.1 The methodology for the design of integral abutment piles incorporates the provisions contained in the *AASHTO LRFD Bridge Design Specifications* Subsections 6.5, 6.9, 6.10, and 6.15. The pile can be divided into two primary zones. The upper zone is subject to flexure and axial loads.

The lower zone is considered fully braced by the surrounding zones and is subject to only axial loads. A single plastic hinge is permitted to form where the pile connects to the pile cap.

3.9.5.2 The basic design equation for the capacity of a pile as a structural member is obtained from *AASHTO LRFD Bridge Design Specifications* Sections 6.9 and 6.15 for combined axial load and flexure. The following shall be considered in selecting the pile sections:

1. As the axial load on the pile increases, the moment that causes a plastic hinge to form will decrease. Once the plastic hinge forms, the pile head will be considered a pin with a constant moment applied. For compact sections, the interaction equation contained in the *AASHTO LRFD Bridge Design Specifications* Article 6.9.2.2 shall use the plastic moment capacity as a limiting condition for the applied moment.
2. Bi-axial bending shall be evaluated in bridges with skews over 20º.
3. Slender sections are not permitted to be used in integral abutment bridges because of the inability of these pile sections to reach yield in bending prior to flange local buckling (AISC[7], Chapter F, Section F1).

3.9.5.3 The initial choice of pile section shall be based upon the recommendations contained in the Geotechnical Report. The preliminary design axial loads shall be based upon the *AASHTO LRFD Bridge Design Specifications* Strength I Load Combination. Use a minimum of 1 pile per beam line at each abutment. The preliminary nominal compressive structural pile resistance may be computed as:

$$P_n = 0.66^{\lambda} F_y A_s \approx 0.80 F_y A_s$$

3.9.5.4 The live load dynamic load allowance shall be considered in the design of integral abutment piles.

3.9.5.5 The permissible total length of integral abutment bridges is sensitive to the relative slenderness of the pile section. Sections that satisfy the provisions of *AASHTO LRFD Bridge Design Specifications* Article 6.12.2.2.1 are capable of developing a fully plastic stress distribution and may be used where plastic hinge formation is expected. Sections that satisfy the provisions of *AASHTO LRFD Bridge Design Specifications* Article 6.9.4.2, but do not satisfy Article 6.12.2.2.1, are capable of reaching yield, but flange local buckling may precede the development of a fully plastic stress distribution. Therefore, these sections may not be used where plastic hinge formation is expected.

1. Acceptable pile sections (F_y = 50 ksi):
   A. Satisfies Article 6.9.4.2 and 6.12.2.2.1: HP10X57; HP12X84.
   B. Satisfies Article 6.9.4.2, but not 6.12.2.2.1: HP12X74; HP14X102; HP14X117.
2. Unacceptable pile sections (F_y = 50 ksi):
   Do not satisfy Article 6.9.4.2 or 6.12.2.2.1: HP10X42; HP12X53; HP12X63; HP14X73; HP14X89.

3.9.5.6 The Geotechnical Report shall contain a statement indicating whether the lateral support of the piles provided by the soil is sufficient enough to assume that the lower zone of the piles are fully braced against Euler buckling. In cases where the piles extend through regions of very soft soils, such as peat, the piles shall be assumed to behave like unbraced columns.

3.9.6 Modeling - General

3.9.6.1 All integral abutment bridges (excluding the pre-engineered ones) with a skew angle over 20º or those that exceed the guideline limits of Section 3.9.2 shall be modeled as 3D space frames that includes, as a minimum, a "stick" model of the superstructure, abutments, wingwalls, piers (if any), piles, soils springs, and shall be representative of the geometry, including skew (Figure 3.8).

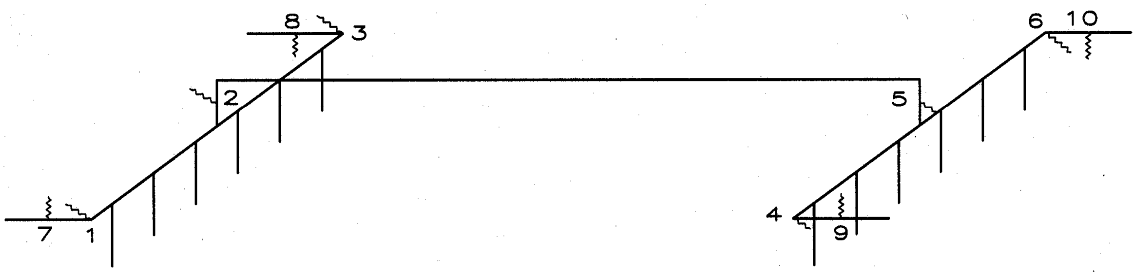


Figure 3.3: "Stick" Model Geometry

The soil behind the abutments shall be modeled with at least 3 horizontal springs that are oriented perpendicular to the wall face, one at mid-height and mid-length of the abutment wall (see nodes 2 and 5 above), and one at the bottom of each end of the abutment (see nodes 1, 3, 4, and 6 above). The soil spring stiffness behind each abutment shall be distributed based on the tributary area for the middle portion (50%) and end quarters (25%) at each abutment end. The non-linear soil spring stiffness shall be based on K values determined in accordance with Paragraph 3.9.4.7 for assumed incremental displacements. The soil springs shall not carry tension forces. The same K values shall be used for both static and dynamic loads. Similarly, the soil behind the integral wingwalls shall be modeled as a horizontal soil spring located at the one-third point from the wingwall end (see nodes 7, 8, 9, and 10 above) with stiffness calculated as stated above.

3.9.6.2 HP-Piles shall be modeled as beam elements. The length of pile from the base of the abutment to the point of fixity shall be the equivalent length, L_e , defined as the theoretical equivalent length of a free standing column with fixed/fixed support conditions translated through a pile head horizontal displacement δ_T. The equivalent length for each pile, L_e, shall be determined from the following multivariable regression equation:

$$L_e = A(EI/d) + B(\delta_T) + C$$

This equation correlates L_e with the pile head horizontal displacement, δ_T, and the ratio of the pile's flexural rigidity to the pile section's depth in the plane of bending, EI/d. The calculation of L_e shall be made using the average of the temperature rise and temperature fall. The equation coefficients were derived from a parametric[10] study using various assumed soil profiles.

Due to similar results for the dry crushed stone overlying the different sand conditions, those cases were condensed into one equation. Similarly, loose and dense sand underlying wet crushed stone were grouped together, resulting in the six equations outlined below. The Designer shall interpolate equivalent length between soft (c = 575 psf) and stiff (c = 2600 psf) clays. Additionally, if the water table is located intermediate to the cases presented, the Designer shall linearly interpolate between the equation coefficients presented here.

IDEALIZED SOIL CONDITIONS	EQUATION COEFFICIENTS FOR L_e			FIXITY RATIO
$L_e = A(EI/d)+B(\delta_T)+C$	A	B	C	L_f / L_e
	inch/(inch-kip)	inch/inch	inch	
Dry crushed stone over wet or dry sand	3.28E-05	11.9	89.1	2.2
Wet crushed stone over wet sand	3.59E-05	13.9	98.8	2.2
Dry crushed stone over wet stiff clay	3.06E-05	15.4	81.9	1.8
Dry crushed stone over wet soft clay	4.80E-05	21.1	76.4	2.5
Wet crushed stone over wet stiff clay	2.99E-05	18.1	87.9	1.8
Wet crushed stone over wet soft clay	5.26E-05	25.8	86	2.2

Table 3.1: Equation Coefficients to Determine Equivalent Pile Length.

Due to the inherent uncertainty involved in obtaining soil properties, the above equations should be adequate for most cases encountered. If more accurate site specific soil properties are available, or if variable stratified soil conditions exist in the upper 15 feet of soil, a separate lateral pile analysis using a computer program such as COM624 or L-Pile® should be performed and presented in the Geotechnical Report.

3.9.6.3 In order to obtain the pile behavior associated with the calculated equivalent lengths, the piles must be installed to a point of fixity or deeper. The practical depth to pile fixity is defined as the depth along the pile to the second point of zero lateral deflection. The required length of fixity, L_f, is normalized to the equivalent length, L_e, and the resulting ratios are summarized in Table 3.1. If piles are installed by driving, they must be embedded to the length of fixity, L_f , or greater, as calculated based upon Table 3.1. Additionally, driven piles must derive their axial capacity at a point below the bottom of the pre-drilled hole. If the required length to achieve fixity is not feasible, then the piles shall be predrilled and socketed into rock or dense till, and the socket shall be filled with concrete up to the top of rock or dense till. In this case, the equivalent length shall be taken as the depth from the bottom of the integral abutment to the top of the concrete filled socket.

3.9.7 Final Pile Design

3.9.7.1 The loading applied to the pile head shall be determined for all appropriate Load Combinations. The pile response shall be determined using a COM624 or LPILE model using the full pile for soil and pile interaction. Evaluate pile deflections, bending moments and stresses using the LPile or COM624 computer programs.

3.9.7.2 A plastic hinge is permitted to form in the upper zone of the pile where it enters the pile cap. To design a pile with a plastic hinge, the pile will be assumed to be pinned with a constant moment at the pile cap interface and is assumed to be pinned at the point of first zero moment. This is the first pile segment to analyze. The second segment of the upper zone of the pile to analyze shall be located between the two points of zero moment. The segment with the controlling axial strength will be used to determine the pile size. For additional information, please refer to the AISI, Highway Structures Design Handbook, Volume II, Chapter 5, Integral Abutments for Steel Bridges, as well as the VTrans Integral Abutment Bridge Design Guidelines.

Determine the structural adequacy of the preliminary pile section using the following criteria:

1. Using COM624 or LPILE, apply the pile head deflection, as determined from the movement calculation or space frame model for thermal, creep, and shrinkage, the applied factored axial load P_u, and a fixed zero rotation of the pile cap. In order to use the pile sections efficiently, the ratio of applied factored axial load P_u to the calculated compressive structural pile resistance P_r, shall generally be greater than or equal to 0.2.

$$P_u < P_r = \phi_c P_n$$
$$\frac{P_u}{P_r} \geq 0.2$$

2. Using the *AASHTO LRFD Bridge Design Specifications* Equation 6.9.2.2-2 below, with the applied axial load P_u, the calculated compressive structural pile resistance P_r based upon the unbraced length of the top segment, and flexural strength, M_{ry}, of the top segment of the pile, equate to one and solve for the applied factored moment M_{uy}. Bending about the strong axis shall only be considered where necessary.

$$\frac{\mathrm{P_u}}{\mathrm{P_r}} + \frac{8.0}{9.0}\left(\frac{M_{uy}}{M_{ry}}\right) \leq 1.0$$

Set the equation equal to 1, solve for M_{uy}, and equate to M_{py}:

$$M_{uy} = M_{py} = \frac{9.0}{8.0}\left(1.0 - \frac{P_u}{P_r}\right)\mathrm{M_{ry}}$$

Where:
P_u = Applied factored axial load determined from analysis;
P_r = Factored compressive structural pile resistance $= \phi_c P_n$, with $\phi_c = 0.70$ for a calculated unbraced length.
M_{uy} = Applied factored moment determined from analysis & P-Δ moment;
M_{ry} = factored moment resistance about the weak axis $= \phi_f M_n$, with $\phi_f = 1.0$.

3. If the applied moment M_{uy}, is greater than M_{py}, a plastic hinge will form. The pile head transforms from a fixed connection to a pinned connection thereby changing the effective length of the top segment for stability checks. A new analysis will then need to be performed using the lateral deflection and the axial load from Step 2 and M_{py}. This analysis will be used to revise the unbraced lengths of the pile. The axial capacity of the top segment and second segment will be recalculated using the revised unbraced lengths. If the applied moment M_{uy}, is less than M_{py}, then the pile is in the elastic range and no additional analysis is required.

4. The maximum moment in the second segment of the pile will be obtained from the revised analysis. The unbraced length of the second segment will then be used to calculate a revised Factored compressive structural pile resistance. Use the same axial load and resistance factors from Step 2 to verify that *AASHTO LRFD Bridge Design Specifications* Equation 6.9.2.2-2 is satisfied.

5. The axial capacity of the lower zone of the pile will be verified. The axial resistance will assume that the pile is fully braced and $\phi_c = 0.50$ if a pile shoe is required or $\phi_c = 0.60$ if a pile shoe is not required.

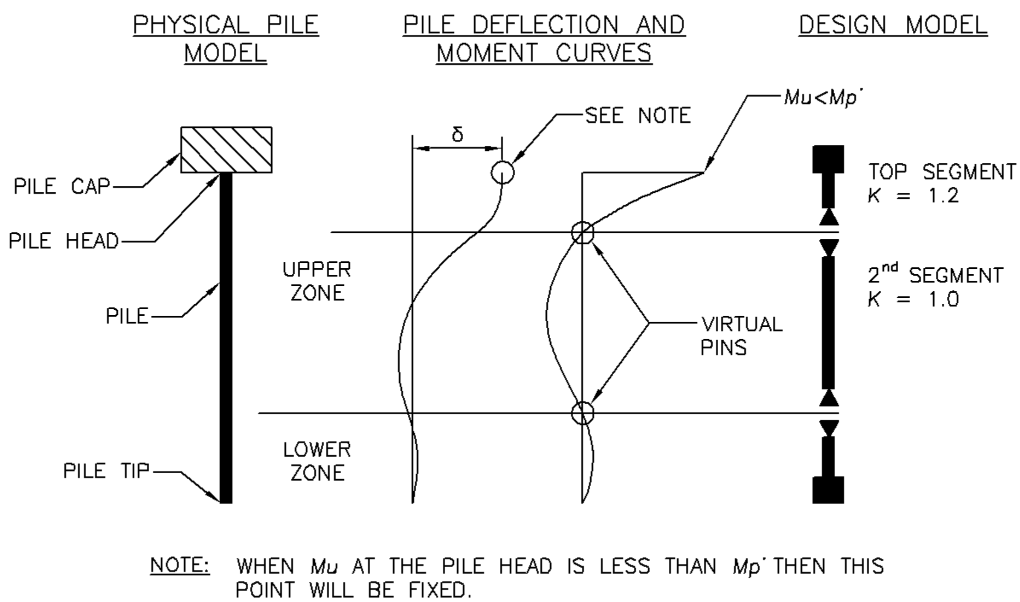


Figure X.X: Pile Design Model when M_u<$M_{p'}$

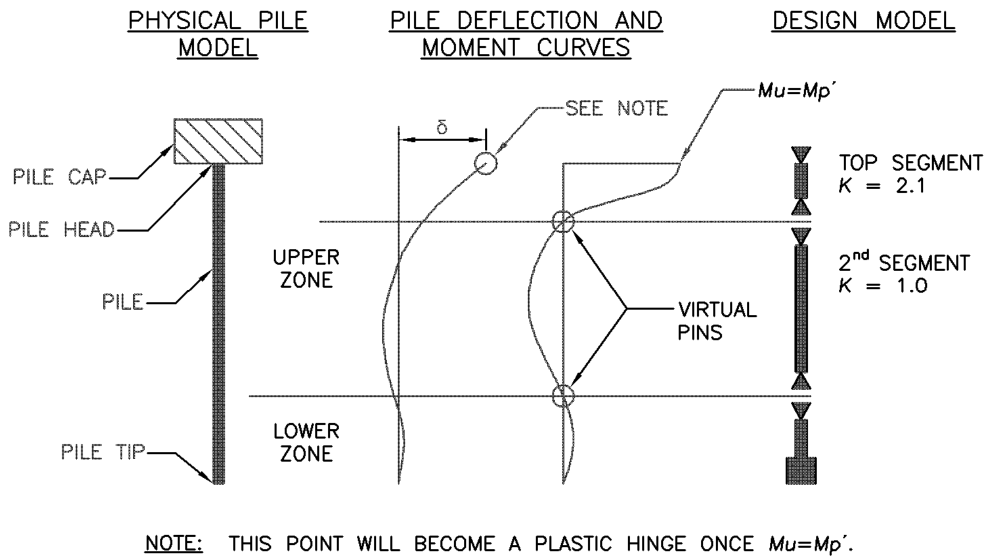


Figure X.X: Pile Design Model when M_u=$M_{p'}$

3.9.7.3 COM624 or L-Pile® pile-soil interaction analysis software shall be used to determine the moment developed throughout the pile length due to pile head displacement. The software allows loads and deflections to be included in a single load case for analysis of the pile. Typically, the Geotechnical Engineer will develop the COM624 or L-Pile® input file as part of the foundation design. Important parameters used in the pile design are determined from the output as follows:

1. The <u>Lateral Load at Pile Head</u> that is required to generate the design pile head displacement due to temperate, creep, and shrinkage loading.

2. The <u>Pile Deflection and Moment</u> throughout the length of the pile due to the head displacement can be determined. The maximum negative moment at the pile head (X = 0") and the maximum positive moment within the pile unbraced length are established. The location of the point of maximum positive moment will depend upon the soil conditions and will vary from project to project..

3. The <u>Unbraced Lengths</u> along the pile are between the top of pile and the first point of zero moment if a plastic hinge forms or between the first and second points of zero moment for calculation of the pile buckling stress.

4. The <u>Depth to Fixity</u> is the depth to second zero deflection in the pile.

3.9.8 Integral Wingwall Design

Integral wingwall reinforcement shall be designed for all loading combinations and detailed as shown in Part II of this Bridge Manual. For single spans less than or equal to 100’ span lengths, calculate the soil pressures behind the wingwall based upon a coefficient of earth pressure K = 1.0. For multiple span bridges, design the wingwall reinforcement based upon the soil spring forces from the 3D model.

3.9.9 References

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3.10 REHABILITATION OF STRUCTURES

3.10.1 General Requirements

Every bridge rehabilitation project shall ensure a bridge structure that meets current code and load capacity provisions. Where feasible, structures shall be made jointless.

3.10.2 Options for Increasing Carrying Capacity

3.10.2.1 General. The following are traditional options for increasing the resistance of existing main load carrying members. They can be used independently or in combination to achieve the desired effect. Not every structure can be upgraded using these options, therefore sound engineering judgement should be employed when evaluating them.

1. Where the existing beams are of non-composite construction, redesigning the beams for composite action and providing for the addition of shear connectors may be sufficient to increase the carrying capacity.

2. Using a full depth HP Cement Concrete deck with a ¾" thick integral wearing surface may be used in lieu of a regular deck with a bituminous concrete wearing surface to reduce the added dead load. Thin HP Cement Concrete overlays shall not be considered due to the potential for constructability problems.

3. Using lightweight concrete for the deck instead of regular weight concrete. When using lightweight concrete, the Designer must take into account the reduced Modulus of Elasticity in the calculation of composite section properties as well as the increase in the development and lap lengths for reinforcing bars, as specified in the *AASHTO LRFD Bridge Design Specifications*.

4. On rolled steel beam sections, adding cover plates. On bridges with existing cover plates, consideration can be given to adding additional cover plates on the top of the bottom flange. This is usually accomplished by adding two small plates to the top of the bottom flange, placed symmetrically either side of the web plate. Addition of any cover plates to an existing structure changes the stress distribution in the beam which must be accounted for in design, e.g. the bottom flange carries dead load stresses while the added cover plate is unstressed.

5. Where existing members have cover plates on the bottom flange, it is usually not economically feasible to remove them, especially if the bridge is over a road that has a high ADT.

6. Construct continuity retrofit of simply supported main members over the pier(s) in order to reduce live load stresses in positive moment region(s).

3.10.2.2 The standard 1½" haunch shall not be used in calculating composite section properties. However, where an excessive haunch depth occurs due to changes in bridge cross slope or changes in vertical profile, the haunch depth in excess of the standard haunch can be utilized in calculating composite section properties. For example, if the profile change results in a 6" haunch, the excess 4½" may be used in calculating section properties.

3.10.3 Fatigue Retrofits

3.10.3.1 All fatigue-susceptible details shall be fully investigated in bridge rehabilitation projects. Of particular concern are the ends of cover plates where a fatigue category E or E′ exists. In most cases, older cover plated beams will not meet current fatigue requirements for allowable stress ranges.

3.10.3.2 Reference is made to the *AASHTO LRFD Bridge Design Specifications* and the *AASHTO Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR) of Highway Bridges*, Chapter 7, Fatigue Evaluation of Steel Bridges, for evaluating the remaining fatigue life of existing steel members.

3.10.3.3 For existing rolled beams with cover plates, if remaining fatigue life is inadequate or if cracks are found at the cover plate ends during visual inspection, the beams will be retrofitted by installing splice plates on the bottom flange which will span over the cover plate end. These splices will be designed for the maximum force in the cover plate based on the cross sectional area and the stress in the cover plate under the Service and Strength Limit States. The splices will be designed as bolted slip-critical connections.

3.10.3.4 By itself, installing bolts through the existing cover plate termination is not acceptable as a retrofit for the following reasons:

1. This detail will not address a crack at the end of the cover plate that was invisible at the time of the inspection and may subsequently grow.

2. This type of retrofit cannot be made slip-critical, since the use of oils during the drilling operation will contaminate the beam flange/cover plate interface that cannot be cleaned as required to make it a slip-critical connection.

3. Since this connection is not slip-critical, there will be some live load stress flow through the end weld that could continue to contribute to the formation and/or growth of a fatigue crack.

3.11 ANCILLARY STRUCTURES

3.11.1 Pedestrian Bridges

Bridges whose primary function is to carry pedestrian and/or bicycle traffic shall be designed in accordance with the AASHTO *Guide Specifications for Design of Pedestrian Bridges*. Pedestrian bridges shall be designed to comply with the Americans with Disabilities Act (ADA) law.

3.11.2 Temporary Bridges

Pre-Engineered Temporary Panelized Bridges are to be used wherever feasible to maintain traffic flow during bridge reconstruction projects. The design of Pre-Engineered Temporary Panelized Bridge superstructures shall be performed by the supplier and shall be reviewed and approved by the Designer. Where the use of Pre-Engineered Temporary Panelized Bridge superstructures is not feasible, all elements of the temporary bridge structure shall be designed by the Designer. The design of all temporary bridge substructures that are to be used by the public during a bridge project shall be the responsibility of the Designer. Temporary bridge substructures that support Pre-Engineered Temporary Panelized Bridges shall be designed for assumed loads from the superstructure. The temporary bridge substructures shall be located and detailed on the bridge Construction Drawings. The assumed vertical and horizontal geometry of the Pre-Engineered Temporary Panelized Bridge and the assumed design loads for the substructure shall be specified on the bridge Construction Drawings. All temporary bridge structures shall be designed as if the structure was intended to be a permanent installation. Provisions for seismic design may be waived with the approval of the Director of Bridges and Structures.

3.11.3 Sign Attachments to Bridges and Walls

3.11.3.1 All sign attachments, their connections and their appurtenances shall be designed in accordance with the latest version, including current interims, of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*. The effect of loads from the sign structure on the bridge structure in conjunction with the bridge dead and live loads will be considered during design.

3.11.3.2 Sign supports shall be fabricated from steel conforming to AASHTO M 270 Grade 36 and shall be galvanized in accordance with AASHTO M 111. All steel hardware shall be galvanized in accordance with AASHTO M 232.

3.11.3.3 The minimum size of angles to be used shall be L3x3x5/16. The minimum size weld to be used shall be ¼". Expansion bolts embedded into existing copings shall have a minimum diameter of ¾".

3.11.3.4 The distance between sign support panels shall be selected so that the maximum positive and maximum negative moments in the panels shall be approximately equal. The bottom of the sign panel shall be a minimum of 6" above the bottom of the stringer.

3.11.3.5 In the design of sign supports, the wind velocity to be used shall be in accordance with the basic wind speed figure contained in the latest version, including current interims, of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

3.11.3.6 No holes shall be drilled in existing prestressed concrete beams. Concrete inserts, if used, shall be cast into the beam during fabrication.

3.12 BRIDGE INSPECTION

3.12.1 Requirements for Bridge Inspection Access

3.12.1.1 The main purpose of a bridge inspection is to assure the safety of a bridge for the travelling public by uncovering deficiencies that can affect its structural integrity. The results of a bridge inspection are used to initiate maintenance activities and/or a load rating. In order to comply with these requirements, all structural components of a bridge must be accessible for a hands-on inspection.

The standard MassHighway bridge, as detailed in Part II of this Bridge Manual, allows inspectors to access all structural members through the use of ladders, bucket trucks or the Bridgemaster (Inspector 50) truck. However, this equipment does have limitations, outlined below, that may prevent full access in some locations. Also, non-standard bridges may require special considerations for inspection access and maintenance. In these cases, inspection access must be secured through the use of rigging, platforms, walkways, scaffolding, barges, and in some cases, special travelling gantries.

The Designer is obligated to properly plan for safe inspection access as part of the design process and to provide accommodation for inspection access equipment in the Construction Drawings. This will insure that the bridge will be thoroughly inspected in the future. Otherwise, bridge inspectors may be faced with an impossible task of trying to properly inspect an inaccessible structure.

3.12.1.2 Ladders. Typically, the maximum safe reach for a ladder is about 25 feet. In addition, ladders must be set on firm and level ground. If the topography of the ground under a bridge is sloping, unstable, too rough or if the bridge is directly over water, ladders probably cannot be used.

3.12.1.3 Bucket trucks. Bucket trucks can be used to access the underside of a bridge from below. The maximum safe vertical reach for a bucket truck is about 25 feet. In order to use a bucket truck, there must be a road directly under the bridge. If there is no road, a bucket truck cannot be used. Bucket trucks also cannot be used on sloping ground.

3.12.1.4 Bridgemaster (Inspector 50) Truck. The Bridgemaster is a versatile inspection truck that allows access to the underside of a bridge from the bridge deck. The vehicle has a maneuverable boom with a bucket that can reach over the side of the bridge and move around underneath. The Bridgemaster, however, does have the following limitations:

- The maximum width of sidewalk that the Bridgemaster can reach over from the curb is 6 feet.

- The Bridgemaster cannot be operated with one set of wheels on the sidewalk and the other on the roadway.

- If the sidewalk can support the truck's weight, the minimum width of sidewalk that the Bridgemaster requires for driving on is 10 feet and there must be a ramp type access to the sidewalk.

- The Bridgemaster bucket can be deployed over a railing or fence with a maximum height of 6 feet. If the fence extends beyond that up to a height of 8 feet, the Bridgemaster boom can only drive along the fence with the bucket already deployed. The bucket must be deployed before or after the start of the 8 foot high fence and there can be no obstructions, such as light poles, in the travel path of the boom. The Bridgemaster cannot reach over fences greater than 8 feet in height.

- The minimum safe vertical underclearance for operating the bucket is 10 feet.

- The maximum roadway cross slope that the Bridgemaster can operate on is 7%.

- The bucket and boom must stay a minimum of 10 feet away from power lines.

- Underneath, the maximum reach under favorable conditions is 50 feet, which is reduced to 25 feet on bridges with problematic access.

- The Bridgemaster bucket cannot reach up around deep girders to allow access to the deck or upper parts of the girder.

- The Bridgemaster cannot be used to access a bridge from below.

3.12.1.5 Bridges with confined spaces in which inspectors must work require special considerations in order to ensure that they will be safe for inspection personnel. OSHA's definition of a confined space is a space large enough and so configured that an employee can bodily enter and perform assigned work but has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. Examples of such confined spaces on a bridge include the inside of steel box girders, hollow abutments, etc. The Designer is obligated to insure that there is sufficient room inside the confined space for a reasonably sized individual to move and turn around, that there is sufficient means of egress in an emergency or access by emergency personnel to rescue a stricken or incapacitated inspector.

3.12.1.5 In all cases of non-standard bridges or bridges with difficult access, the MassHighway Bridge Inspection Unit will review the bridge Construction Drawings and make recommendations for providing adequate and safe access for bridge inspection.

3.12.2 Fracture Critical Bridge Inspection Procedures

3.12.2.1 If a bridge is designed with fracture critical members, the Designer must prepare and submit a Fracture Critical Inspection Procedure as part of the design process in addition to the contract documents. This procedure will be used to properly inspect these structures in accordance with federal regulations, 23 CFR Part 650, Subpart C, §650.303 (e)(1).

3.12.2.2 The Fracture Critical Inspection Procedure shall be prepared on standard MassHighway forms as supplied by the Bridge Inspection Unit and shall consist of the following parts:

1. Index

2. Identification of Fracture Critical Members
   Identify all Fracture Critical members or Fracture Critical portions of members (such as tension zones of non-redundant plate girders or floorbeams) both by text and visually by using key Construction Drawings, diagrams and elevation views of members. This list will be used by the inspectors to identify and inspect all Fracture Critical members on the bridge. The required inspection frequency shall also be noted.

3. Identification of Fatigue Sensitive Details
   Identify all Fatigue Sensitive details on the Fracture Critical members both by text and through the use of the standard Fatigue Sensitive category diagrams. This list will be used by inspectors to identify and inspect all Fatigue Sensitive details on the Fracture Critical members. The required inspection frequency shall also be noted.

4. Inspection Procedure for Inspection of Fracture Critical Members

Outline the procedure the inspectors are to follow when inspecting Fracture Critical members. The required inspection frequency shall also be noted.

5. Inspection Procedure for Inspection of Fatigue Sensitive Details
   Outline the procedure the inspectors are to follow when inspecting Fatigue Sensitive details. The required inspection frequency shall also be noted.

6. Photographs
   Provide inventory photographs of the bridge structure and photographs of the typical Fracture Critical members and Fatigue Sensitive details for identification purposes.

The Federal Highway Administration Report No. FHWA-IP-86-26 “Inspection of Fracture Critical Bridge Members”, dated September 1986, can be used as a reference and guide in preparing the inspection procedures of parts 3 and 4.

3.12.2.3 Since a Fracture Critical Inspection requires a very detailed, close visual “hands-on” inspection as a means of detecting cracks, the Designer shall make sure that all Fracture Critical members of the bridge can be accessed in accordance with Subsection 3.12.1.

3.12.3 Bridges Requiring Special Inspection and Maintenance Procedures

3.12.3.1 For all structures having unique or special features whose condition cannot be fully assessed through a standard visual inspection, or which require additional attention during an inspection to insure the safety of such bridges, the Designer will prepare a Special Inspection Procedure and will submit it along with the contract documents as a design deliverable. The Special Inspection Procedure will outline the procedures and methods required to properly inspect their condition and could include the use of Non-Destructive Testing equipment, periodic measurements at identified locations, and elevation surveys to properly assess the condition of such features.

Examples of such special and unique features are:

Cable stayed bridges: cable stays, their anchorage to the bridge and the tower, structural tower inspection.

Segmental concrete bridges: post tensioning cables and their anchorages, sagging of the structure due to strand relaxation or deterioration.

Bridge with settling substructures: periodic survey of elevations at piers to monitor settlement rates.

Since it is impossible to outline every potential type of unique or special feature, it is incumbent upon the Designer to consider future inspection needs if the design calls for details which are not part of the MassHighway standards as detailed in Part II of this Bridge Manual. If the Designer is not certain if a Special Inspection Procedure is required, the MassHighway Bridge Inspection Unit should be consulted as early as possible in the design process.

3.12.3.2 For those structures that have unique or special features which require special periodic maintenance to insure their satisfactory and safe operation, the Designer will prepare a Special

Maintenance Procedure Manual and submit it along with the contract documents as a design deliverable. This manual will outline the maintenance work that is required, the frequency of the required maintenance, and any special procedures required to perform the work.

CHAPTER 4
CONSTRUCTION DRAWINGS

4.1 GRAPHICAL STANDARDS

4.1.1 Introduction

A consistent approach to the drafting of details makes it easier for a person reading a set of Construction Drawings to understand what is being shown, and, thereby, to correctly interpret without confusion the intentions of the Designer. By maintaining this uniformity on all MassHighway bridge Construction Drawings, the users become accustomed to the graphical conventions, thereby enhancing the visual recognition and discernment of details. Autodesk AutoCAD 2002® was used to prepare the Bridge Manual drawings and this version, or a latter version, shall be used to prepare Construction Drawings.

Since there are many Designers who prepare Construction Drawings for MassHighway, achieving this uniformity on all bridge Construction Drawings can only be arrived at by setting up drafting standards and conventions. The purpose of this section is to standardize the following components of drafting and establish guidelines for their usage:

1. AutoCAD layers, including linetypes and lineweights.
2. Symbols.
3. Lettering style and sizes.
4. Abbreviations.

By establishing standard AutoCAD layers, a given linetype will denote the same thing on all Construction Drawings. The lineweights have also been standardized along a hierarchy of importance. The proposed object lines are heavier than the existing object lines, which in turn are heavier than the dimension and leader lines. In this way, the more important object details stand out and, subsequently, it is easier to differentiate between the many different lines that are encountered on a drawing.

Standardization of symbols, lettering sizes and abbreviations complements the linetypes by enhancing the reader's recognition of dimensions and notations.

4.1.2 Standard AutoCAD Layers, Linetypes, and Lineweights

4.1.2.1 Table 4.1 shows the standard Bridge Section AutoCAD layers and their respective lineweights. The linetypes are AutoCAD defaults. These linetypes and lineweights are based on those that had been used for years in the Bridge Section for hand drafting. The names refer to the layers and linetypes as developed for the In-House Bridge Section AutoCAD system. These names are used here only for purposes of reference between the figures and the text that follows. In order to ensure uniformity in the drawing appearance, the In-House Bridge Section developed drawing templates for every available scale. The templates include layer names, linetypes, lineweights, and all necessary text and dimension styles. The Bridge Manual drawings and drawing templates use a common layering scheme to facilitate their utilization on Construction Drawings. The common layering scheme provides the path for mapping a Bridge Manual drawing into any template, thus minimizing necessary editing. The layer names have been abbreviated for ease of layer recognition within AutoCAD.

TABLE 4.1 STANDARD BRIDGE SECTION LAYERS, LINETYPES, AND LINEWEIGHTS

DESCRIPTION	LAYER NAME	LINETYPE	LINEWEIGHT	APPEARANCE
PROPOSED OBJECTS:				
SCALES $\frac{1}{4}$" OR LARGER:				
	PROPOSED	CONTINUOUS	0.014"	
	PROP HID LONG	HIDDENX2	0.014"	
	PROP HID SHORT	HIDDEN	0.014"	
SCALES $\frac{1}{8}$" OR SMALLER:				
	PROPOSED	CONTINUOUS	0.010"	
	PROP HIDDEN	HIDDEN2	0.010"	
EXISTING OBJECTS:				
	EXISTING	DASHDOT2	0.005"	
	EXISTING HIDDEN	HIDDEN	0.005"	
	EXISTING GROUND	DASHDOT	0.005"	
PROPOSED REBAR ELEVATION:				
SCALES 1" AND $1\frac{1}{2}$":	REBAR	CONTINUOUS	0.028"	
SCALES $\frac{3}{8}$", $\frac{1}{2}$" AND $\frac{3}{4}$":	REBAR	CONTINUOUS	0.024"	
SCALES $\frac{3}{16}$" AND $\frac{1}{4}$":	REBAR	CONTINUOUS	0.020"	
REBAR ELEVATION EXISTING:				
	REBAR EXIST	DASHDOT2	0.024"	
MISCELLANEOUS:				
	CENTERLINE	CENTER	0.006"	
	CENTER CONST	CENTER	0.016"	
	CENTER LONG	CENTERX2	0.006"	
	CENTER SHORT	CENTER2	0.006"	
	CONST JOINT	ZIGZAG	0.010"	
	DIMENSION	CONTINUOUS	0.006"	
	HATCHING	CONTINUOUS	0.006"	

4.1.2.2 Proposed Objects. All proposed construction will be drawn using the following layers and linetypes:

LAYER NAME	LINETYPE	LINEWEIGHT	APPLICATION
PROPOSED	CONTINUOUS	0.014”	For all visible edges of proposed construction with ¼” or larger scales.
PROP HID LONG	HIDDENX2	0.014”	For hidden proposed construction with ¼” or larger scales.
PROP HID SHORT	HIDDEN	0.014”	For hidden proposed construction with ¼” or larger scales for depicting intricate shapes.
PROPOSED	CONTINUOUS	0.010”	For all visible edges of proposed construction with ⅛” or smaller scales.
PROP HIDDEN	HIDDEN2	0.010”	For hidden proposed construction with ⅛” or smaller scales.

4.1.2.3 Existing Objects. The following layers and linetypes are used to depict existing construction in details where existing and proposed construction are shown together:

LAYER NAME	LINETYPE	LINEWEIGHT	APPLICATION
EXISTING	DASHDOT2	0.005”	For existing objects.
EXISTING HIDDEN	HIDDEN	0.005”	For hidden existing objects.
EXISTING GROUND	DASHDOT	0.005”	For existing ground surfaces.

4.1.2.4 Proposed Rebar Elevations. These layers and linetypes are used to depict elevation views of proposed rebars in section views through proposed concrete construction. They are to be used to represent all rebars for the given drawing scale regardless of the actual bar diameter.

LAYER NAME	LINETYPE	LINEWEIGHT	APPLICATION
REBAR	CONTINUOUS	0.028”	For all straight bars or bent bars lying entirely in the plane of 1” and 1½” scale drawings.
REBAR	CONTINUOUS	0.024”	For all straight bars or bent bars lying entirely in the plane of 3/8”, ½”, and 3/4” scale drawings.
REBAR	CONTINUOUS	0.020”	For all straight bars or bent bars lying entirely in the plane of 3/16” and 1/4” scale drawings.

Rebars should be drawn with bend radii drawn accurately to the correct scale. This is important so that the Designer can quickly see any conflicts with rebar placement and development length.

4.1.2.5 Existing Rebar Elevations. This layer and linetype shall be used to depict existing reinforcing bars in details where existing and proposed rebars are shown together:

LAYER NAME	LINETYPE	LINEWEIGHT	APPLICATION
REBAR EXIST	DASHDOT2	0.024”	For all existing straight bars or existing bent bars lying entirely in the plane of the drawing.

4.1.2.6 Excavation Surface Line. The CONST JOINT layer and ZIGZAG linetype shall be used to represent the concrete cut line (on elevation views) or the concrete cut surface (in section views) on existing concrete construction when defining limits of concrete excavation. On details with existing and proposed construction, this line is used to represent the interface between old and new concrete ONLY if this interface was created through the excavation of the existing concrete construction. If proposed concrete is cast onto an existing un-excavated concrete surface, the interface should be shown using the PROPOSED layer and CONTINUOUS linetype.

The CONST JOINT layer and ZIGZAG linetype shall also be used to represent the raked finish given to a concrete surface against which a second pour of concrete will be placed, such as the top of a bridge deck under the sidewalk slab.

4.1.2.7 Centerlines. The CENTERLINE, CENTER LONG, and CENTER SHORT layers and CENTER, CENTERX2, and CENTER2 linetypes shall be used wherever the centerline of an object needs to be indicated. This includes:

1. The centerlines of beams, both for dimensioning purposes and for indicating the location of beams on the plan view of an abutment or pier.
2. The centerlines of bearings, on abutment or pier plan views, on bridge seat cross sections, on framing Construction Drawings, and elsewhere.
3. The centerlines of bolts, holes, and any other object for the purpose of dimensioning.

Centerlines of construction and baselines of survey shall be created using the CENTER CONST layer, CENTER linetype, 0.016” lineweight, WHOLE STATION symbol, and TICK MARK symbol. The WHOLE STATION symbols shall be located at each whole station point and the TICK MARK symbol shall be located at each +50 point.

4.1.2.8 Witness/Hatch Lines. The HATCHING layer and CONTINUOUS linetype shall be used for drawing witness lines when dimensioning. Also to be used for hatch and cross hatch lines.

4.1.2.9 Dimension Lines. The DIMENSION layer and CONTINUOUS linetype shall be used with an ARROW symbol at both ends with the dimension being placed over the line.

4.1.2.10 Arrow Lines. The DIMENSION layer and CONTINUOUS linetype shall be with an ARROW symbol at one end for pointing from a block of text to an object.

4.1.2.11 Double Arrow Lines. The DIMENSION layer and CONTINUOUS linetype shall be with two ARROW symbols at one end to indicate that a particular dimension or spacing of objects continues beyond the edge of the given detail in the direction of the double arrows.

4.1.3 Symbols

4.1.3.1 Table 4.2 shows the standard Bridge Section symbols and their dimensions for rebars in section views, arrow heads to be used with dimension lines, arrow lines, double arrow lines, whole stations and half station symbols to be used with centerlines of construction and baselines of survey, symbols for indicating the limits of riprap/rockfill on plan drawings, symbols to depict boring and probe locations, and symbols for denoting the location of section views.

4.1.3.2 Proposed Rebar Sections. These symbols represent the end view of a proposed rebar in section views and also represent bent bars, such as L or U bars, where the bent leg is not in the plane of the drawing. The filled circle of the given diameter is used to represent all rebars in the specified scale regardless of the actual diameter.

4.1.3.3 Existing Rebar Sections. These symbols represent the end view of an existing rebar in section views where existing and proposed rebars are shown together and also represent bent bars, such as L or U bars where the bent leg is not in the plane of the drawing. The open circle of the given diameter is used to represent all existing rebars in the specified scale regardless of the actual diameter.

4.1.3.4 Section Symbols and Section Tails. These symbols are used together to indicate the plane along which a section view is being taken. The section symbol is comprised of a split circle superimposed on an arrow. This arrow, along with the tail arrow, indicates the direction of the section view. The line which divides the split circle into two text blocks is always drawn horizontal. The top text block gives the section number, the bottom text block gives the sheet number on which the section view is shown. Sections shall be numbered in consecutive order from the start to the end of the bridge construction drawings. The first section that appears on the bridge construction drawings shall be Section 1 and there shall be no repetition of any section number.

4.1.3.5 Welding Symbols. Weld and welding symbols shall be consistent with AWS 2.4 Standard Symbols for Welding, Brazing, and Nondestructive Examination. Figure 4.1 provides an example that shall be modified as required to convey all information necessary to construct the welded joint as designed.

FIGURE 4.1 STANDARD WELDING SYMBOL

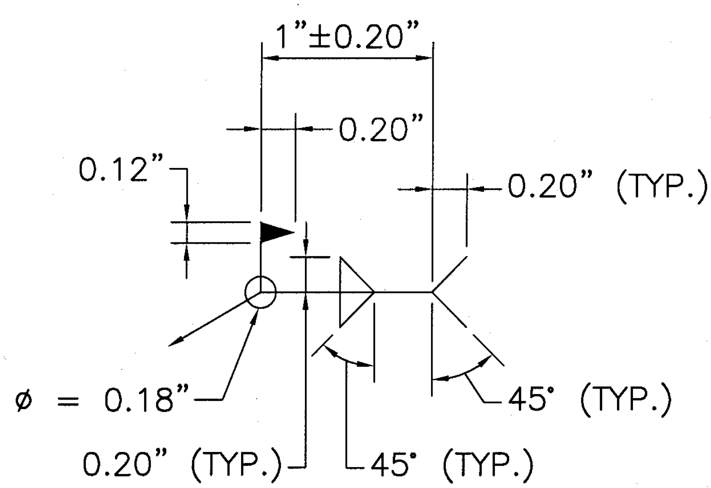


TABLE 4.2 STANDARD BRIDGE SECTION SYMBOLS

DESCRIPTION	SYMBOL	SIZE	TO BE USED WITH	APPEARANCE
ARROW HEAD	►	0.100"	DIMENSION LINES	
			ARROW LINES	
			DOUBLE ARROW LINES	

DESCRIPTION	SYMBOL	DIA.	TO BE USED WITH	APPEARANCE
REBAR SECTION PROPOSED:				
SCALES $\frac{3}{16}$", $\frac{1}{4}$", $\frac{3}{8}$", $\frac{1}{2}$" AND $\frac{3}{4}$":	•	0.050"	SINGLE BENT (L–BAR)	
SCALES 1" AND $1\frac{1}{2}$":	●	0.063"	DOUBLE BENT (U–BAR)	
			SINGLE REBAR SECTION	●
REBAR SECTION EXISTING:				
SCALES $\frac{3}{16}$", $\frac{1}{4}$", $\frac{3}{8}$", $\frac{1}{2}$" AND $\frac{3}{4}$":	○	0.050"	SINGLE BENT (L–BAR)	
SCALES 1" AND $1\frac{1}{2}$":	○	0.063"	DOUBLE BENT (U–BAR)	
			SINGLE REBAR SECTION	○

DESCRIPTION	SYMBOL	HEIGHT	DIA.	TO BE USED WITH	APPEARANCE
WHOLE STATION:					
PROPOSED PLAN	○		0.125"	℄ OF CONST. & SURVEY ℄	
KEY PLAN	○		0.094"	℄ OF CONST. & SURVEY ℄	
TICK MARK:					
PROPOSED PLAN	|	0.125"		℄ OF CONST. & SURVEY ℄	
KEY PLAN	|	0.094"		℄ OF CONST. & SURVEY ℄	

DESCRIPTION	SYMBOL	WIDTH	HEIGHT	TO BE USED WITH	APPEARANCE
RIPRAP/ROCKFILL:					
PROPOSED PLAN		0.600"	0.094"	LIMITS OF RIPRAP/ROCKFILL	
KEY PLAN		0.300"	0.047"	LIMITS OF RIPRAP/ROCKFILL	

DESCRIPTION	SYMBOL	TAIL HEIGHT	SECTION DIA.	LINEWEIGHT
SECTION			0.500"	0.020"
TAIL		0.276"		0.020"
BORING LOCATION			0.150"	0.020"
PROBE LOCATION			0.100"	0.010"

4.1.4 Text Styles, Layers, Lineweights, Heights, and Usage

4.1.4.1 The text style to be used on Bridge Section Construction Drawings shall be one that approximates K&E Leroy lettering style, such as Roman Simplex in AutoCAD. The following layers and lettering heights are to be used as outlined below:

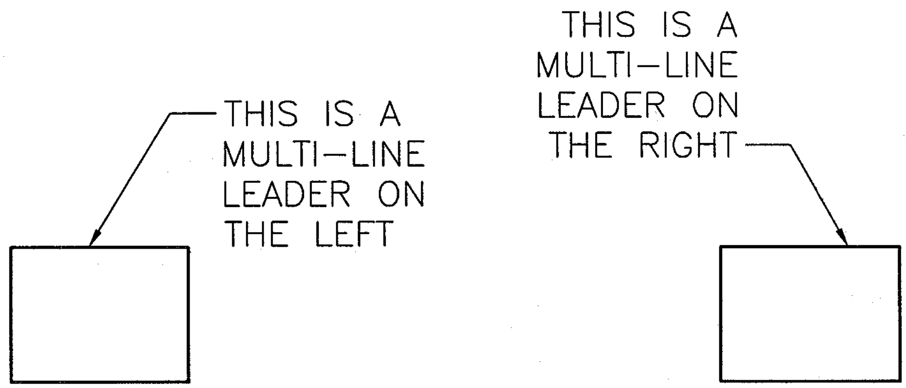
TABLE 4.3 STANDARD BRIDGE SECTION TEXT

LAYER NAME	LINEWEIGHT	TEXT HEIGHT	APPEARANCE
TEXT 3	0.010"	3/32"	FEDERAL TEXT
TEXT 4	0.010"	1/8"	STANDARD TEXT
TEXT 5	0.014"	5/32"	SUBTITLE TEXT
TEXT 6	0.020"	3/16"	DETAIL/SECTION TEXT
TEXT 8	0.020"	1/4"	SHEET TITLE TEXT

Layer Name	Lineweight	Height	Usage
TEXT 3	0.010”	3/32”	Only to be used to fill in the Federal Aid No. in the upper right hand title block or, for In-House drawings only, to fill in the names for Designed By, Drawn By, etc., in the main title block on the first sheet.
TEXT 4	0.010”	⅛”	To be used for all lettering on the Construction Drawings. This includes annotating details, notes, dimensions, etc.
TEXT 5	0.014”	5/32”	Subtitles on drawings.
TEXT 6	0.020”	3/16”	Individual detail drawing titles, including section designations.
TEXT 8	0.020”	1/4”	When giving a title to a set of drawings, or when giving a title to an entire sheet.

4.1.4.2 Multiple lines of text shall be left justified and the leader line start point shall be located just to the left of the start of the text. In cases where it is advantageous to have the leader line located to the right of the text, the text shall be right justified and the leader line start point shall be located just to the right of the last line of text. Refer to the examples in Figure 4.2.

FIGURE 4.2 STANDARD MULTIPLE TEXT LINES



4.1.5 Abbreviations

4.1.5.1 Table 4.4 lists the acceptable standard abbreviations that are to be used on MassHighway bridge Construction Drawings. Periods where shown are <u>not</u> to be omitted so that the reader can be sure that these abbreviations are intentional rather than being misspelled words.

4.1.5.2 When using abbreviations, the following guidelines will be adhered to:

1. An abbreviation may be used when there is no doubt of its meaning and when it saves significant space on the drawings.
2. Avoid abbreviations on the plan and elevation sheet.
3. Do not abbreviate important words in titles.
4. For words whose abbreviations are not universally recognized in the construction industry the word should be spelled out and followed with the abbreviation in parenthesis the first time it appears on the Construction Drawings.
5. Abbreviations should not be used in the text of notes unless they are conventional abbreviations, such as H.S. Bolt for High Strength Bolt.

TABLE 4.4 STANDARD ABBREVIATIONS

<u>A</u>		At	@
Abutment	ABUT.	Avenue	AVE.
Alternate	ALT.		
And	&	<u>B</u>	
Annual Average Daily Traffic	AADT	Barrels	BBL.
Approach slab	APPR. SLAB	Beam Number 1	BM. #1
Approximate	APPROX.	Bearing, Bearings	BRG., BRGS.

TABLE 4.1 STANDARD ABBREVIATIONS (Continued)

Bench mark	B.M.
Bituminous	BIT.
Bottom	BOT.
Boulevard	BLVD.
Bridge Number A-01-001	BR. NO. A-01-001
C	
Catch basin	C.B.
Cast-in-place	C.I.P.
Cast iron pipe	C.I. PIPE
Cement	CEM.
Center To Center	C. TO C.
Clearance, Clear	CL.
Concrete	CONC.
Construction	CONST.
Culvert	CULV.
Chamfer	CHAMF.
D	
Degrees (angular)	º
Degrees (thermal)	ºF
Diameter	DIA. *or* ∅
Distance	DIST.
Dowel	DWL.
Drive	DR.
E	
Each	EA.
East	E.
East (for survey bearings)	E
Eastbound	E.B.
Elevation	EL.
Equal (as in equal spaces)	EQ.
Expansion	EXP.
Existing	EXIST.
Exterior	EXT.
F	
Far Face	F.F.
Federal Highway Administration	FHWA
Figure, Figures	FIG., FIGS.
Floor Beam Number 1	F.B. #1
G	
Galvanized	GALV.
Gage	GA.
H	
Hexagonal Head	HEX. HEAD
High Performance Concrete	H.P.Concrete
High Performance Steel	H.P.S.
High Strength	H.S.
Highway	HWY.
Horizontal	HORIZ.
Hot Mix Asphalt	HMA
I	
Inside Diameter	I.D.
Interior	INT.
J	
Joint	JT.
K	
Kips	K
Kips per square inch	KSI
Kips per square foot	KSF
L	
Latex Modified Concrete	L.M.C.
Longitudinal	LONGIT.
Lump sum	L.S.
M	
Manhole	M.H.
Massachusetts Highway Department	MHD
MassHighway	MHD
Maximum	MAX.
Miles per Hour	MPH
Minimum	MIN.
Miscellaneous	MISC.
Modified	MOD.
N	
Near Face	N.F.
New Jersey Barrier	N.J. BARRIER
North	N.
North (for survey bearings)	N
Northbound	N.B.
Northeast(erly)	N.E.
Northwest(erly)	N.W.
Not to scale	N.T.S.
Number	NO. *or* #
Numbers	NOS.

TABLE 4.1 STANDARD ABBREVIATIONS (Continued)

O	
On Center	O.C.
Outside Diameter	O.D.
Outside To Outside	O. TO O.
P	
Pavement	PVMT.
Perpendicular	PERP.
Point of Compound Curvature	P.C.C.
Point of Curvature	P.C.
Point of Intersection	P.I.
Point of Tangency	P.T.
Point of vertical curvature	P.V.C.
Point of vertical intersection	P.V.I.
Point of vertical tangency	P.V.T.
Polyvinyl chloride pipe	P.V.C. PIPE
Pounds per square inch	PSI
Proposed	PROP.
R	
Radius =	R =
Railroad	RR.
Reinforced, Reinforcing	REINF.
Remove	REM.
Remove and Reset	R. & R.
Required	REQ'D
Retaining Wall	RET. WALL
Right Of Way	R.O.W.
Road	RD.
Roadway	RDWY.
Route	RTE.
S	
Seconds	SEC.
Section	SECT.
Sheet number 1	SH. #1
Sidewalk	SDWK.
South	S.
South (for survey bearings)	S
Southeast(erly)	S.E.
Southwest(erly)	S.W.
Southbound	S.B.
Spaces	SP.
Specification	SPEC.
Speed (design speed)	V
Square	SQ.
Square feet	SF
Square inches	SI
Stainless steel	S.S.
Station	STA.
Stay-In-Place Forms	S.I.P. FORMS
Street	ST.
Surfacing	SURF.
Symmetrical	SYM.
T	
Tangent	TAN.
Temporary	TEMP.
Tons per square foot	TSF
Typical	TYP.
V	
Variable	VAR.
Vertical	VERT.
Vertical Curve	V.C.
W	
Wearing Surface	W.S.
West	W.
West (for survey bearings)	W
Westbound	W.B.
Wingwall	W.W.
Working Point	W.P.
Wrought Iron Pipe	W.I. PIPE

4.2 PREPARATION OF CONSTRUCTION DRAWINGS

4.2.1 General

4.2.1.1 Construction Drawings shall clearly and accurately depict all pertinent aspects and details necessary to construct the proposed structure. They should be organized in a logical sequence, as outlined below, which follows the flow of the construction work. Ideally, related details should be grouped on the same sheet. If this is not possible, related details should then be located on adjacent sheets so that flipping between sheets is minimized. In no way should related details be scattered throughout the construction drawings. Appropriate scales shall be used to show a clear presentation of the details of the structure.

Sections shall be numbered in consecutive order from the start to the end of the bridge construction drawings. The first section that appears on the bridge construction drawings shall be Section 1 and there shall be no repetition of any section number. Details shall be identified by a title or by a letter consistent with the Bridge Manual drawings. The first detail identified by a letter that appears on the bridge construction drawings shall be Detail A and subsequent lettered details shall be ordered in an alphabetical sequence without repetition.

4.2.1.2 The baseline of survey shall be the basic reference line for the layout of the bridge. The centerlines of bearings on the abutments and piers shall be the basic lines to be tied to the baseline of survey. Thus, the beam layout, footing layout, Construction Drawings of piers and abutments should be referenced by the station of the intersection of the baseline and the centerline of bearings and by the angle between them. In some cases, the baseline of survey may be away from the structure, in which case the centerline of construction shall be used. Where the bridge is on a curve, the skew angles of the centerlines of bearings of the beams should be computed to a tangent to the horizontal curve at the centerline of bearings, and all offsets for the layout should be at right angles to that tangent. Radial offsets to the curve are not acceptable.

4.2.1.3 Construction Drawings shall be drafted on mylar (plastic drafting film) having a minimum thickness of 4 mils and matte on one side only.

4.2.1.4 The standard sheet size shall be as shown on Drawing No. 1.1.1 of Part II of this Bridge Manual.

4.2.2 Organization

4.2.2.1 The following is an accepted sequence for organizing Construction Drawings:

1. First Sheet
2. Boring Sheets
3. Plan and Elevation Sheet
4. Stage Construction Detail Sheets
5. Substructure Sheets
6. Beam Detail Sheets
7. Deck Detail Sheets
8. Miscellaneous Detail Sheets

The first sheet including borders and title blocks shall be laid out as shown on Drawing No. 1.1.1 of Part II of this Bridge Manual. All subsequent sheets including borders and title blocks shall be laid out as shown on Drawing No. 1.1.2 of Part II of this Bridge Manual.

4.2.2.2 First Sheet. The first sheet shall contain the following information:

Standard Title Block: The project description will be specified as follows:

PROPOSED BRIDGE - New substructure and superstructure. Any existing bridge structure may be retained, in whole or in part, or may be removed in its entirety, however no portion of the existing bridge structure will be incorporated into the proposed bridge structure.

PROPOSED SUPERSTRUCTURE REPLACEMENT - All elements of the superstructure are replaced. Substructure elements are retrofitted to meet current code requirements and/or some, but not all, substructure elements are replaced.

PROPOSED BRIDGE REHABILITATION - Some superstructure and substructure elements are replaced and/or existing elements that are to remain are retrofitted to meet current code requirements.

Federal Aid Block

Key Plan: Same as for Sketch Plans, see Paragraph 2.7.3.2

Locus: Same as for Sketch Plans, see Paragraph 2.7.3.2

Profiles: Same as for Sketch Plans, see Paragraph 2.7.3.2

General Notes: The standard general construction notes are outlined in Paragraph 4.2.2.10 and are intended to be located on the first sheet on the right hand side between the Federal Aid Block and the Standard Title Block.

Hydraulic Data: The same hydraulic data as shown on the Sketch Plans shall also appear on the construction drawings. See Paragraph 2.7.3.2 for the information required and the standard format.

Estimated Quantities: The estimated quantities of the bridge related items only shall typically be located to the left of the General Notes.

If the Key Plan, Locus and Profiles take up too much space or if the General Notes, Hydraulic Data and Estimated Quantities are too extensive to fit on the First Sheet, a separate second sheet, conforming to the layout for standard subsequent sheets (Drawing No. 1.1.2 of Part II of this Bridge Manual) may be added specifically for the General Notes, Hydraulic Data and Estimated Quantities. In this case, an Index To Drawings should be provided on the First Sheet.

4.2.2.3 Boring Sheets. The information provided will be the same, including the same Boring Notes, as required for Sketch Plans. See Paragraph 2.7.3.3. If a separate second sheet is provided for General Notes, etc., the Boring Notes can also be included on that sheet.

4.2.2.4 Plan and Elevation Sheet. A large scale plan view and one elevation view of the proposed bridge structure showing roadway and sidewalk dimensions, layout and all dimensions of the railings and paraffin joints, location of the substructure elements, in square dimensions, in relation to the features crossed, proposed minimum clearances.

4.2.2.5 Stage Construction Detail Sheets. These sheets will show all details and dimensions necessary to layout and construct all elements of the bridge in accordance with the approved traffic management plan. At a minimum, these details will include:

1. Plan and cross section for each stage of construction. It is essential that all critical dimensions be included.
2. Temporary earth support details.
3. Temporary bridge barrier details.

4.2.2.6 Substructure Sheets. These sheets will show all details and dimensions necessary to layout and construct all substructure elements for the bridge. At a minimum, these details will include:

1. Plan and elevation view of abutments and piers showing all dimensions, bridge seat elevations, footing elevations, top of wall and other controlling elevations.
2. Foundation support details.
3. Footing layout.
4. Substructure joint details.
5. Typical sections with all reinforcement details.

4.2.2.7 Beam Detail Sheets. These sheets will show all details and dimensions necessary for the fabrication of the bridge's load carrying members. At a minimum these details will include:

1. Framing plan.
2. All beam details and notes necessary for correct fabrication.
3. Beam camber requirements (steel only).
4. All connection details.
5. Diaphragm details along with their connections.
6. Utility support details.
7. Shear connector details.
8. Bearing details.

4.2.2.8 Deck Detail Sheets. These sheets will show all details and dimensions necessary for constructing the bridge deck and all related elements. At a minimum these details will include:

1. Typical superstructure cross section.
2. Deck details including required thickness and reinforcement.
3. Haunch detail.
4. Top of Form elevations (if required).
5. Sidewalk, safety curb, barrier details including reinforcement.
6. Reinforcement details for continuous bridges including pouring sequences if required.

4.2.2.9 Miscellaneous Detail Sheets. These sheets will show all additional details necessary to construct the bridge structure. These sheets may include the following:

1. Joint details.
2. Bridge Rail to Highway Guardrail Transition Sheet (MassHighway standard sheet).
3. Railing details (MassHighway standard sheet).
4. Type II Protective Screen details (MassHighway standard sheets).

4.2.2.10 The following are standard general construction notes. The wording and content may vary to suit the particular needs of the project:

GENERAL NOTES

DESIGN:

IN ACCORDANCE WITH THE 20-- SPECIFICATIONS OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS WITH CURRENT INTERIM SPECIFICATIONS THROUGH 20--, FOR HS25 LOADING. (*If the bridge carries Interstate traffic, the note shall be modified by adding:* MODIFIED FOR MILITARY LOADING. *If the design loading is different from HS25, specify the actual design loading*.)

If the bridge carries a railroad, substitute the following note:
IN ACCORDANCE WITH THE 20--SPECIFICATIONS OF AREMA FOR RAIL BRIDGES, INCLUDING INTERIM SPECIFICATIONS THROUGH 20--.

BENCH MARK:

Give location and elevation of control bench mark. It is to be noted that if a structure is in a pre-loaded area and the nearest bench mark becomes covered, another benchmark outside the area should be selected. Following the elevation of the bench mark, the following note should be added:

ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.

DATE:

TO BE PLACED ON THE INSIDE FACE OF THE -- AND – HIGHWAY GUARDRAIL TRANSITIONS. A SHEET SHOWING SIZE AND CHARACTER OF NUMERALS WILL BE FURNISHED. THE DATE USED SHALL BE THE LATEST YEAR OF CONTRACT COMPLETION AS OF THE DATE THE FIRST HIGHWAY GUARDRAIL TRANSITION IS CONSTRUCTED. ALL HIGHWAY GUARDRAIL TRANSITIONS SHALL FEATURE THE SAME DATE.

SURVEY NOTEBOOKS:

List survey notebooks used in the preparation of construction drawings:
Baseline __________, Details __________, Cross-sections __________, or, if electronic survey was used, state that copies of files may be obtained from MassHighway.

FOUNDATIONS:

FOUNDATIONS MAY BE ALTERED, IF NECESSARY, TO SUIT CONDITIONS ENCOUNTERED DURING CONSTRUCTION, WITH THE APPROVAL OF THE ENGINEER.

UNSUITABLE MATERIAL:

ALL UNSUITABLE MATERIAL SHALL BE REMOVED WITHIN THE LIMITS OF THE FOUNDATIONS OF THE STRUCTURE, AS DIRECTED BY THE ENGINEER.

ANCHOR BOLTS:

If none of the these conditions is present:
a. Uplift
b. The bridge has a severe skew
c. There is more than the usual amount of reinforcing steel in the bearing area.
the following note may be used:
ALL BRIDGE BEARING ANCHOR BOLTS SHALL BE SET BY TEMPLATE BEFORE THE CONCRETE IS PLACED, EXCEPT AT ABUTMENTS, WHERE CORING AND GROUTING MAY BE USED AT THE CONTRACTOR'S OPTION, PROVIDED THAT THE METHOD OF INSTALLATION WILL NOT CUT REINFORCING STEEL.

Otherwise, use the following note:
ALL ANCHOR BOLTS SHALL BE SET BY TEMPLATE BEFORE THE CONCRETE IS PLACED.

REINFORCEMENT:

REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M 31 GRADE 60. UNLESS OTHERWISE NOTED ON THE CONSTRUCTION DRAWINGS, ALL BARS SHALL BE LAPPED AS FOLLOWS:

MODIFICATION CONDITION	#4 BARS	#5 BARS
1. NONE	21”	26”
2. 12” OF CONCRETE BELOW BAR	29”	36”
3. COATED BARS, COVER < $3d_b$, OR CLEAR SPACING < $6d_b$	31”	39”
4. COATED BARS, ALL OTHER CASES	24”	30”
5. CONDITION 2. AND 3.	35”	44”
6. CONDITION 2. AND 4.	33”	42”

IF THE ABOVE BARS ARE SPACED 6” OR MORE ON CENTER, THE LAP LENGTH SHALL BE 80% OF THE LAP LENGTH GIVEN ABOVE. ALL OTHER BARS SHALL BE LAPPED AS SHOWN ON THE CONSTRUCTION DRAWINGS.

4.3 SUBMISSION OF CONSTRUCTION DRAWINGS

4.3.1 First Structural Submittal

Two (2) sets of Construction Drawing prints and one (1) set of design calculations along with one (1) set of independent design check calculations shall be submitted to MassHighway for initial review. These Construction Drawings, except for quantities, shall be in a completely finished state, fully designed and checked before being submitted to MassHighway. The date of submission should be stamped on the first sheet of the Construction Drawings. The design calculations and the independent check calculations shall also be identified, at a minimum, with the Bridge No. and BIN (Bridge Identification Number).

If the structure carries a railroad, an additional three (3) sets of prints and three (3) sets of design calculations shall be submitted for review by the railroad involved. If excavation for the construction of any bridge or wall requires sheeting for the protection of an existing railroad embankment, three (3) sets of drawings showing the proposed sheeting and three (3) sets of supporting design calculations shall be submitted for railroad review.

The Bridge Section will review the initial submission of construction drawings, and return marked-up prints to the Designer for reconciliation of comments.

4.3.2 Second Structural Submittal

After all Bridge Section review comments have been reconciled, the Designer shall submit two (2) sets of updated Construction Drawing prints to MassHighway. At this time the Designer shall also submit two (2) sets of Special Provisions and two (2) sets of Preliminary Estimate of Quantities. If Federal Highway Administration (FHWA) review is required, an additional half size set of construction drawing prints, one (1) set of Special Provisions, and one (1) set of Preliminary Estimate of Quantities shall be submitted.

4.3.3 Submission of Mylars

Review comments made by the FHWA will be sent to the Designer for response in writing. When MassHighway receives FHWA approval, the Designer will submit construction drawing mylars to the Bridge Section for final back-check. Mylars submitted by outside consultants shall have the name and address of the Designer as well as the stamp and signature of a Registered Professional Engineer incorporated into the Standard Title Block, as shown on Drawing No. 1.1.4 of Part II of this Bridge Manual.

4.4 REVISIONS TO CONSTRUCTION DRAWINGS

4.4.1 Approval Procedure

4.4.1.1 General. It may be necessary to revise the Contract Drawings for a variety of reasons such as errors, omissions, changes in design conditions, changes requested during construction, etc. The procedure for initiating and approving these changes is outlined below and is taken from the Commonwealth of Massachusetts, Massachusetts Highway Department, Standard Operating Procedure No. CSD-24-16-1-000, *Structural Approval Procedures*.

4.4.1.2 Errors on the Construction Drawings. If errors on the Construction Drawings or in the Special Provisions are found by the Designer or Contractor's fabricator, the information with recommended corrective action shall be referred through the Designer directly to the Bridge Engineer. Only a copy of the letter shall be sent to the District Highway Director and the Construction Engineer. The Bridge Engineer will review the corrective action for approval and the Designer will distribute revised Construction Drawings and/or shop drawings. If revisions to the Construction Drawings are not necessary, the Bridge Engineer will inform the Construction Engineer who in turn will inform the Contractor through the District Highway Director.

Errors discovered by all others will be processed through normal MassHighway channels.

4.4.1.3 Requested Changes. No request for any change shall be initiated unless all of the four following questions can be answered in the affirmative:

1. Is the change in the public interest?
2. Does it provide an equal or better material or product than originally specified?
3. Does it provide a better method of construction than originally planned?
4. If the Contractor benefits from the change, is there a corresponding benefit to MassHighway?

The Construction Engineer will determine the validity of the reasons given for any change.

I. Changes Requested by the Fabricator:

These requests shall be submitted by the Fabricator to the Designer with copies of the letter to the Prime Contractor and the District Highway Director. The Designer will review the requests and make comments and/or recommendations to the Bridge Engineer. Approval or disapproval will be given by the Bridge Engineer and any necessary revisions to the Construction Drawings will be made and distributed in accordance with the current revision procedure. The Designer will inform the fabricator of the approval or disapproval (copies of the letter to the prime contractor and the District Highway Director) and the shop drawings will be submitted accordingly.

II. Changes requested by the Contractor:

If the Contractor requests a change in the Construction Drawings and/or Special Provisions, he/she shall submit all the necessary information to the District Highway Director, who will forward the request to the Construction Engineer with the District's comments and/or recommendations. If the Construction Engineer determines that there is no question of structural design, he/she shall approve or disapprove the request at that level. If a design review is required it shall be processed by the Bridge Engineer and the conclusions regarding structural integrity only will be forwarded to the Construction Engineer. The Contractor will then be informed of the approval or disapproval through the District Highway Director.

III. Changes Requested by Outside Agencies:

If requests for changes in the Construction Drawings and/or Special Provisions are made by outside agencies the same procedure as specified above for changes by the Contractor shall be followed.

4.4.1.4 Corrective Repairs. When errors are made by the Contractor during construction, and in the opinion of the District Construction Engineer corrective repairs are possible, the complete proposed method of correction including calculations, shall be submitted to the District Highway Director and forwarded to the Construction Engineer with the District's comments and/or recommendations. The Construction Engineer will review and check fully and refer to the Bridge Engineer for structural acceptance, if deemed necessary. Approval or disapproval will be given by the Construction Engineer and the Contractor shall be so informed through the District Highway Director.

4.4.1.5 Railroad Approval. Whenever railroad approval is required for structural changes, the approval will be handled solely by the Bridge Engineer.

4.4.1.6 FHWA Concurrence. When FHWA concurrence is required for structural matters it will be obtained by the Bridge Engineer prior to issuance of revised Construction Drawings. The Construction Engineer will handle all other matters directly with the FHWA.

4.4.1.7 Proper Channels. District Highway Directors shall instruct all Resident Engineers and others connected with a project during construction that structural field problems shall not be referred directly to the Bridge Engineer and/or the Designer. All information shall be reviewed and checked by the Construction Engineer before being referred to the Bridge Engineer.

4.4.1.8 Supplemental Instructions to Resident Engineers.

1. Review the Construction Drawings and Special Provisions with your assistants as soon as possible.
2. Discuss any apparent errors and/or discrepancies with the District Construction Engineer or his/her assistants who in turn will inform the Boston Construction Division.
3. Get clarification on any part of the Construction Drawings and/or Special Provisions that are not clear.
4. Avoid future claims by correcting ambiguities, discrepancies and errors before additional costs result.
5. Do not make changes or initiate changes unless they are justified and agreed to in writing by the Bridge Engineer to be necessary.

4.4.2 Revising Construction Drawings

4.4.2.1 Drawing No.'s 1.1.6 and 1.1.7 of Part II of this Bridge Manual illustrate the proper method for making and recording revisions to contract drawings.

4.4.2.2 MassHighway policy requires that all original Contract Drawing mylars remain within MassHighway offices. Therefore, the Designer will not be allowed to remove contract drawings from MassHighway offices in order to make these revisions.

4.4.2.3 Since the Contract Drawings are part of the Contract Documents, NO ERASURE of any existing details is allowed. All deletions on the Construction Drawings must be made by drawing a box around the part to be deleted and drawing a cross through that box as indicated on Drawing No. 1.1.7 of Part II of this Bridge Manual. If extensive changes to a detail are required, then the old detail should be deleted in its entirety and a new detail should be drawn and identified as a revision by a revision symbol.

4.4.2.4 MassHighway does not require a separate set of "As-Built" drawings, but instead uses the revisions to the Construction Drawings to document the as-built condition of the bridge structure. For this reason, any changes made during construction that deviate significantly from the original Construction Drawings and which will affect the ability to perform future maintenance and rehabilitation work and/or load rating of the bridge shall be documented as revisions. Any such changes that warrant as-built documentation but which have not been previously issued as revisions during construction can be issued as a final "As-Built" revision at the conclusion of construction.

4.4.3 Distribution of Revised Construction Drawings

The distribution of prints of revised Contract Drawings will be made by the Bridge Section. After the Bridge Section makes the necessary number of print sets, the mylars will be forwarded to the MassHighway Construction Plans and Records office for electronic archiving. The normal processing of revised Construction Drawings to all parties concerned requires the following distribution of prints:

MassHighway Construction Engineer (non-Federal Aid):	9 Sets
MassHighway Construction Engineer (Federal Aid):	11 Sets
Designer:	2 Sets

CHAPTER 5
SPECIAL PROVISIONS AND ESTIMATE

5.1 GENERAL

This chapter is intended to instruct the Designer in the preparation and submission of Special Provisions and Estimate to the Bridge Section.

After the first design review comments have been resolved, the Designer shall submit two (2) sets of Special Provisions and two (2) sets of Preliminary Estimate of Quantities along with the updated Construction Drawing prints. This is considered part of the Second Structural Submittal.

5.2 SPECIAL PROVISIONS

5.2.1 General

The MassHighway Standard Specifications, Supplemental Specifications, and Standard Special Provisions cover most of the standard items, materials and construction methods used to construct bridges in Massachusetts. Where a Standard Specification item adequately describes the work required, no Special Provision item is needed. However, there may be situations where either there is no Standard Specification or Supplemental Specification or the ones that exist do not adequately cover all of the work, construction methods or materials to be used. In these situations, a Special Provision must be written.

Thus, the purpose of a Special Provision is:

- to provide requirements regarding materials or methods of construction that are not covered in the Standard Specifications or Supplemental Specifications.
- to modify or supplement the Standard Specifications or Supplemental Specifications such that any unique aspects regarding the requirements for a particular item of work are adequately explained.

Furthermore, Special Provisions provide a means of eliminating all ambiguities from the project. However, Special Provisions should not be written merely for the sake of writing something, nor should they duplicate or paraphrase the text of a Standard Specification or Supplemental Specification item. Also, Special Provisions must not contradict or be in conflict with any other provision of the Standard Specifications, Supplemental Specifications, other Special Provisions or any other specifications or requirements included as part of the contract documents, such as railroad specifications.

5.2.2 Payment Items

5.2.2.1 GENERAL: It is important to select the appropriate type of payment item in the preparation of a special provision. The two basic types of payment items are Lump Sum and quantity driven Unit Price.

5.2.2.2 LUMP SUM: In a Lump Sum payment item, the Contractor is paid a fixed price for a particular component of work done and no measurement of the final pay quantity is required. However, a Lump Sum can only be used for an item in which the scope of work, the methods of construction, and the type and quantity of materials to be furnished can be accurately defined on the Construction Drawings and/or in the Special Provision, such as a Lump Sum for the construction of the bridge structure.

5.2.2.3 UNIT PRICE: All other items must utilize a Unit Price basis of payment since the Contractor's bid is based on estimated quantities that may vary considerably from the actual quantities required during construction. The Contractor's payment is determined on the basis of measured quantities and his/her contract unit price bid for the particular item. A partial listing of unit price items and their units is as follows:

1.	All types of Excavation	Cubic Yard
2.	All types of Gravel Borrow	Cubic Yard
3.	All types of Crushed Stone	Ton
4.	All types of Borings	Linear Foot
5.	Hot Mix Asphalt	Ton
6.	Cement Concrete for Tremie Seals	Cubic Yard
7.	Drilled and Chemical Anchored #X Dowels	Each
8.	Drilled and Chemical Anchored X In. Dia. Threaded Rods	Each
9.	Driven Piles or Drilled Shafts	Linear Foot
10.	Dynamic Load Test	Each
11.	Piles Shoes	Each
12.	Excavation Support System	Square Yard
13.	Permanent, Temporary, or Interim Steel Sheeting	Square Yard
14.	Temporary Waterway Diversion Structure	Each
15.	All types of Riprap and Rock Fill	Ton

5.2.3 Preparing a Lump Sum Item

5.2.3.1 A Lump Sum item pays for several components of the bridge that have readily measurable and essentially fixed quantities and which require separate material and/or construction requirements. Normally used Lump Sum items include: ITEM 114.1, DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. X-XX-XXX (XXX); ITEM 115.1, DEMOLITION OF BRIDGE NO. X-XX-XXX (XXX); ITEM 992.1, ALTERATION TO BRIDGE STRUCTURE NO. X-XX-XXX (XXX); ITEM 995., BRIDGE SUPERSTRUCTURE, BRIDGE NO. X-XX-XXX (XXX); and ITEM 995.01, BRIDGE STRUCTURE, BRIDGE No. X-XX-XXX (XXX).

Lump Sum items that make up a large percentage of the total cost of a project shall include a *Schedule of Basis for Partial Payment* at the end of the item listing all materials that are required to do the work under this item.

5.2.3.2 ITEM 114.1, DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. X-XX-XXX (XXX), shall only be used when the existing superstructure is not a rigid frame and is to be demolished and removed in its entirety. The cost of this item shall be estimated by computing the deck surface area in square yards and multiplying this by an estimated average price obtained from the latest copy of the Bridge Section's "Bridge Listing" of estimated average unit prices. Substructure demolition shall be estimated and paid for separately using dedicated Unit Priced based items such as Reinforced Concrete Substructure Demolition or Stone Masonry Substructure Demolition.

5.2.3.3 ITEM 115.1, DEMOLITION OF BRIDGE NO. X-XX-XXX (XXX), shall only be used when the existing bridge is a rigid frame or culvert and is to be demolished and removed in its entirety. The cost of this item shall be estimated by computing the volume of the structure and multiplying this by an estimated average price obtained from the latest copy of the Bridge Section's "Bridge Listing" of estimated average unit prices.

5.2.3.4 ITEM 992.1, ALTERATION TO BRIDGE STRUCTURE NO. X-XX-XXX (XXX), shall only be used for projects defined as PROPOSED BRIDGE REHABILITATION or when the existing bridge is to have its deck replaced, is to be widened, or is to be strengthened by the addition, replacement, or repair of main members, or some combination thereof. The format of the estimate and the special provision for this item shall be the same as that used for Item 995.01.

5.2.3.5 ITEM 995., BRIDGE SUPERSTRUCTURE, BRIDGE NO. X-XX-XXX (XXX), shall only be used for projects defined as PROPOSED SUPERSTRUCTURE REPLACEMENT, where the existing bridge is to have its superstructure replaced in its entirety and the substructure elements are retrofitted and/or some, but not all, of them may also be replaced. The format of the estimate and the special provision for this item shall be the same as that used for Item 995.01.

5.2.3.6 ITEM 995.01, BRIDGE STRUCTURE, BRIDGE NO. X-XX-XXX (XXX), shall only be used for projects defined as PROPOSED BRIDGE, where an entirely new bridge structure (superstructure and substructure) is to be built or the existing bridge is to be replaced in its entirety (both new superstructure and substructure).

5.2.3.7 ITEM 995.01 SPECIAL PROVISION: The standard format for an Item 995.01 Special Provision consists of the following:

- A standard, three paragraph preamble, where the second paragraph includes a comprehensive listing of all physical parts of the bridge structure to be furnished under Item 995.01.
- A heading for each component of work and its specific requirements, if needed, that will be provided under Item 995.01. If a particular component of work included in Item 995.01 has a Standard Specification or Supplemental Specification that adequately describes what is required as it pertains to this bridge structure, no heading should be provided. A separate heading accompanied by project specific requirements is needed only if there is no Standard Specification or Supplemental Specification for this work or if these need to be modified to adequately describe the unique work that will be required for this particular bridge structure.
- The Schedule of Basis of Partial Payment. This schedule lists all of the components that will be paid for under Item 995.01, whether or not they have a separate heading.

Figure 5.1 shows the basic format and standard language for preparing Item 995.01.

The Item 995.01 Lump Sum shall include only those components of work that will be a permanent part of the new bridge structure. Any temporary work that is required for the construction of the new permanent bridge, such as a temporary pedestrian bridge or, if a bridge structure is being replaced in stages, any temporary support beams, bridge structure modifications or temporary sidewalk must not be included in the Item 995.01 Lump Sum, but should be paid for under other appropriate Lump Sum or Unit Price items.

5.2.4 Schedule of Basis For Partial Payment

The purpose of this schedule is to track unit prices and to make available a method of providing proportional payments to the Contractor on an incremental basis as the work progresses. The format and standard language accompanying the schedule is shown in Figure 5.1, which utilizes Item 995.01 as an example. The nomenclature used in the schedule must match either the headings that are included in the Lump Sum Special Provision or the nomenclature of the component as listed in the Standard Nomenclature. Sub-item numbers that are consistent with the Standard Nomenclature shall also be provided in the breakdown to facilitate unit price tracking via database entry. The listing of the Lump Sum components in the schedule shall also provide the estimated quantity and the units but not the unit prices and total costs. The Contractor shall provide his/her bid unit price and the total cost for each component after the award of the contract. Lump Sum units are not allowed for components listed within a Lump Sum Item. The total of all partial payments to the Contractor shall equal the Lump Sum contract price regardless of the accuracy of the quantities furnished by the Designer in the schedule.

5.3 QUANTITY CALCULATIONS

5.3.1 General

All estimated quantities shall be calculated in the appropriate customary U.S. units and shall be shown on the estimate sheet and on the Construction Drawings. There shall be no increase in the estimated quantities by fixed percentages in order to allow for overruns that might occur when the structure is constructed. All estimated quantities shall be computed to exact amounts and rounded off to the nearest ten, hundred, or thousand, as applicable. Normal allowance for shrinkage of certain quantities, as indicated herein, will be included in the estimate. Estimators shall make certain to include all anticipated quantities in their computations. When Lump Sum items are used, a breakdown estimate of all the work on that item shall be furnished on the estimate forms.

Three (3) complete sets of quantity calculations shall be supplied by the Designer for the Bridge Section records. Each complete set shall consist of two (2) independent sets of calculations that have been compared by the Designer and all differences resolved before submission.

Quantity calculations shall be neatly arranged, legible, and supplemented with sketches so that all quantities and materials can be easily verified during construction.

5.3.2 Standard Nomenclature For Bridge Related Items

5.3.2.1 General. The basic document used by MassHighway to describe various items of work and their appropriate item numbers and units of measure is the *Standard Nomenclature and List of Standard Items*. This is essentially a companion document to be used in conjunction with the latest edition of *The Standard Specification for Highways and Bridges* in preparing Special Provisions and Estimates.

5.3.2.2 Using the *Standard Nomenclature and List of Standard Items*. All bridge related items in the *Standard Nomenclature* are listed in the 100 series or 900 series of items with the exception of items 460 and 462, which pertain to the Hot Mix Asphalt bridge wearing surface (if any). Any item asterisked in the *Standard Nomenclature* requires a special provision. Items without an asterisk do not require special provision; however, if the existing Standard Specifications or Supplemental Specifications do not adequately describe all aspects of the work that will be required for a particular project under this item, the Designer must develop a special provision for a non-asterisked item which covers only the unique, project specific aspect of the work.

It is important to recognize that all items listed in the *Standard Nomenclature* are stored in the computer database of the MassHighway Information Technology Section. Therefore, when a standard item number is selected, neither the item nomenclature nor the unit of measure can be modified by the Designer in the preparation of an estimate or special provision for a particular project.

5.3.2.3 Non-Standard Items. To modify the item description or unit of measure for a listed item, it is necessary to create a non-standard item number. For example changing the unit of measure for Item 920. (Plain Elastomeric Bearing) from “Each" to "Cubic Inch" would be accomplished by using an alternative item number such as 920.1. This non-standard item would then be stored in the computer for this project only.

Similarly, a non-standard item can be established for any unique item of work not included in the *Standard Nomenclature*. Example:

ITEM 960.364 STEEL M270 GRADE 36 PAINTED - REPAIRS POUND

5.3.3 Guidelines For Estimating Quantities

Below is a partial listing of selected Items that are often used in the bridge estimate which require some explanation and guidance:

ITEM 107.95 STEEL GRID DECKING SQUARE YARD

Each grid size shall be a separate item. Item numbers shall be obtained from the Construction Contracts Section, when the item is not included in the Lump Sum. Also, the item name should make clear whether the grid is to be concrete filled or not. For example: “Steel Grid Decking - 5 Inch Depth - Open Grid” shall have a different item number than “Steel Grid Decking – 5 Inch Depth – Concrete Filled”.

ITEM 114.1 DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. X-XX-XXX (XXX) LUMP SUM

This item shall include demolition of all non-hazardous materials above the bridge seats. The removal of portions of the substructure, if required, shall be included under another appropriate item. When the superstructure and substructure are one unit such as a reinforced concrete culvert or rigid frame, the entire structure shall be removed under Item 115.1.

ITEM 140 BRIDGE EXCAVATION CUBIC YARD

BRIDGE EXCAVATION is described in the *Standard Specifications* and shall be measured as stipulated therein, except where the bridge is located in a highway excavation area, in which case, bridge excavation shall be measured from the subgrade of the proposed lower roadway and its sideslopes, or from the existing ground, whichever is lower, down to the bottom of the concrete substructure or to the bottom of gravel borrow (or crushed stone) for bridge foundation.

Where the bridge is located in a preloaded area, bridge excavation shall be measured from the subgrade of the proposed lower roadway and its sideslopes down to the bottom of the concrete superstructure.

BRIDGE EXCAVATION shall also include concrete and stone masonry in existing substructures unless included in another item.

If there is an item for BRIDGE EXCAVATION or BRIDGE EXCAVATION-PIERS IN DEEP WATER there shall also be a corresponding item for CLASS B ROCK EXCAVATION or CLASS B ROCK EXCAVATION - PIERS IN DEEP WATER, respectively.

ITEM 143. CHANNEL EXCAVATION CUBIC YARD

Channel excavation shall include all quantities removed to conform to the proposed channel cross-section. If channel paving is used to protect the channel bottom and slopes, the excavation to the bottom of this paving is included as channel excavation.

ITEM 144. CLASS B ROCK EXCAVATION CUBIC YARD
ITEM 144.1 CLASS B ROCK EXCAVATION - PIERS IN DEEP WATER CUBIC YARD

An assumed but reasonable percentage of the Bridge Excavation quantity is often used as a quantity for either of these two Items as appropriate.

ITEM 151.2 GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES CUBIC YARD

When gravel borrow is used for backfill at structures, the quantity is based on filling the space between the back of the structure and a vertical plane 12 inches outside the back of the footing as shown in Part II of this Bridge Manual.

In all cases, this volume shall be increased by 20%. The figure shall be rounded off to the nearest 5 cubic yards.

ITEM 151.1 GRAVEL BORROW FOR BRIDGE FOUNDATION CUBIC YARD

Gravel Borrow For Bridge Foundation shall be placed and compacted 2'-0" higher than the bottom of footing.

Excavation from the top of GRAVEL BORROW FOR BRIDGE FOUNDATION to the bottom of the footing shall be classified as BRIDGE EXCAVATION.

There shall be no swelling of quantities for GRAVEL BORROW FOR BRIDGE FOUNDATION.

ITEM 156.1 CRUSHED STONE FOR BRIDGE FOUNDATION TON

Crushed Stone For Bridge Foundations is normally used where water is present and therefore gravel borrow for bridge foundation is not applicable.

ITEM 460. HOT MIX ASPHALT TON
ITEM 462. HOT MIX ASPHALT DENSE BINDER COURSE FOR BRIDGES TON

For quantity calculations assume that the unit weight of the Hot Mix Asphalt is 160 pounds/cubic foot.

Any leveling shall be accomplished with the dense binder course and shall be included as part of that item. The top course shall be of uniform thickness.

ITEM 904. 4000 PSI, ¾ IN, 610 CEMENT CONCRETE CUBIC YARD

When brick is used in backwalls to close utility openings, the gross volume occupied by the brick shall be included in the appropriate concrete quantity, and no further payment shall be made for the brick. The Contract price for concrete includes full compensation for the short lengths of pipe that function as utility sleeves through the backwall.

Where the bridge has U wings, the sidewalk slab off the bridge deck, between the wing and the roadway, shall be included within the Highway Estimate.

ITEM 910. STEEL REINFORCEMENT FOR STRUCTURES POUND
ITEM 910.2 STEEL REINFORCEMENT FOR STRUCTURES - COATED POUND

Include sufficient weight for laps. Assume 40 feet as the maximum length of bar when figuring the required number of laps.

ITEM 912.X DRILLED AND CHEMICAL ANCHORED #X DOWELS EACH
ITEM 913.X DRILLED AND CHEMICAL ANCHORED X IN. DIA. THREADED RODS EACH

Drilling And Chemical Anchored Dowels or Threaded Rods shall be a separate pay item with the drilling of the hole, the chemical anchoring material, and the dowels or threaded rods included as part of this Item.

ITEM 915.X ARCH FRAME UNIT (X TO X FT. WIDE - X TO X FT. SPAN) EACH

In most cases, Precast Concrete Arch Frame Units with defined widths and spans will be a part of the Lump Sum Breakdown of the bridge with a component quantity determined on an each basis.

ITEM 916.X PRECAST CONCRETE CULVERT (X FT. SPAN - X FT. HEIGHT) LINEAR FOOT

In most cases, Precast Concrete Culverts with defined spans and heights will be a part of the Lump Sum Breakdown of the bridge with a component quantity determined on a linear foot basis.

ITEM 920. PLAIN ELASTOMERIC BEARING EACH
ITEM 921.X LAM. ELASTOMERIC BEARING W/ANCHOR BOLTS (XX-XXXK) EACH
ITEM 922.X LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (XX-XXXK) EACH
ITEM 923.X LAM. SLIDING ELASTOMERIC BEARING W/ANCHOR BOLTS (XX-XXXK) EACH
ITEM 924.X LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (XX-XXXK) EACH

Plain Elastomeric Bearings are to be listed in the Lump Sum Breakdown on an each basis. Laminated Elastomeric Bridge Bearing Pads are to be listed in the Lump Sum Breakdown on an each basis with sliding or not sliding, with or without anchor bolts, and design vertical dead plus live load range included within the description. According to M9.14.5, MassHighway requires one additional bearing pad of each size and type identified on the Construction Drawings for destructive testing. However, this additional bearing for testing is regarded as incidental and only the actual number of bearings installed shall be included in the Lump Sum Breakdown quantities.

ITEM 930.301 thru ITEM 930.308	**PRESTRESSED CONCRETE DECK BEAMS (SXX-XX)**	**LINEAR FOOT**
ITEM 930.401 thru ITEM 930.418	**PRESTRESSED CONCRETE BOX BEAMS (BXX-XX)**	**LINEAR FOOT**
ITEM 930.501 thru ITEM 930.518	**HIGH PERFORMANCE PRESTRESSED CONCRETE BOX BEAMS (BXX-XX)**	**LINEAR FOOT**
ITEM 931.01 thru ITEM 931.05	**PRESTRESSED CONCRETE BULB TEE BEAMS (NEBT XXXX)**	**LINEAR FOOT**
ITEM 931.11 thru ITEM 931.15	**HIGH PERFORMANCE PRESTRESSED CONCRETE BULB TEE BEAMS (NEBT XXXX)**	**LINEAR FOOT**
ITEM 960.XXX	**STEEL M270 GRADE XX (COATING TYPE, BRIDGE TYPE)**	**POUND**

In most cases, Prestressed Concrete beam and Structural Steel Items with well defined quantities will be a part of the Lump Sum Breakdown of the bridge. However, there may be cases, such as for a repair contract, where beams are being installed that are not part of an overall Lump Sum Item. Prestressed Concrete Deck Beams, Prestressed Concrete Box Beams, and Prestressed Concrete Bulb-Tee Beams (NEBT) shall be listed in the Lump Sum Breakdown with a total quantity measured horizontally along the centerline of each beam from centerline of bearing to centerline of bearing

ITEM 953.	**PERMANENT STEEL SHEETING**	**SQUARE YARD**
ITEM 953.1	**TEMPORARY STEEL SHEETING**	**SQUARE YARD**
ITEM 953.2	**INTERIM STEEL SHEETING**	**SQUARE YARD**
ITEM 953.3	**EXCAVATION SUPPORT SYSTEM**	**SQUARE YARD**

Permanent Steel Sheeting shall be used when a specific section of sheeting is designed and called for on the Construction Drawings and is to be left in place as a finished structure. Temporary Steel Sheeting and Excavation Support Systems shall be entirely removed from the job site after their function has been accomplished. Interim Steel Sheeting shall be cut-off and removed only to the elevation shown on the Construction Drawings. This cut off elevation shall generally coincide with the top of footing or zone of influence slope line, whichever is higher. The remaining steel sheeting shall be left in place.

The quantity of Permanent Steel Sheeting, Temporary Steel Sheeting, and Interim Steel Sheeting to be paid for shall be the number of square yards obtained by multiplying the vertical length of sheeting measured between the original ground surface at the site at the time the work commences and the elevation shown on the Construction Drawings as the minimum embedment depth by the horizontal length measured along a projection of the sheeting on a plane parallel to and midway between the front and rear face of the sheeting wall.

The quantity of Excavation Support System to be paid for shall be the number of square yards obtained by multiplying the vertical length measured between the original ground surface at the site at the time the work commences and the bottom of the excavation immediately adjacent to the Excavation Support System by the actual length of protection system installed measured as shown on the Construction Drawings. When the support system is used in stage construction, the quantity of support system to be paid shall be the maximum number of square yards satisfactorily installed between the payment lines shown in the Contract Documents measured on either, but not both sides, of adjacent construction stages.

ITEM 954.	**COFFERDAM**	**EACH**
ITEM 954.1	**TEMPORARY WATERWAY DIVERSION STRUCTURE**	**EACH**

Cofferdams shall be estimated on an each basis and shall consist of designing, furnishing, placing, maintaining, and removing cofferdams together with all necessary waling and bracing, and dewatering equipment within the limits shown on the Construction Drawings. When a Cofferdam requires incorporation of Permanent or Temporary Steel Sheeting as part of the Cofferdam, the Permanent or Temporary Steel Sheeting shall be paid for under a separate item. Temporary Waterway Diversion Structures shall be estimated on an each basis and shall consist of designing, furnishing, installing, maintaining, and removing a Temporary Waterway Diversion Structure at the location(s) shown on the Construction Drawings or as directed by the Engineer.

ITEM 983.1	**RIPRAP**	**TON**

The estimated weight of Riprap shall be determined using an in-place unit weight of 125 pounds per cubic foot of required riprap volume. This corresponds to a void ratio of approximately 0.3.

5.4 PREPARATION OF ESTIMATE

5.4.1 General

The bridge estimate is combined with the highway estimate to form a composite estimate. The proposal form, (located at the back of the project Proposal Book), which the Contractor fills out in preparing his/her bid, is generated directly from this composite estimate by the MassHighway Information Technology Section. Therefore, it is essential that the payment items listed in the estimate cover all aspects of the work to be done and that they be correct with respect to item number, item description and unit of measure. In addition, the estimate and the special provisions must be compatible with each other and with the *Standard Nomenclature*.

When preparing any Lump Sum breakdown estimate, only finite quantities shall be used and no option items shall be used. Also, sub-item numbers that match the Standard Nomenclature item numbers are required on the breakdown estimate. After the total of the Lump Sum has been figured, the total figure shall be rounded off to the next larger thousand dollars. For example, if the total estimate for the Lump Sum were $125,202.00, it would be rounded off to “Call $126,000.00”. This figure would then be the amount used for **ITEM 995.01, BRIDGE STRUCTURE, BRIDGE NO. X-XX-XXX (XXX)**.

5.4.2 Unit Prices

Estimated prices for determining the Bridge Estimate should be derived using the following guides:

1. A few items of work over lap with the Highway Estimate such as Hot Mix Asphalt concrete pavement. The unit prices for these Items shall agree.

2. The Bridge Section regularly generates a "Bridge Listing" of estimated average prices for the major components of bridges. This should be used, but only for Items of work which are very ordinary in scope and complexity.

3. In the absence of the above, the Designer must determine appropriate unit costs estimates from other sources such as: discussions with contractors; the MassHighway booklet, *Weighted Average Bid Prices*; Means Tables, etc.

5.4.3 Submittals

The first submission of the Bridge Estimate sheets shall contain all the items of work that will be required to construct the proposed structure. The Bridge Estimate shall be comprised of at least two sheets. The first sheet shall have all the items of work, and the following sheets shall be the breakdown of any Lump Sum estimates. After all comments have been reconciled, the final submission shall be made. The final submission shall be printed in black ink. Estimates are <u>not</u> to be done in pencil or blue ink.

The following pages give example format and standard language for the Bridge Structure Lump Sum Special Provision (Figure 5.1), example Bridge Estimate sheets (Figure 5.2), and the Estimated Quantities table that is to be located on the Construction Drawings (Figure 5.3).

FIGURE 5.1 STANDARD FORMAT FOR ITEM 995.01 LUMP SUM

ITEM 995.01 BRIDGE STRUCTURE, BRIDGE NO. S-11-001 (WE1) LUMP SUM

The work under this Item shall conform to the applicable provisions of Section 995 of the Standard Specifications and the specific requirements stipulated below for the component parts of this Item. For those component parts where no specific requirement is stipulated, the Standard Specifications shall apply except for payment.

Work under this Item shall include all materials, equipment and labor needed to construct the following: *(itemize all physical parts of the bridge that will be constructed under this Lump Sum Item)*

The work does not include any items listed separately in the proposal. Payment for materials shown on the Plans as being part of this bridge structure or which may be incidental to its construction and are not specifically included for payment under another Item shall be considered incidental to the work performed under this Item and shall be included in the unit price of the component of which they are a part.

(Starting here, provide a Heading for each component of work that requires a special provision)

METAL BRIDGE RAILING (3 RAIL), STEEL (TYPE S3-TL4)

The work under this Heading shall conform to the applicable provisions of Section 975 of the Standard Specifications as modified by the following:

(example of the preface language to be used where an existing Standard Specification is to be modified for a project specific requirement)

FIGURE 5.1 STANDARD FORMAT FOR ITEM 995.01 LUMP SUM, CONTINUED

SCHEDULE OF BASIS FOR PARTIAL PAYMENT

Within ten (10) days after the award of the Contract, the Contractor shall submit, in duplicate, for the approval of the Engineer, a schedule of unit prices for the major components of the bridge structure as listed below. The bridge structure Lump Sum breakdown quantities provided below are estimated and not guaranteed. The total of all partial payments to the Contractor shall equal the Lump Sum contract price regardless of the accuracy of the quantities furnished by the Engineer for the individual bridge components. The cost of labor and materials for any Item not listed but required to complete the work shall be considered incidental to Item 995.01 and no further compensation will be allowed.

Sub-Item	Description	Quantity	Unit	Unit Price	Total
901.	4000 PSI, 1½ in, 565 Cement Concrete	91	CY		
904.	4000 PSI, ¾ in, 610 Cement Concrete	4	CY		
904.3	5000 PSI, ¾ in, 685 HP Cement Concrete	12	CY		
904.4	4000 PSI, ¾ in, 585 HP Cement Concrete	128	CY		
910.2	Steel Reinforcement for Structures - Coated	56500	LB		
922.4	Lam. Elastomeric Bearing W/O Anchor Bolts (151-200K)	12	EA		
930.518	High Performance Prestressed Concrete Box Beams (B48-48)	613	LF		
970.	Bituminous Damp-Proofing	180	SY		
971.	Asphaltic Bridge Joint System	56	LF		
975.1	Metal Bridge Railing (3 Rail), Steel (Type S3-TL4)	231	LF		

Total Cost of Item 995.01=

The above schedule applies only to Bridge Structure No. S-11-001 (WE1). Payment for similar materials and construction at locations other than at this bridge structure shall not be included under this Item. Sub-Item numbering is presented for information only in coordination with MassHighway Standard Nomenclature.

FIGURE 5.2 STANDARD BRIDGE ESTIMATE SHEET

MASSACHUSETTS HIGHWAY DEPARTMENT
PROJECTS DIVISION
BRIDGE SECTION

BRIDGE NO. S-11-001 (WE1)
Page 1 of 3

27-Mar-07

TOWN	SMALLVILLE			CLASS	HS25
STATION		ROAD	SOUTH STREET	OVER	SWIFT RIVER
TYPE	SP.PC BOXES	ROADWAY	28'-0"	WALKS	1 @ 5'-0"
NO. SPANS	1	LENGTH	100'-6"	VERTICAL CL.	

< PRELIMINARY ESTIMATE OF QUANTITIES AND COST OF BRIDGE >

ITEM	QUANTITY	UNITS	DESCRIPTION	UNIT PRICE	AMOUNT
114.1	1	LS	DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. S-11-001 (ME2)	$199,000.00	$199,000.00
140	500	CY	BRIDGE EXCAVATION	$22.00	$11,000.00
144	34	CY	CLASS B ROCK EXCAVATION	$170.00	$5,780.00
151.1	216	CY	GRAVEL BORROW FOR BRIDGE FOUNDATION	$45.00	$9,720.00
156.1	80	TON	CRUSHED STONE FOR BRIDGE FOUNDATIONS	$40.00	$3,200.00
912.5	55	EA	DRILLED AND GROUTED #5 DOWELS	$130.00	$7,150.00
945.101	57	LF	DRILLED SHAFT EXCAVATION 3 FOOT DIAMETER	$800.00	$45,600.00
945.201	20	LF	ROCK SOCKET EXCAVATION 3 FOOT DIAMETER	$1,300.00	$26,000.00
945.301	12	LF	OBSTRUCTION EXCAVATION 3 FOOT DIAMETER	$2,000.00	$24,000.00
945.501	89	LF	DRILLED SHAFT 3 FOOT DIAMETER	$600.00	$53,400.00
945.71	360	LF	CROSS HOLE SONIC TESTING ACCESS PIPES	$13.00	$4,680.00
945.72	8	EA	CROSS HOLE SONIC TEST	$1,500.00	$12,000.00
983.1	345	TON	RIPRAP	$50.00	$17,250.00
995.01	1	LS	BRIDGE STRUCTURE, BRIDGE NO. S-11-001 (WE1)	$911,000.00	$911,000.00
				TOTAL =	**$1,329,780.00**

ESTIMATED BY: HLJ & HN CHECKED BY: MLM APPROVED BY: DSC

FIGURE 5.2 STANDARD BRIDGE ESTIMATE SHEET, CONTINUED

MASSACHUSETTS HIGHWAY DEPARTMENT
PROJECTS DIVISION
BRIDGE SECTION

BRIDGE NO.
S-11-001 (WE1)
Page 2 of 3

26-Mar-07

TOWN	SMALLVILLE			CLASS	HS25
STATION		ROAD	SOUTH STREET	OVER	SWIFT RIVER
TYPE	SP.PC BOXES	ROADWAY	28'-0"	WALKS	1 @ 5'-0"
NO. SPANS	1	LENGTH	100'-6"	VERTICAL CL.	

< PRELIMINARY ESTIMATE OF QUANTITIES AND COST OF BRIDGE >

ITEM	QUANTITY	UNITS	DESCRIPTION	UNIT PRICE	AMOUNT
			BREAKDOWN OF ITEM 114.1 DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. S-11-001 (ME2)		
	265	SY	REMOVAL AND DISPOSAL OF BRIDGE SUPERSTRUCTURE	$750.00	$198,750.00

TOTAL = $198,750.00
CALL = $199,000.00

ESTIMATED BY: HLJ & HN CHECKED BY: MLM APPROVED BY: DSC

FIGURE 5.2 STANDARD BRIDGE ESTIMATE SHEET, CONTINUED

MASSACHUSETTS HIGHWAY DEPARTMENT
PROJECTS DIVISION
BRIDGE SECTION

BRIDGE NO.
S-11-001 (WE1)
Page 3 of 3

26-Mar-07

TOWN	SMALLVILLE			CLASS	HS25
STATION		ROAD	SOUTH STREET	OVER	SWIFT RIVER
TYPE	SP.PC BOXES	ROADWAY	28'-0"	WALKS	1 @ 5'-0"
NO. SPANS	1	LENGTH	100'-6"	VERTICAL CL.	

< PRELIMINARY ESTIMATE OF QUANTITIES AND COST OF BRIDGE >

SUB-ITEM	QUANTITY	UNITS	DESCRIPTION	UNIT PRICE	AMOUNT
			BREAKDOWN OF ITEM 995.01 BRIDGE STRUCTURE, BRIDGE NO. S-11-011 (WE1)		
901	91	CY	4000 PSI, 1 1/2 IN, 565 CEMENT CONCRETE	$900.00	$81,900.00
904	4	CY	4000 PSI, 3/4 IN, 610 CEMENT CONCRETE	$1,000.00	$4,000.00
904.3	12	CY	5000 PSI, 3/4 IN, 685 HP CEMENT CONCRETE	$1,600.00	$19,200.00
904.4	128	CY	4000 PSI, 3/4 IN, 585 HP CEMENT CONCRETE	$1,300.00	$166,400.00
910.2	56500	LB	STEEL REINFORCEMENT FOR STRUCTURES - COATED	$2.00	$113,000.00
922.4	12	EA	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (151-200K)	$925.00	$11,100.00
930.518	613	LF	HIGH PERFORMANCE PRESTRESSED CONCRETE BOX BEAMS (TYPE B48-48)	$700.00	$429,100.00
970	180	SY	BITUMINOUS DAMP-PROOFING	$18.00	$3,240.00
971	56	LF	ASPHALTIC BRIDGE JOINT SYSTEM	$150.00	$8,400.00
975.1	231	LF	METAL BRIDGE RAILING (3 RAIL), STEEL (TYPE S3-TL4)	$320.00	$73,920.00
				TOTAL =	$910,260.00
				CALL =	**$911,000.00**

ESTIMATED BY: HLJ & HN CHECKED BY: MLM APPROVED BY: DSC

FIGURE 5.3 ESTIMATED QUANTITIES TABLE FOR BRIDGE CONSTRUCTION DRAWINGS

ESTIMATED QUANTITIES (NOT GUARANTEED)	
DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO. S-11-001 (ME2)	1 LS
BRIDGE EXCAVATION	500 CY
CLASS B ROCK EXCAVATION	34 CY
GRAVEL BORROW FOR BRIDGE FOUNDATION	216 CY
CRUSHED STONE FOR BRIDGE FOUNDATIONS	80 TON
DRILLING AND GROUTING #5 DOWELS	55 LF
DRILLED SHAFT EXCAVATION 3 FOOT DIAMETER	57 LF
ROCK SOCKET EXCAVATION 3 FOOT DIAMETER	20 LF
OBSTRUCTION EXCAVATION 3 FOOT DIAMETER	12 LF
DRILLED SHAFT 3 FOOT DIAMETER	89 LF
CROSS HOLE SONIC TESTING ACCESS PIPES	360 LF
CROSS HOLE SONIC TEST	8 EA
RIPRAP	345 TON
BRIDGE STRUCTURE, BRIDGE NO. S-11-001 (WE1)	1 LS

CHAPTER 6
SHOP DRAWINGS, CONSTRUCTION PROCEDURES, AND OTHER SUBMISSIONS

6.1 APPROVAL PROCESS

6.1.1 General

The official MassHighway procedure for submission of and approval of shop drawings is set forth in the Commonwealth of Massachusetts Department of Public Works (former name of the Massachusetts Highway Department) Standard Operating Procedure No. HED 10-15-1-000, *Approval Of Shop Drawings*, dated May 23, 1977. This chapter is a supplement to the referenced S.O.P. If there are conflicts between the two, the information in this Chapter shall take precedence. Drawings or plans for which the Contractor is responsible for the original design, such as for, but not limited to: steel sheeting; cofferdams; sign, signal and lighting supports; temporary structures; erection drawings; demolition drawings; and computations submitted by the Contractor for approval shall bear the seal of a Professional Engineer of the appropriate discipline registered in Massachusetts.

6.1.2 Responsibility

It will be the responsibility of the Resident Engineers and Project Engineers to advise respectively the Contractors and Designers concerning the proper procedures to be followed with regard to submitting and distributing shop drawings. Shop drawings not submitted in compliance with these procedures shall be returned immediately by the Resident or Project Engineer to the Contractor for resubmission in accordance with the established procedure.

The Designer, as part of their review of shop drawings, must verify that the fabricators of metal elements, such as structural steel, steel railings, and aluminum protective screen, are on MassHighway's "Approved Fabricator List" when the shop drawings are first received. An up to date copy of the "Approved Fabricator List" may be obtained from the MassHighway website at www.state.ma.us/mhd. In addition, the MassHighway Research and Materials Engineer shall be contacted to verify that the fabricator of precast concrete elements is approved by MassHighway.

The Designer shall not review and approve cement concrete mix designs, welding procedures, and other materials-related submittals. All welding procedures shall be forwarded to the MassHighway Bridge Section for review and approval. All other materials-related submittals shall be forwarded to the MassHighway Research and Materials Engineer for review and approval.

6.1.3 Approval of Shop Drawings

6.1.3.1 MassHighway policy does not allow for the approval of shop drawings with an "APPROVED AS NOTED" stamp. Shop drawings will either be approved as submitted or else they will be returned for corrections.

6.1.3.2 On shop drawings for structural steel, prestressed beams, steel or iron castings, bronze or wrought iron plates, metals railing and machinery, and structural timber the Designer shall make sure that the following notation is on the shop drawings before approval is given:

INSPECTION TO BE PERFORMED BY THE MASSACHUSETTS HIGHWAY DEPARTMENT OR DESIGNATED REPRESENTATIVE

6.1.3.3 The Designer shall affix his/her own approval stamp to every sheet of all shop drawings approved. For all projects designed by private consultant firms, the Designer shall be the consultant firm as indicated on the Contract Drawings. For projects designed by MassHighway, the Designer may be the District, the Bridge, Highway or Traffic Engineer depending on the origin of the design.

6.1.3.4 If catalog cuts or manufacturer's specifications are submitted in lieu of or in addition to shop drawings, the number of copies required for distribution shall be in accordance with Table 6.1.

6.1.3.5 In case a Railroad is involved, the following procedures shall be followed:

Highway Over Railroad: Railroad will not approve shop drawings.

Railroad Over Highway: Railroad will approve all drawings of the structure.

6.1.4 Approval of Construction Materials, Products, and Fabrication Procedures

The Designer shall verify that all AASHTO or ASTM material designations on the shop drawings comply with the material specifications in either the MassHighway Standard Specifications, Supplemental Specifications, or Special Provisions. The MassHighway Research and Materials Engineer will approve the use of all products and materials other than metals whose use requires pre-approval or material certification for conformance with the MassHighway Approved Products List or the MassHighway Standard Specifications, Supplemental Specifications, or Special Provisions. Examples of such products and materials include, but are not limited to: concrete mix designs for both redi-mix concrete and precast concrete products; concrete patch materials; grouts; epoxies; concrete sealers; membranes; joint sealers and fillers; geotextiles; mechanical reinforcing bar splicers; and coatings. The MassHighway Metals Control Engineer will approve all welding procedures, metal certifications, and any metal repair procedures for any fabrication related errors.

6.1.5 Telephone Calls from Contractors, Fabricators, and Suppliers

Contractors, Fabricators, and Suppliers often directly call the Designer with inquiries. In order to avoid confusion and potential claims, all answers to the Contractor shall be made through the appropriate MassHighway District Construction personnel, except in cases where the inquiry is related to resolving review comments on shop drawings. Direct communication between the Contractor, Fabricator, or Supplier and the Designer is encouraged for the timely and effective resolution of review comments on shop drawings.

6.2 SHOP DRAWINGS

6.2.1 Structural

6.2.1.1 General. The procedure outlined below shall be followed for the following shop drawings:

1. Prestressed Concrete Beams.
2. Structural Steel.
3. Elastomeric Bearings.
4. Steel or Iron Castings.
5. Bronze or Wrought Iron Plates.
6. Grid Decking.
7. Metal Railings and Protective Screens.
8. Machinery (When used on Bridges).
9. Reinforcing Steel.
10. Structural Timber
11. Stay-In-Place Forms
12. Strip Seal Bridge Joint Systems

6.2.1.2 Approval Procedure.

The Fabricator or Supplier shall send three sets of prints of the shop drawings to the Contractor who shall then send two sets of these prints directly to the Designer for comments or approval. The Contractor shall send a copy of this transmittal to the appropriate District Office, to the attention of the District Construction Engineer.

The Designer, after checking the prints and making any necessary comments, shall return one set of marked-up prints through the Contractor to the Fabricator for correction, retaining one set for back-checking to see that the comments have been reconciled. The Designer shall send a copy of this transmittal to the appropriate District Office, to the attention of the District Construction Engineer.

After the Fabricator or Supplier has reconciled all of the comments on the shop drawings with the Designer, he/she shall send to the Designer as many sets of prints as are required for distribution, as specified in Table 6.1.

6.2.1.3 Required Project Information on Shop Drawings. All shop drawings submitted for the approval of the Designer shall feature a title block that contains all of the project information presented in Figure 6.1.

6.2.2 Traffic

6.2.2.1 General.

Overhead, cantilever, and ground mounted signs, light standards, and traffic signal assemblies shall be designed by the Contractor. The design calculations and shop drawings shall be reviewed by the Engineer.

Signs supported on bridges or walls shall be designed by the Designer of record for those structures.

6.2.2.2 Sign Supports.

Unless the structures have been pre-approved by MassHighway, complete design calculations must be prepared for all structures and must accompany the shop drawing submittals. The design calculations must include analysis of the sign structure, foundations, and all connections.

6.2.2.3 Light Standards, Traffic Signal Assemblies, and High Mast Lighting Assemblies.

The requirements of Paragraph 6.2.2.2 shall apply, except that for High Mast Lighting Assemblies the following criteria shall also be met:

1. The lowering device motor must have a sufficient rating to withstand the torque imposed on it by the ring assembly as it is lowered or raised.

2. The lowering device housing must be made of a material able to withstand the shear and tensile stresses imposed on it by the lowering and raising of the ring assembly.

3. Two (2) copies of the Manufacturer's test results must be submitted with the shop drawings as documentary proof that the aforementioned requirements are met.

If designed by the Contractor, two (2) copies of shop drawings and two (2) copies of design calculations shall be submitted to the Designer for review and comment. After the comments have been reconciled, the required number of shop drawings and two (2) copies of design calculations shall be returned to the Engineer for approval and distribution.

For bridge mounted sign supports designed by the Designer, the same procedure as outlined in Subsection 6.2.1 shall be followed.

6.2.3 Distribution

Only after the shop drawings have received the FINAL approval by the Designer, the shop drawings will be distributed as shown in Table 6.1.

All distributions will be made by the Designer. Copies of transmittal letters will be sent to respective MassHighway Engineers concerned. MassHighway will not distribute any shop drawings on projects handled by Design Consultants.

6.3 EFFECT OF CONTRACT DRAWING REVISIONS ON SHOP DRAWINGS

When Contract Drawings are revised after the contract has been awarded for construction and the revision affects the work of a supplier or fabricator, the following procedures shall apply:

1. Where shop drawings have not been prepared, the drawings shall be processed in accordance with the standard procedure incorporating the revisions.

2. Where part of a series of related shop drawings is in the process of approval and a revision relative to this series is made to the Contract Drawings, those shop drawings of this series not yet submitted for approval shall include and make note of such Contract Drawing revisions. Those drawings, already approved shall be revised as outlined below (3).

3. Where the shop detail drawings have been approved prior to a revision to the Contract Drawings, revised shop drawings shall be made and processed in accordance with the standard procedure. A note shall be shown on the shop drawings to include the date and nature of revision.

When it becomes necessary to issue revised shop drawings after the approved prints have been distributed, the Designer shall notify the Construction Engineer as to the extent of the revisions and the probable time of issuance of the revised drawings. The Construction Engineer will then notify the District Highway Director that revisions are being made. The District Highway Director will, in turn, inform the Resident Engineer.

6.4 CONSTRUCTION PROCEDURES

6.4.1 General

6.4.1.1 Approval Where a Railroad is Not Involved. See Table 6.2 for a description of each construction procedure category and the required distribution. All Construction Procedure submittals shall be initially forwarded by the Contractor through the District.

For Category 1 procedures, the Designer will review these submittals for structural adequacy and conformance with the project specifications and will inform the District accordingly. When all comments have been resolved, the Designer shall notify the District that the submission is acceptable.

For Category 2 and 3 procedures, the Designer will review these submittals and return them to the Contractor for resolution of comments. When all comments have been resolved and the submittal is found acceptable, the Designer will approve and distribute the submittals.

For Category 4 procedures, the District will perform all reviews, approvals and distributions.

6.4.1.2 Approval Where a Railroad is Involved. See Table 6.2 for a description of each construction procedure category and required distribution. All submittals shall be initially forwarded by the Contractor through the District.

The railroad will approve demolition procedures, erection procedures, sheeting procedures, and anything concerning the safety of railroad traffic and personnel. The District shall forward the Contractor's submittals under Categories 1 and 2 to the railroad for their review. The District shall also coordinate the railroad comments with those made by the Designer in order to ensure that all comments are resolved and the required approvals are obtained.

6.4.2 Erection of Structural Steel

6.4.2.1 The following procedure for the erection of structural steel is taken from the Commonwealth of Massachusetts Department of Public Works (former name of the Massachusetts Highway Department) Standard Operating Procedures No. CSD 24-12-1-000, *Procedures For Erection Of Structural Steel*, dated December 1, 1977.

6.4.2.2 As soon as possible after being assigned to a project, the Resident Engineer shall determine the ratio of the span to width of the compression flange, (L/B), for main load-carrying structural steel members of each bridge, if not already shown on the plans. This determination shall be documented as part of the project records. Each structure will then be classified in one of the following three groups:

GROUP	DEFINITION
I.	Members with L/B ratios of less than 80
II.	Members with L/B ratios between 80 and 100
III.	Members with L/B ratios over 100

Where: L = length of beam being erected; B = width of compression flange.

For continuous spans, the span length shall be considered as the distance between the dead load points of contraflexture.

6.4.2.3 GROUP I represents structures whose main load carrying members are comparatively rigid and which are relatively easy to erect. Approval for the erection procedures to be used shall be given at the project level by the Resident Engineer. Control of traffic around and under these structures will be as directed by the Resident Engineer.

6.4.2.4 GROUP II represents structures whose main load carrying members are less rigid and are more difficult to erect. Approval for the erection procedures to be used shall be given at the District level by the District Construction Engineer. Control of traffic around and under these structures will be as directed by the District Construction Engineer.

6.4.2.5 GROUP III represents structures whose main load carrying members are unstable without sufficient lateral support and require extreme care and caution during erection. Final approval for the erection procedures and provisions for control of traffic around and under the structure shall be vested with the Construction Engineer (Boston Construction Office). Traffic will be allowed to flow under a structure in this group only after a representative from the Boston Construction Office has made an inspection and given approval.

6.4.2.6 Nothing contained herein shall supersede the project specifications.

6.4.3 Erection of Prestressed Concrete

If the Contractor wants to use any previously erected span to erect subsequent spans, the procedure shall be reviewed and approved by the Designer.

TABLE 6.1 SHOP DRAWING DISTRIBUTION

NUMBER OF APPROVED COPIES REQUIRED FOR DISTRIBUTION BY THE DESIGNER

DRAWING	CONTRACTOR	RESEARCH & MATERIALS ENGINEER	METALS CONTROL ENGINEER	BRIDGE ENGINEER	DESIGNER	TRAFFIC ENGINEER	DISTRICT HIGHWAY DIRECTOR
STRUCTURAL STEEL, METAL BRIDGE RAILINGS, PROTECTIVE SCREENS, METAL CASTING, METAL PLATES AND MACHINERY, STRUCTURAL TIMBER	2		2	1	1		2
PRECAST AND/OR PRESTRESSED CONCRETE STRUCTURAL UNIT	2	2		1	1		2
REINFORCING STEEL AND STEEL S.I.P. FORMS	2			1	1		2
ELASTOMERIC BEARINGS	2	2		1	1		2
STRIP SEAL BRIDGE JOINT SYSTEMS	2	2	2	1	1		2
SPECIAL NON-TRAFFIC PRECAST CONCRETE UNITS (PIPES, MANHOLES, ETC.)	2	2					2
TRAFFIC: PRECAST CONCRETE UNITS, SIGNS, SUPPORTS, CASTINGS, SIGNAL MECHANISMS, HIGHWAY LIGHTING, ETC.	2	*2	*2	1	1	2	2
SPECIAL METAL PIPES, PIPE ARCHES, STRUCTURAL PIPES, PLATE PIPES, AND PLATE ARCHES	2	1		1	1		2

* If drawings are for steel or aluminum structures, they shall be sent to the Metals Control Engineer. All other drawings shall be sent to the Research and Materials Engineer.

TABLE 6.2 DISTRIBUTION OF CONSTRUCTION PROCEDURES

NUMBER OF APPROVED COPIES REQUIRED FOR DISTRIBUTION

CATEGORY	DESCRIPTION	DISTRICT	DESIGNER
1	STEEL BEAM ERECTION PRESTRESSED CONCRETE BEAM ERECTION BRIDGE DEMOLITION DECK REMOVAL & SHIELDING DESIGN	6 * (9)	
2	SHEETING / COFFERDAM DESIGNS TEMPORARY BRIDGES BEAM OR PIPE JACKING PROCEDURE		6 ** (9)
3	PILE DRIVING (WAVE EQUATION METHOD) PILE LOAD TESTS DRILLED SHAFT CONSTRUCTION PROCEDURES EMBANKMENT SETTLEMENT SIGN SUPPORTS / STRAIN POLES		6 **
4	PILE CAPACITY (UNDER 100 KIPS) SCHEDULES & CONSTRUCTION EQUIPMENT	3	
5	ERRORS AND CHANGES	See: CSD 24-16-1-000	

( ) Number of copies when a Railroad is involved.

* District shall distribute as follows: 1 to Designer, 1 to Resident Engineer, 1 to District Construction Office, 3 to Contractor, 3 to Railroad (if involved).

** Designer shall distribute. Distribution shall be the same as for *.

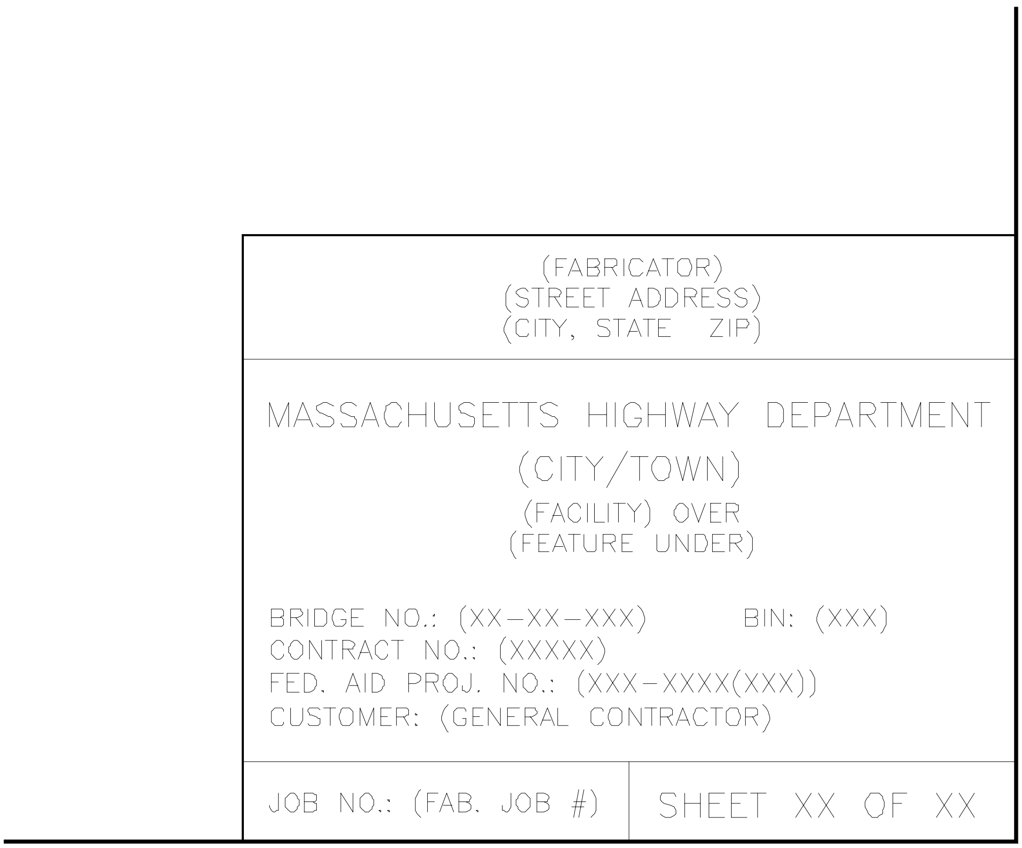


FIGURE 6.1: PROJECT INFORMATION REQUIRED ON SHOP DRAWING TITLE BLOCKS

CHAPTER 7
BRIDGE LOAD RATING GUIDELINES

7.1 POLICY

7.1.1 Purpose

To establish a uniform policy to be used by MassHighway and Consultant Rating Engineers in determining the live load capacity of bridges.

7.1.2 Definitions

For the purpose of this document, the following definitions shall be used:

Statutory Load
Statutory load levels are defined as follows:

H20 truck	(Two Axle)	20 Tons
Type 3 truck	(Three Axle)	25 Tons
Type 3S2 truck	(Five Axle)	36 Tons
HS20 truck	(Three Axle)	36 Tons

Posting Vehicles are the trucks whose load rating is used when a bridge is posted. MassHighway currently uses the following posting trucks: H20 truck, Type 3 truck, Type 3S2 truck.

7.1.3 Qualifications

All bridges shall be rated by a Professional Engineer, registered in Massachusetts, or by MassHighway Engineers under the direction of the Director of Bridges and Structures. Engineers performing the rating analysis shall be knowledgeable in Bridge Design and familiar with the relevant AASHTO specifications.

7.1.4 Field Inspection

The rating engineer shall verify in the field what is contained on the latest Construction Drawings, latest inspection reports and prior bridge rating reports. If during the verification, the Rating Engineer finds a changed condition that is not noted or documented sufficiently on the latest inspection report, the Rating Engineer shall notify the Director of Bridges and Structures and shall obtain documented measurements of the changed condition prior to incorporating the findings into the Rating Report. Section losses used to calculate the ratings shall be based on documented measurements and shall not be based on assumed conditions.

7.2 APPLICATION OF LIVE LOADS AND LOAD RATING INSTRUCTIONS

7.2.1 Objective

The object for rating a bridge is to determine the highest permissible live loads that a bridge can safely carry, consistent with sound engineering judgment.

7.2.2 Load Rating Software

7.2.2.1 MassHighway currently utilizes AASHTOWare™ Virtis version 5.5.0 as the standard software for load rating purposes. Where it is determined by the Rating Engineer, and the MassHighway Director of Bridges and Structures concurs that a structure cannot be properly analyzed using the AASHTOWare™ Virtis load rating software, an alternate approved computer program shall be utilized. Virtis is capable of performing load rating analysis for the majority of structure types, including multiple stringer steel, prestressed concrete, and concrete T-beam bridges, slab bridges, truss - floorbeam - floor stringer and truss - floorbeam bridges (load factor method only), girder - floorbeam - floor stringer and girder floorbeam bridges, and sawn lumber multiple stringer bridges. Culverts and post-tensioned concrete multiple girder bridges shall be rated using the latest version of Brass™ from the Wyoming Department of Transportation. Curved steel girder bridges shall be load rated using MDX software.

7.2.2.2 Rating Engineers working for firms that do not have licensed copies of the required software may perform the load rating(s), with prior approval, by utilizing one of the two guest computers located in the Bridge Section office in Room 6500 of the State Transportation Building.

7.2.2.3 MassHighway has prepared example guides for load rating a number of different bridge types using AASHTOWare™ Virtis. Example guides are currently available for simple and continuous span rolled beam and adjacent deck beam bridges, single span plate girder, AASHTO girder, adjacent box beam and T-beam bridges, and a three span reinforced concrete frame bridge.

7.2.3 Live Loads, Methods, and Units

7.2.3.1 All bridges shall be rated for Inventory and Operating Ratings for the H20, Type 3, Type 3S2 and HS20 truck loadings, as defined by AASHTO, or as modified by MassHighway. In general, lane loadings shall not be used for the H20 and HS20 vehicles when the span between the centerline of bearings on adjacent substructure units is less than 200 feet in length. However, if a component of a structure is rated for the H vehicle, and the rating is determined to be 12 tons or less, the component must also be rated using lane loading if applicable. For spans greater than 200 feet in length vehicles other than the H20 and HS20 vehicles should be spaced with 30 feet clear distance between vehicles to simulate a repetitive train of vehicles in one lane and a single vehicle load should be applied in the adjacent lane(s). The truck train axle load intensities for vehicles other than H20 and HS20 vehicles shall be 75% for truck 1, 100% for truck 2, and 75% for trucks 3 and 4 for each repeated 4 truck train (AASHTO *Standard Specifications for Highway Bridges, Appendix B*). Truck train loading shall be checked in all spans of continuous span bridges where at least one span is greater than 200 feet in length.

7.2.3.2 The Statutory Load vehicular ratings for posting purposes shall be obtained using the Allowable Stress Method and shall be reported in English tons, even if the bridge was designed in metric units. Structures designed using the Load Factor Method need only be rated using the Load Factor Method.

7.2.3.3 In addition to the posting ratings, an Inventory and Operating Rating shall be obtained for the HS20 vehicle using the Load Factor Method for compliance with the requirements of the December 1995 FHWA NBIS Coding Guide. Calculations shall use the HS20 truck and the resulting English ton ratings shall be converted to metric tons using a conversion factor of 0.9, as specified in the Coding Guide, instead of the exact conversion of 0.907185 metric tons per English tons. The resulting MS18 metric ton ratings shall be specified on the summary sheet in the spaces provided for Item 64 and Item 66.

7.2.3.4 When rating bridges designed in Customary U.S. units, Customary U.S. units shall be used throughout. When rating bridges designed in metric units, calculations shall be done completely in Customary U.S. units using the exact soft conversion to Customary U.S. units of the metric bridge geometry and properties.

7.2.3.5 Bridges with non-mountable sidewalks that are 6 feet or greater in width shall be rated at the Operating Level for special snow removal equipment. Sidewalks with curb reveals greater than or equal to 12 inches shall be considered non-mountable. The snow removal equipment shall be assumed to have 2 axles with 2 wheels per axle. The total weight of the snow removal equipment shall be 4 tons divided equally between the 4 wheels with each wheel load evenly distributed over a tire contact area that is 8 inches wide and 3 inches long. The wheelbase shall be 4 feet and the wheel lines shall be 5 feet apart. The outer wheel line shall be located no closer than 12 inches from the face of railing. When calculated, the Operating Level Rating of the sidewalk and/or supporting members shall be reported in the Breakdown of Bridge Rating and omitted from the Summary Sheet.

7.2.3.6 Pedestrian live loading will generally not be included in ratings, unless, based on engineering judgment, its application will produce the maximum anticipated loading.

7.2.4 Special Instructions for Load Ratings

7.2.4.1 Any request for clarification of or deviation from these guidelines must be submitted in writing (FAX is acceptable) to the Director of Bridges and Structures. Written responses shall be provided.

7.2.4.2 Bridges shall be rated in accordance with the provisions of the current AASHTO *Manual For Condition Evaluation Of Bridges (MCEB)*, including all interims except where modified by this Bridge Manual.

7.2.4.3 In general, substructure elements, except steel, timber, and pile bent structures, shall not be rated unless, in the opinion of the rating engineer, this shall influence the rating of the bridge. The AASHTO *MCEB* states in part, “Careful attention should be given to all elements of the substructure for evidence of instability which affects the load-carrying capacity of a bridge. Evaluation of the conditions of a bridge’s substructure shall in many cases be a matter of sound engineering judgment”. The report shall contain a statement noting the rating engineer’s judgment with regards to the substructure. If required to be rated, reinforced concrete substructure elements shall be rated using the Load Factor Method, all other substructure elements shall be rated using the Allowable Stress Method.

7.2.4.4 Engineering judgment alone shall not be accepted as a valid method for rating superstructure elements. For structures with unknown structural detail and a lack of Construction Drawings, detailed field measurements, nondestructive testing and material testing as described in Paragraph 7.2.4.17 shall be utilized.

7.2.4.5 Rating values shall be calculated for all members in negative and positive moment regions, in shear regions, at flange transitions, at cover plate cut-offs, at hold down points in precast prestressed concrete beams, and at any change in section along the member.

7.2.4.6 Where two or more methods of determining the distribution of live and dead loads to a member are valid, (see Paragraphs 7.2.4.7 and 7.2.4.9 for examples) that method that produces the higher rating shall govern. The Rating Engineer shall also consider and rate alternate load paths if this shall produce a higher overall bridge rating.

7.2.4.7 The live load distribution factor for an exterior beam may be calculated assuming a hinge forms in the slab over the first interior beam. In such cases, the wheel line shall be located 2 feet from the face of rail if the curb is mountable or 2 feet from the face of the curb if the curb is not mountable. In cases with mountable curbs and/or safety walks with widths of 2 feet or less as measured from the curbline to the face of bridge rail, the wheel line shall be located 2 feet from the curb line. Inventory distribution factors for exterior beams shall not exceed distribution factors for interior beams unless an irregular beam spacing exists.

7.2.4.8 On bridges with mountable curbs and/or safety walks with widths greater than 2 feet, as measured from the curb line to the face of bridge rail, the wheel line shall be located 2 feet from the face of bridge rail for the Operating Rating Level. The Inventory Ratings shall be calculated with the wheel line located 2 feet from the curb line.

7.2.4.9 For stringer bridges with deck slabs, the sidewalk, safety curb, railing and median superimposed dead loads can be distributed to beams using either a 60/40 distribution, as specified in Paragraph 3.5.3.3, or be distributed equally to all beams. If the use of both these methods creates a disparity in the ratings between the interior and exterior beams, that distribution method which produces the highest overall bridge rating shall be utilized to rate the affected components. The wearing surface superimposed dead loads shall always be distributed uniformly between all beams. The use of superimposed dead load distribution factors which lie in between those specified above shall not be used.

7.2.4.10 Tandem axle formulas for deck ratings may be taken from the 1983 AASHTO *Manual for Maintenance Inspection of Bridges* which are no longer in the AASHTO *MCEB.* Article 5.3.3 of the 1983 Manual states:

> <u>Distribution of Loads to Concrete Slabs</u>
>
> Span Lengths:
>
> For simple spans, the span length shall be the distance center to center of supports but not to exceed clear span plus thickness of slab.

The following effective span lengths shall be used in calculating distribution of loads and bending moments for slabs continuous over more than two supports:

Slabs monolithic with beams (without haunches). S = clear span.
Slabs supported on steel or precast prestressed concrete stringers. S = as determined from Bridge Manual, Part II, Drawing No. 7.1.2.
Slabs supported on timber stringers. S = clear span plus ½ thickness of stringer.

Bending Moment:

Bending moment per foot width of slab shall be calculated according to methods given below:

S = effective span length in feet as defined above
E = width of slab in feet over which a wheel load is distributed.
P = load on one wheel of axle, in thousands of pounds.

Main Reinforcement Perpendicular to Traffic
Formulae for Moments Per Foot Width of Slab

Distribution of Wheel Loads Tandem Axles	Freely Supported Spans	Continuous Spans
Spans 2´ - 7´: $E = 0.36S + 2.58$	$M = +\ 0.25(P/E)S$	$M = 0.2(P/E)S$
Spans over 7´: $E = 0.063S + 4.65$	$M = +\ 0.25(P/E)S$	$M = 0.2(P/E)S$

7.2.4.11 When a truck is placed on a mountable sidewalk, mountable strip or mountable median, only the Operating Rating is to be considered for supporting members, and this shall be noted in the Breakdown of Bridge Rating section of the report. Curb reveals less than 12 inches shall be considered mountable.

7.2.4.12 Do not overlook the restraining moment effects caused by fixity, overhangs, or continuity. Consider the possibility that composite action may exist when a beam is sufficiently embedded in concrete or that an exterior beam may act compositely with a concrete barrier.

7.2.4.13 The Allowable Inventory Stresses for various timber species and grades are shown in AASHTO *Standard Specifications for Highway Bridges*, in the table for Allowable Unit Stresses for Structural Lumber. The Allowable Operating Unit Stresses shall equal 1.33 times the values determined for the Allowable Inventory Unit Stresses.

7.2.4.14 Where the actual species and grade of lumber are unknown, the rating engineer shall determine the species and grade by field observation and/or testing.

7.2.4.15 When a concrete arch, rigid frame or slab has a cover greater than 12 inches, use the same impact factor as for culverts.

7.2.4.16 Unless there is a mix formula or design strength given on the plans, concrete for superstructures shall be assumed as 2000 psi concrete before 1931, 3000 psi concrete from 1931 to 1984 and 4000 psi concrete from 1984 on. If a mix proportion is given, the strengths shall be taken from the 1916 Joint Committee Report (see values below).

Mix =	1:1:2	1:1$^1/_2$:3	1:2:4	1:2$^1/_2$:5	1:3:6
f'_c =	3000 psi	2500 psi	2000 psi	1600 psi	1300 psi

Based on f'_c, the Allowable Inventory and Operating Stresses may be taken from AASHTO *MCEB.*

7.2.4.17 For bridges that feature materials of unknown composition or strength, the use of assumed properties produces unreliable ratings. For such situations a program of material sampling and testing shall be developed and shall be submitted in sufficient detail to the Bridge Engineer for approval prior to performing the testing. All material sampling and testing shall be performed in accordance with applicable ASTM and AASHTO standards.

7.2.4.18 For critical connections, such as truss joints, the capacity of the connection, i.e., the rivets, gusset plates, etc., should be analyzed and rated.

7.2.4.19 The Allowable Tensile Stress at Inventory Stress Levels in the precompressed tensile zone for serviceability ratings of prestressed concrete members shall be $6\sqrt{f'_c}$ psi, as noted in the AASHTO *MCEB,* Article 6.6.3.3. The Allowable Compressive Stress at Inventory Stress Levels for prestressed concrete members shall be calculated using the formulas presented in the AASHTO *MCEB*, Article 6.6.3.3. The formulas for the prestressing steel Allowable Tension Stress rating presented in Article 6.6.3.3. need not normally be checked for either the Inventory or Operating Stress Levels. The only situation these rating values might control a rating would be in the unlikely case of very lightly prestressed members. All Allowable Tensile Stress values and Allowable Compressive Stress values used in the preparation of the rating report must be clearly stated in the Rating Analysis Assumptions and Criteria section of the rating report.

7.2.4.20 The AASHTO *MCEB*, in Article 6.6.3.3, provides one set of rating factor formulas for the rating of prestressed concrete members that consider both strength and serviceability together. Therefore, when calculating either Load Factor or Allowable Stress Ratings of prestressed concrete members, the flexural and shear strength rating factors for both Inventory and Operating Levels shall be obtained using these formulas as specified in Article 6.6.3.3.

7.2.4.21 Presentation of serviceability and strength rating values for prestressed concrete type superstructures shall follow the format of Figure 7.2 and 7.4. Please note that the *MCEB* makes no provisions for serviceability Operating Ratings and therefore these rating values shall not be calculated.

7.2.4.22 Virtis can only model linearly and parabolically varying web depths for reinforced concrete tee beam superstructures. If a beam's web depth varies along a circular curve, the concrete tee beams can only be modeled in Virtis using cross sections and cross sectional ranges with linear varying web depths.

7.2.5 Special Instructions for Arch Load Ratings

7.2.5.1 When analyzing an arch structure, the arch shall be modeled using MassHighway accepted finite element analysis software, such as STAAD or GT-STRUDL. The arch shall be modeled as a series of prismatic two-noded beam elements, with the loads applied at each node or applied as linearly varying loads to each member. A minimum of 10 straight beam elements or 1 straight beam element per 4 feet of clear span, whichever results in the most members, shall be used. Each member shall be of equal horizontal length. The node locations shall correspond to the mid-depth points of the arch segments. The arch geometry used in the analysis shall be determined using either a parabolic, circular, elliptical, or fifth order polynomial curve that achieves the best fit with the actual arch. Field measurement and confirmation of the arch geometry is critical. Assuming an arbitrary geometry is not acceptable since it may result in inaccurate results.

7.2.5.2 Vertical dead loads shall be calculated along horizontal length of each member and shall be applied as linearly varying loads to each member. The height of fill shall be computed from the extrados to the bottom of the wearing surface.

7.2.5.3 The weight of sidewalks, wearing surfaces, railings, curbs, and spandrel walls shall be computed and equally distributed across the width of the arch. In some cases, the spandrel wall can function as an independent member capable of supporting its self-weight and perhaps a portion of the arch. However, the ability of the spandrel walls to support itself and a portion of the arch is uncertain and should be neglected in the analysis.

7.2.5.4 The horizontal earth pressure loads shall be calculated assuming a lateral earth pressure coefficient of 0.25. The loads shall be computed along the vertical heights of each member and shall be applied as linearly varying loads to each member.

7.2.5.5 Live load effects, in the form of pressure applied at the wearing surface over the tire contact area for the given wheel loads, shall be computed and distributed in the longitudinal and transverse directions in accordance with AASHTO *Standard Specifications for Highway Bridges* Article 6.4. Live load impact shall be calculated in accordance with AASHTO *Standard Specifications for Highway Bridges* Article 3.8.2.3.

7.2.5.6 The AASHTO *MCEB*, states that environmental loads, in combination with dead and live load effects, shall be included at the Operating Level. Furthermore, the AASHTO *MCEB*, states that thermal effects should not be considered in calculating load ratings except for long span bridges and concrete arches. Therefore, stone masonry arches need not consider thermal effects in calculating load ratings. Concrete arches with spans greater than 100 feet shall consider thermal loading at the Operating Level.

7.2.5.7 Unit loads shall be applied to each node in the model to generate influence coefficient tables and lines for moment, shear, and axial load at given nodes. Extreme care shall be exercised to ensure that proper sign convention is maintained. From these influence lines, the maximum moment and corresponding shear and axial loads shall be calculated. As a minimum, influence lines shall be developed at the springlines, crown, quarter points, and at points where significant changes in section properties occur.

7.2.5.8 Live loads shall be positioned in order to maximize moment at each joint. It may be helpful to superimpose a transparent wheel load pressure umbrella over a scaled longitudinal section that depicts the wearing surface and arch extrados. The objective is to load those members so that live load moment shall be maximized at joints of interest.

7.2.5.9 In the load rating of stone masonry arches, the maximum eccentricity shall be calculated in order to determine the critical joint locations. The eccentricities shall be calculated by dividing the combined dead and live load moments by the combined dead and live load thrusts.

7.2.5.10 In the load rating of stone masonry arches, the concept of a "kern" or middle third section is used to determine whether any portion of the masonry shall be subject to tension.

The kern points are located above and below the neutral axis of the arch at a distance r^2/c, where r equals the radius of gyration $=\sqrt{\frac{I}{A}}$, and c equals the distance from the neutral axis to the extreme fiber.

In cases where the combined dead and live load thrust falls outside the kern points, resulting in tension in the masonry, a pressure wedge analysis shall be used to calculate the maximum compressive stress. The portion of the arch masonry in tension shall be effectively ignored by redistributing the pressure over a smaller depth.

If the eccentricity (e) of the combined thrust is located below the bottom kern point, the maximum compressive stress shall be determined as follows:

$f_t = 0$ (no tension assumed at top of masonry)
$f_b = (P/A)(d/c) = (P/A)(d/(d/2)) = 2P/A$

Where:
A = 3(d/2-e)(Unit Width)
d = Depth of Arch Section
e = Combined Moment / Combined Thrust

If the eccentricity (e) of the combined thrust is located above the top kern point, the maximum compressive stress shall be similarly determined as follows:

$f_t = (P/A)(d/c) = (P/A)(d/(d/2)) = 2P/A$
$f_b = 0$ (no tension assumed at bottom of masonry)

If the eccentricity (e) of the combined thrust is located between the kern points, the maximum compressive stress shall be determined as follows:

f_b or $f_t = (P/A)(1 + 6e/d)$

Where:
A = Cross sectional area
d = Depth of Arch Section

7.2.5.11 The Inventory Allowable Compressive Stresses for stone masonry shall be determined in accordance with Article 6.6.2.6 of the AASHTO *MCEB*. Professional judgment based upon field observations and testing is pivotal to the proper determination of Inventory Allowable Compressive Stresses for stone masonry. Based upon the rating engineer's judgment, Allowable Compressive Stresses may be lowered for low quality masonry, or raised if justified by testing of samples taken from the bridge. Ratings for stone masonry arches shall only be provided at the Inventory Stress Level.

7.2.5.12 The combined axial load and moment capacities of reinforced concrete arches shall be determined in accordance with Article 8.15 of the AASHTO *Standard Specifications for Highway Bridges*. Interaction diagrams for combined flexural and axial load capacities shall be produced. Inventory Capacities shall be obtained by using 35% of the capacities determined in accordance with Article 8.16.4. Operating Capacities shall be obtained by using 50% of the capacities determined in accordance with Article 8.16.4.

7.2.6 Special Instructions for Adjacent Beam Load Ratings

7.2.6.1 Unless there is physical evidence that the grouted keyway(s) between adjacent prestressed concrete beams are not transferring shear, all loads applied to the system of adjacent beams shall be distributed assuming the beams function together as a unit.

7.2.6.2 When analyzing adjacent prestressed deck and box beam systems, the superimposed dead loads shall be distributed to all adjacent beams evenly unless beams of different moments of inertia are used together. In this case, the distribution of superimposed dead loads to each beam shall be in proportion to its tributary moment of inertia according to the formula provided in Subsection 3.8.1 of Part I of this Bridge Manual.

7.2.6.3 Non-adjacent exterior beams with sidewalk utility bays shall have 60% of the barrier weight applied to the exterior beam and 40% to the group of adjacent interior beams as described in Paragraph 7.2.6.2. The wearing surface superimposed dead load shall be distributed in accordance with Paragraph 7.2.6.2 to all adjacent beams.

7.2.6.4 Sidewalk utility loads for structures with sidewalk utility bays shall be distributed by placing 50% of the utility loads to the exterior beam and 50% to the group of adjacent interior beams.

7.2.7 Special Instructions for Corroded Steel Stringer/Girder Web Load Ratings

7.2.7.1 Corrosion of steel stringer/girder webs due to exposure to deicing chemicals is a very common problem that must be addressed in load ratings. This deterioration is typically located below leaking deck joints and consists of reduced web thicknesses with irregularly shaped web holes in advanced cases. This may result in web crippling or web buckling. When web section losses equal or exceed an average of 1/8", the simplified methods presented below for computing the reduced capacity of the section shall be used to establish load ratings.

7.2.7.2 The web crippling capacity (F_{crip}) for rolled beams shall be calculated only at inventory level as follows:

$$F_{crip} = F_{cr} * t_w * L_{eff}$$

Where:

F_{cr} = the allowable stress for web crippling = 0.75 * F_y
t_w = the average thickness of the deteriorated web above the bearing
L_{eff} = the effective length = $L_{eff} = N + k$

Where:
N = the bearing length
k = distance from outer face of flange to web toe of fillet (per AISC)

7.2.7.3 The web buckling capacity (F_{buc}) shall be calculated using the following AASHTO LRFD derived resistances divided by defined factors of safety at inventory and operating levels. For rolled beams, the effective column section of the web consists a strip of web extended not more than 9*t_w (t_w is the average thickness of the deteriorated web) on each side of the centerline of bearing (b =18*t_w and h = t_w). For plate girders, the effective column section shall consist of all stiffener elements, plus a strip of web extended not more than 9*t_w (t_w is the average thickness of the deteriorated web) on each side of the centerline of bearing. The calculation shall be performed as follows:

$$F_{buc} = F_{cr} * A_g$$

Where:

$$A_g = bh = 18t_w^2$$

F_{cr} = column critical buckling stress determined as a function of the column slenderness factor λ:
If λ < 2.25, then $F_{cr} = 0.66^{\lambda} F_y$

If λ >2.25, then $F_{cr} = \dfrac{0.88}{\lambda} F_y$

Where:

$$\lambda = \left(\frac{kl}{r\pi}\right)^2 \frac{F_y}{E}$$

r = radius of gyration about the plane of buckling (in)

$$r = \sqrt{\frac{I}{A}} \quad \text{With } I = \frac{bh^3}{12} = \frac{3t_w^4}{2} \text{ and } A = bh = 18t_w^2$$

k = 0.75 (effective length factor – Article 6.10.11.2.4a LRFD)
l = unbraced length = web depth – end diaphragm height, when diaphragm is present (in)
E = modulus of elasticity of steel (ksi)
Fy = minimum yield strength (ksi)

Inventory: $F_{buc}^{INV}(ASD) = \dfrac{F_{buc}(LRFD)}{F.S.}$

Where: F.S. = 1.70 – To accommodate members designed using ASD

Operating: $F_{buc}^{OPER}(ASD) = F_{buc}^{INV}(ASD) * \frac{0.75}{0.55}$

7.2.7.4 The corroded web rating shall be determined using the governing capacity of the web crippling and web buckling checks as follows:

Capacity = Min [F_{crip}, F_{buc}]

Rating Factor:

$$RF = \frac{Capacity - DL_{shear}}{(L+I)_{shear}}$$

7.2.8 Guidelines for Recommendations

The Rating Engineer may make general or specific recommendations to address a structural deficiency or to improve the load carrying capacity of the bridge. Such recommendations should be based on sound engineering judgment and the results of the rating analysis. The rating engineer must examine all ramifications of such recommendations so that any recommendation included in the rating report is feasible, safe and shall not adversely affect the structure or its long-term performance and maintainability.

The Rating Engineer is cautioned against making unrealistic or impractical recommendations just for the sake of making a recommendation. Any specific recommendation that shall alter the bridge's load carrying capacity shall include rating calculations, located in Appendix C, that shall indicate the revised rating if the recommendation is implemented.

7.3 SUBMITTALS

7.3.1 Calculations

All submitted calculations shall include either sketches or photocopies of the plan, elevation and cross section of the structure.

7.3.2 AASHTOWare™ Virtis File Submission

7.3.2.1 A compact disk (CD) containing all analysis software input and output files for rating a particular bridge and an Adobe Acrobat format (PDF) file of the report shall be submitted. The CD shall be included in a pocketed sleeve attached to the Rating Report. The sleeve shall feature an anti-static poly liner to protect the data and shall prevent the disk from becoming detached from the Rating Report if the report is handled roughly or turned upside down. The disk shall be included with the Bridge Section copy of the Rating Report. The disk should be labeled with a typed title block which includes the following information:

1. Name of the Consulting Firm
2. Bridge Number, BIN Number
3. Facility Carried / Feature Intersected

4. Name of software and version of software used

7.3.2.2 AASHTOWare™ Virtis files shall rate every unique beam element of the structure in order to determine the controlling live load capacity of the structure. The bridge shall be modeled as a Girder System. Links shall be used to define identical girders within a girder system. However, the following members shall be modeled as a Girder Line:

1. When the structure is a concrete slab bridge;
2. When the exterior beam acts composite with a sidewalk or a safety curb. This particular member shall be modeled as a Girder Line and the remaining portion of the structure shall be modeled as a Girder System, wherever possible;
3. When the beams are not parallel to each other. Non-parallel beams shall be modeled as Girder Lines and the parallel beams shall be modeled as a Girder System.

7.3.2.3 The file naming convention shall be consistent with the examples provided with the MassHighway prepared Virtis user example guides. The following Massachusetts specific example is provided:

Bridge No. A-12-345=A-67-890, BIN = ABC, ANYCITY=ANYTOWN, MAIN STREET / BIG RIVER shall be identified without any blank spaces using the following UPPER CASE characters:

Bridge ID (unlimited digits): A-12-345=A-67-890(ABC)
NBI Structure ID (NBI Item 8, 15 digits): A12345ABCMHDNBI
Name (same as Bridge ID): A-12-345=A-67-890(ABC)
Description (unlimited digits): 4 SPAN CONTINUOUS COMPOSITE MULTIPLE STEEL STRINGER (Modify as required.)

Where: The first 13 characters (22 if town line bridge, as shown in the example) reflect the structure's Bridge Number, including hyphens, equal sign, and parentheses, and the characters within the parentheses represent the structure's BIN Number.

For submission purposes, the file shall be exported with the extension .BBD:

A-12-345=A-67-890(ABC).BBD

7.3.2.4 All relevant information from the structure SIA sheet shall be transcribed verbatim into the appropriate fields in the Virtis file's Bridge Workspace Window.

7.3.2.5 Calculations for all loads and distribution factors should be clearly shown within the rating and summarized in a table.

7.3.2.6 The noncomposite dead load for composite structures in excess of that of the beam and reinforced concrete slab shall be calculated and stated in a table. Noncomposite loads may include, but not be limited to, stay in place forms, diaphragms, utilities and utility supports, and sign supports.

7.3.2.7 All information pertaining to the beam layout and cross section should be included in tables.

7.3.2.8 Each girder should specify a minimum of “Points of Interest” (POI) in each span at ratios of 0.45 of the length of the span for simple spans and 0.375 and 0.75 of the length of the span for continuous spans. By default, Virtis performs analyses at each 1/10th point. Additional POI shall be placed at any change in section of a span such as, the theoretical cover plate cut off locations, field splice locations, plate girder transitions, points where reinforcement patterns change and harp points for draped strands. Each girder shall have the results of the analysis summarized in summary reports for both ASD and LFD methods. Each girder shall have two reports produced, the first report shall determine the lowest rating value (analyzed by using POI control #3 from the Brass Engine of the Virtis Program) and the second report shall determine the lowest rating value at each point of interest (analyzed by using POI control #5 from the Brass Engine of the Virtis Program).

7.3.2.9 All Virtis files shall have all four statutory loading vehicles (H20, Type 3, Type 3S2, HS20) used in the rating analysis.

7.3.2.10 The output specifications should be as follows:

1. Deck geometry & load summary report;
2. Girder loads summary report;
3. Beam properties;
4. Prestressed strand properties;
5. All girder actions due to applied static load live load report;
6. Load summary sheet;
7. Prestressing strand properties report (prestressed members only);
8. Virtis produced sketches of the framing plan, structure cross section, and girder details for steel stringer structures;
9. Virtis produced sketches of the framing plan, structure cross section, girder details, and strand locations at midspan and bearings for prestressed concrete structures;
10. Virtis produced sketches of the framing plan, structure cross section, and girders cross section with the reinforcement for reinforced concrete slab, tee beam and I beam structures;
11. The output specifications contained in the rating report shall be printed on doubled-sided 8½” x 11” paper and shall be printed with the text size specified as 6 point font size;
12. The same submission requirements shall apply when an alternate approved computer program is utilized.

7.3.3 Check of Calculations Submission

All ratings calculations shall be reviewed with a check of methods, assumptions and load distributions in addition to a check of the actual calculations. The standard statement of concurrence with the calculations shall be included with the date and signature of the reviewer. The standard statement of concurrence shall be:

> "I HEREBY STATE THAT I HAVE CHECKED THE METHODS, ASSUMPTIONS, LOAD DISTRIBUTIONS, AND ALL CALCULATIONS FOR THIS RATING REPORT FOR BRIDGE NO. A-12-345 (ABC). BY SIGNING BELOW, I CONFIRM THAT I AGREE WITH ALL METHODS, ASSUMPTIONS, LOAD DISTRIBUTIONS, AND CALCULATIONS CONTAINED IN THIS RATING REPORT."

The reviewer shall be a Professional Engineer registered in the Commonwealth of Massachusetts.

7.3.4 Previously Rated Bridges

For all bridges that have been previously rated and have had AASHTOWare™ Virtis files produced for all bridge members requiring a rating, and now require re-rating due to a changed condition, only those members affected by the changed condition shall require new computations. It is not necessary to duplicate all of the rating calculations contained in the original rating. However, the Rating Engineer shall review the old rating report to verify that the original rating and/or design assumptions are still valid. The revised report shall reference and include the original rating report, as an appendix, that was used for the basis of the new rating. For those bridges that have been previously rated without an AASHTOWare™ Virtis file submission, a full AASHTOWare™ Virtis file shall be prepared and submitted for all bridge members requiring a rating.

7.4 REPORT

7.4.1 Format

The Rating Report shall be printed on 8½" x 11" sheets and shall be GBC bound with clear front and back covers. The lettering of the Bridge Number shall be such as to permit easy recognition. Covers with cutouts, which may get torn in filing cabinets, are not acceptable and fold-out pages greater than 8½" x 11" size shall not be included. An Adobe Acrobat format (PDF) file of the report shall be submitted on the CD. Covers shall be red if any rating is 6 tons or less, yellow if more than 6 tons but less than statutory and green for statutory or greater. The Rating Report shall be composed of the following sections:

1. REPORT COVER
   1.1. P.E. Stamp shall be placed here.
   1.2. Formatted as shown in Figure 7.1

2. TITLE SHEET
   2.1. White copy of Report Cover.

3. INDEX
   3.1. Index of sections outlined with page numbers.

4. SUMMARY OF BRIDGE RATING
   4.1. P.E. Stamp shall be placed here.
   4.2. Tabular listing of the controlling rating values from the Rating Report.
   4.3. Formatted as shown in Figure 7.2 for all structures.

5. BREAKDOWN OF BRIDGE RATING
   5.1. Tabular listing of all bridge elements that must be rated to determine the rating of the bridge and at all critical locations as described in Article 7.2.3.4. The controlling rating shall be shaded.
   5.2. Formatted as shown in Figures 7.3 and 7.5 for all structures excluding prestressed concrete structures and as shown in Figures 7.4 and 7.5 for all prestressed concrete structures.

6. LOCATION MAP
   6.1. The location map shall provide sufficient landmarks and adjacent highway information to allow the user to find the bridge in the field without additional information.

7. DESCRIPTION OF BRIDGE
   7.1. Formatted as shown in Figure 7.6

8. RATING ANALYSIS ASSUMPTIONS AND CRITERIA
   8.1. Description of all methods, assumptions, allowable stresses, and strengths used to determine the rating of the structure.

9. EVALUATION OF RATING AND RECOMMENDATIONS
   9.1. Summary of controlling elements of the structure and recommendations to either improve or maintain the condition of the structure as described in Subsection 7.2.6.

10. AVAILABLE PLANS
    10.1. Listing of all plans and their sources that were available to the rating engineer for the purpose of preparing the Rating Report.

11. TRUCK LOADINGS
    11.1. Standard diagrams of H20, Type 3, Type 3S2, and HS20 Vehicles showing axle weights and spacings as shown in Figure 7.7.

12. APPENDIX A - INSPECTION REPORTS
    12.1. Inspection Reports including structure inventory and appraisal (SI&A), structures inspection field report and field notes. The first sheet shall be the SI&A sheet. Inspection Reports must be the latest available Routine and Special Member at the time the Rating Report is submitted and shall include color reproductions of all inspection report photos.

13. APPENDIX B - PHOTOS
    13.1. An abundant number of color photographs of the structure, each no smaller than 3” by 5”, including both elevation views, views of both approaches, framing views (if it

varies, one of each type) and sufficient critical member photos. An index of all photos shall precede the photos.

14. APPENDIX C – COMPUTATIONS
    14.1. Computations shall include an index, sketches, hand calculations, and the written agreement of the independent reviewer.

15. APPENDIX D - COMPUTER INPUT AND OUTPUT
    15.1. Hard copies of all input and output summary pages, including software generated sketches, of computer programs used in rating the structure. These hard copies shall be submitted double-sided with a reduced font in order to conserve paper.
    15.2. A summary sheet of all rating factors and rating values for each structures particular elements shall be created and placed in front of each output of each particular element.

16. APPENDIX E - OLD RATING REPORT
    16.1. The covers shall be removed from the old rating report and the report shall be incorporated in its entirety into Appendix E of the new rating report.

7.4.2 Report Distribution

Two copies of the report shall be submitted to the MassHighway Bridge Section: 1 copy for the Bridge Section and 1 copy for the District.

BRIDGE RATING

Prepared For

COMMONWEALTH OF MASSACHUSETTS
MASSACHUSETTS HIGHWAY DEPARTMENT

ANYCITY=ANYTOWN

MAIN STREET

OVER

BIG RIVER

BRIDGE NO. A-12-345=A-67-890(ABC)

STRUCTURE NO. A12345-ABC-MHD-NBI

DATE OF INSPECTION
DATE OF RATING

PREPARED BY

"Consultant Name & Address"
"P.E. Stamp with Signature"

FIGURE 7.1

SUMMARY OF BRIDGE RATING

TOWN/CITY: ANYCITY=ANYTOWN BRIDGE NO.: A-12-345=A-67-890

CARRIES: MAIN STREET OVER: BIG RIVER

STRUCTURE NO. A12345-ABC-MHD-NBI BIN NO.: ABC

RATINGS (TONS)

Allowable Stress Ratings for Load Posting Purposes Load Ratings in English Tons		
VEHICLE TYPE	INVENTORY	OPERATING
H20	21.7	31.6
TYPE 3	32.5	57.1
TYPE 3S2	36.0	90.1
HS20	32.8	56.9

MS18 Load Factor Ratings in Metric Tons Provided in Compliance with the December 1995 FHWA NBIS Coding Guide			
INVENTORY		OPERATING	
Item 66	MS Equivalent	Item 64	MS Equivalent
32.4	MS18.0	54.5	MS30.2

A posting recommendation has been made based on the results of this Rating Report. This recommendation is contained in the “Memorandum to the NBIS File” for this bridge, dated ___________________.

Director of Bridges and Structures Date

Consultant P.E. Stamp

FIGURE 7.2

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: ANYCITY=ANYTOWN BRIDGE NO.: A-12-345=A-67-890

CARRIES: MAIN STREET OVER: BIG RIVER

STRUCTURE NO. A12345-ABC-MHD-NBI BIN NO.: ABC

BRIDGE ELEMENT	INVENTORY RATING BY WORKING STRESS METHOD				OPERATING RATING BY WORKING STRESS METHOD			
	H20	TYPE 3	TYPE 3S2	HS20	H20	TYPE 3	TYPE 3S2	HS20
DECK SLAB	21.7	39.2	61.9	39.0	31.6	57.1	90.1	56.9
EXTERIOR BEAMS: MIDSPAN	37.0	40.0	43.9	40.0	81.8	85.8	97.2	88.2
EXTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X = 20’-0 1/4”	39.4	37.8	42.5	38.5	87.2	83.5	93.6	85.0
EXTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 30’6 1/4”	35.8	37.5	42.5	38.5	79.8	83.8	94.3	85.7
INTERIOR BEAMS: MIDSPAN	36.8	38.5	43.6	39.6	78.2	81.8	92.9	84.2
INTERIOR BEAMS: BOTTOM PLATE TRANSITION AT X -= 21’-3 1/4”	33.6	32.5	36.0	32.8	76.0	73.3	81.4	73.8
INTERIOR BEAMS: WEB PLATE TRANSITION AT X = 29’-0 1/4”	36.6	38.5	43.6	39.2	77.4	81.3	91.8	82.8
INTERIOR BEAMS: BOTTOM PLATE AND TOP PLATE TRANSITION AT X = 32’-0 1/4”	32.4	33.5	37.8	34.2	72.2	75.0	84.2	76.7

FIGURE 7.3

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: ANYCITY=ANYTOWN BRIDGE NO.: A-12-345=A-67-890

CARRIES: MAIN STREET OVER: BIG RIVER

STRUCTURE NO. A12345-ABC-MHD-NBI BIN NO.: ABC

BRIDGE ELEMENT	INVENTORY RATING (ENGLISH TONS)				OPERATING RATING (ENGLISH TONS)			
	H20	TYPE 3	TYPE 3S2	HS20	H20	TYPE 3	TYPE 3S2	HS20
DECK SLAB (ASD)	17.8	22.3	38.1	23.2	28.0	31.8	44.9	30.4
Interior Beam – Type A Serviceability – Concrete Tension @ 0.45L	36.6	43.5	69.8	47.9				
Interior Beam – Type A Serviceability – Concrete Tension @ 0.50L	36.4	43.5	69.1	48.2				
Interior Beam - Type A Flexural Strength - @ 0.45L	26.5	31.5	50.6	34.6	44.2	52.7	84.5	57.8
Interior Beam - Type A Flexural Strength – 0.5L	26.3	31.6	50.0	34.9	44.0	52.7	83.4	58.3
Interior Beam - #5 – Serviceability - Concrete Tension @ 0.45L	25.0	30.0	47.9	32.9				
Interior Beam – #5 - Serviceability - Concrete Tension @ 0.50*L	24.8	29.8	47.2	32.8				
Interior Beam – #5 – Flexural Strength @ 0.45*L	19.0	22.6	36.3	24.8	31.7	37.8	60.6	41.4
Interior Beam – #5 – Flexural Strength @ 0.50*L	18.8	22.6	35.7	24.9	31.4	37.7	59.6	41.6
Interior Beam – #6 – Serviceability - Concrete Tension @ 0.45*L	20.6	24.5	39.2	27.0				
Interior Beam – #6 – Serviceability -Concrete Tension @ 0.50*L	20.4	24.3	38.5	27.0				
Interior Beam – #6 - Flexural Strength @ 0.45*L	16.0	19.1	30.6	20.9	26.7	31.9	51.1	35.0
Interior Beam – #6 - Flexural Strength @ 0.50*L	15.8	19.0	30.1	21.0	26.5	31.7	50.2	35.1

FIGURE 7.4
(PRESTRESSED CONCRETE EXAMPLE)

BREAKDOWN OF BRIDGE RATING

TOWN/CITY: ANYCITY=ANYTOWN BRIDGE NO.: A-12-345=A-67-890

CARRIES: MAIN STREET OVER: BIG RIVER

STRUCTURE NO. A12345-ABC-MHD-NBI BIN NO.: ABC

BRIDGE ELEMENT	INVENTORY RATING BY LOAD FACTOR METHOD (METRIC TONS)		OPERATING RATING BY LOAD FACTOR METHOD (METRIC TONS)	
	MS18	MS (EQUIV.)	MS18	MS (EQUIV.)
DECK SLAB	36.0	MS20.0	54.5	MS30.3
EXTERIOR BEAMS: MIDSPAN	55.4	MS30.8	83.3	MS46.3
INTERIOR BEAMS: MIDSPAN	47.6	MS26.5	79.7	MS44.3

FIGURE 7.5

DESCRIPTION OF BRIDGE

ANYCITY=ANYTOWN MAIN STREET / BIG RIVER BRIDGE NO. A-12-345=A-67-890

Date of Construction:	1979
Original Design Loading:	HS20
Posted Limit:	None
Bridge Type:	Plate girders with composite reinforced concrete deck
Skew:	40°-16’-2”
Spans:	1 simple span, 131’-0”
Width of Bridge Deck:	45’-2” out-to-out
Roadway Width:	40’-6” curb-to-curb
Roadway Surface:	3” bituminous concrete
Curbs:	Concrete curb both sides
Sidewalk/Walkway/Median:	No sidewalks, 2 - 2’-4” safety curbs
Bridge Railing:	AL-3 metal bridge rail
Approach Railing:	Type SS highway guard (all four corners)
Superstructure:	6 plate girders @ 7-9” spacing with 8” thick composite reinforced concrete deck
Modifications to Original Superstructure:	None
Utilities:	None
Substructure:	Two stub type abutments with adjoining cantilevered U-wingwalls
Modifications to Original Substructure:	None

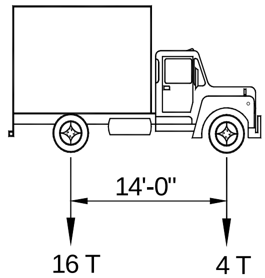
FIGURE 7.6

LOADINGS USED FOR BRIDGE RATING

ANYCITY=ANYTOWN MAIN STREET / BIG RIVER BRIDGE NO. A-12-345=A-67-890

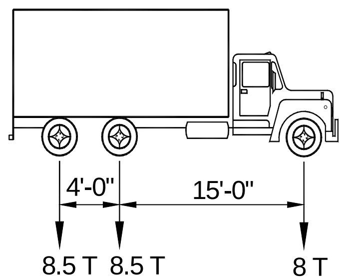
H20 VEHICLE

TOTAL WEIGHT
20 TONS



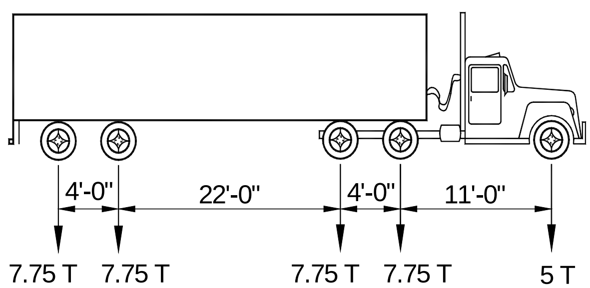
TYPE 3 VEHICLE

TOTAL WEIGHT
25 TONS



TYPE 3S2 VEHICLE

TOTAL WEIGHT
36 TONS



HS20 VEHICLE

TOTAL WEIGHT
36 TONS

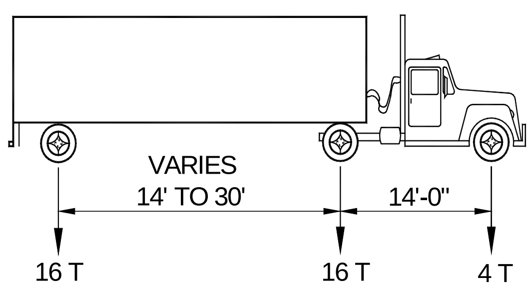


FIGURE 7.7

CHAPTER 8
SPECIAL PERMIT VEHICLE ANALYSIS GUIDELINES

8.1 POLICY

8.1.1 Purpose

To establish a uniform guidelines to be followed by MassHighway and Consultant Rating Engineers in determining the structural adequacy of bridges that are proposed to be crossed by escorted overweight permit vehicles.

8.1.2 Definitions

For the purpose of this Chapter, the following definitions shall be used:

Rating Engineer is the person responsible for the Special Permit Vehicle analysis. In the case where the bridge structure(s) crossed is not on routes analyzed by MassHighway, the engineer shall be the consultant engineer hired by the permit applicant.

Special Permit Vehicles are vehicles with weights in excess of the legal limits that carry loads that are irreducible.

Posting Vehicles are the vehicles whose load rating is used when a bridge is posted. MassHighway currently uses the following posting vehicles: H20 truck, Type 3 truck, Type 3S2 truck.

8.1.3 Qualifications

Special Permit Vehicle analysis reports shall be prepared by a Professional Engineer, registered in Massachusetts, or by MassHighway engineers under the direction of the Bridge Engineer. Rating Engineers performing the Special Permit Vehicle analyses shall be knowledgeable in bridge design and shall be familiar with the relevant AASHTO specifications.

8.1.4 Field Inspection

The Rating Engineer will verify in the field what is contained on the latest Construction Drawings, latest inspection reports and prior bridge rating reports. If during the verification, the Rating Engineer finds an adverse condition that is not noted or documented sufficiently on the inspection report, the Rating Engineer shall notify the Bridge Engineer and shall obtain documented measurements of the adverse condition prior to incorporating the findings into the Special Permit Vehicle analysis report. Section losses used to calculate the capacities shall be based on documented measurements and will not be based on assumed conditions. A statement from the consultant, or certified statement from a flag car company, shall be provided to certify that the Special Permit Vehicle does not violate any height or width restrictions for all structures that the Special Permit Vehicle will go under or over.

8.1.5 Undocumented Bridge Structures

The Rating Engineer shall obtain all pertinent information required to determine the capacity of all structures to safely support the Special Permit Vehicle without damage. If a structure is encountered where no documentation exists that defines the structure's composition, then the Rating Engineer shall take all necessary steps to determine the physical characteristics of the structure so that the safe carrying capacity of the structure can be determined. The documentation shall include all necessary dimensions, non-destructive evaluations, sampling, and physical testing required to determine the safe carrying capacity. Upon gathering all relevant information, the Rating Engineer shall forward this information via a separate letter to the Bridge Engineer, in addition to incorporating the information into the Special Permit Vehicle analysis report.

8.2 APPLICATION OF LIVE LOADS AND LOAD RATING INSTRUCTIONS

8.2.1 Objective

The object of the Special Permit Vehicle analysis is to determine the appropriate rating factors for the given Special Permit Vehicle to ensure that all structures may be safely crossed without damage to the structure, consistent with sound engineering practice.

8.2.2 Live Loads

The live loads applied shall accurately represent the Special Permit Vehicle's wheel and axle loads and wheel and axle spacings. In general, a sufficient number of axles shall be used such that the axle loads are limited to no more than 22,400 pounds. Higher axle loads are possible, but may be subject to additional restrictions. These restrictions may include, but not be limited to, spanning over the bridge with a temporary structure, increasing the number of wheel lines to improve the lateral distribution of the loads, reduced speed limits, and preventing other traffic from using the bridge at the same time as the Special Permit Vehicle.

8.2.3 Special Instructions for Special Permit Vehicle Analysis

Special Permit Vehicle rating calculations shall be performed in accordance with the following guidelines. Request for clarification of or deviation from these guidelines must be submitted in writing (FAX is acceptable). Written responses will be provided.

8.2.3.1 Bridges shall be rated in accordance with the provisions of the current AASHTO *Manual For Condition Evaluation Of Bridges (MCEB)* including all interims except where modified by this Bridge Manual using the allowable stress method.

8.2.3.2 The computed stresses shall not exceed the Operating Allowable Stresses for structures where all of the main load carrying members are in fair or better overall condition. Structures with main carrying members in poor condition or worse shall be avoided where possible, otherwise computed stresses may be limited to values less than Operating Allowable Stresses at the discretion of the Rating Engineer or MassHighway Bridge Engineer.

8.2.3.3 Impact factors shall adhere to the requirements of AASHTO. The impact factor may be reduced to a limit of 10% if the Special Permit Vehicle travels at a speed of 10 miles per hour or less over the structure and the bridge wearing surface has a condition rating of fair or better.

8.2.3.4 Rating factor calculations shall be prepared for each structure to be traversed by the Special Permit Vehicle. Live load comparison methods shall not be considered as a substitute for rating factor calculations.

8.2.3.5 AASHTO live load distribution factors shall be used. The use of alternative distribution factors less than those provided in AASHTO is not acceptable without calibrated load testing.

8.3 SPECIAL PERMIT VEHICLE ANALYSIS REPORT

8.3.1 Format

The Special Permit Vehicle Analysis Report submitted by a Consultant Rating Engineer shall be GBC bound with clear front and back protective covers. The inside cover of the report must contain the permit applicant's name, start and end points of the move, the name and address of the Consultant engineering firm that prepared the report, the date of the report, and a print of the Rating Engineer's registration stamp along with an original signature. The Special Permit Vehicle Analysis Report shall be composed of the following sections:

1. REPORT COVER

2. TITLE SHEET
   2.1. White copy of report cover.

3. INDEX
   3.1. Index of sections outlined with page numbers.

4. TABULAR SUMMARY BREAKDOWN
   4.1. Provide all pertinent information concerning every structure proposed to be crossed. Format the table with separate columns for bridge number, structure number, BIN number, latitude, longitude, rating factor values, method of analysis, Item 58, Item 59, Item 60, the last bridge inspection date, and codes for any restrictions to be placed during the crossing of the structure. Each row in the table shall represent a particular structure to be crossed.
   4.2. The rows shall be ordered in sequence from the start to the end of the move.

5. ROUTING MAPS

6. PURPOSE AND CRITERIA

7. DESCRIPTION OF ROUTE

8. RECOMMENDATIONS

9. CONSTRUCTION PROJECTS
   9.1. Include a detailed description of all construction projects along the proposed route. Indicate what, if any, restrictions must be imposed to allow the Special Permit

Vehicle to safely travel through the construction project(s).

10. SPECIAL PERMIT VEHICLE DATA
    10.1. Provide a silhouette indicating the Special Permit Vehicle axle loads, distance between axles, vehicle width, vehicle height and overall vehicle length.
    10.2. Provide a cross section indicating the Special Permit Vehicle wheel lines and spacing between each wheel line.

11. APPENDIX A – COMPUTATIONS
    11.1. The consultant shall submit on CD, all computerized AASHTOWare™ Virtis input and output summary sheets and hand calculations.
    11.2. The AASHTOWare™ Virtis files for all structures analyzed using AASHTOWare™ Virtis shall be prepared as described in Chapter 7 of Part I of this manual. Where a structure cannot be analyzed using AASHTOWare™ Virtis, then an alternate program, approved by the Bridge Engineer, shall be utilized.

12. APPENDIX B – INSPECTION REPORT
    12.1. Include a photocopy of the latest inspection report for each structure to be crossed.

8.3.2 Submission and Processing Protocol

Sufficient lead time must be provided to allow MassHighway to process the permit requests. **IN GENERAL, 1 WEEK OF LEAD TIME IS REQUIRED TO PROCESS THE PERMIT APPLICATION. CONSULTANT RATING ENGINEERS SHALL ADVISE THE PERMIT APPLICANTS ACCORDINGLY.** The Special Permit Vehicle Analysis Report and cover letter shall be sent to the MassHighway Highway Operations Engineer and a single copy of the report and cover letter shall be submitted to the MassHighway Bridge Engineer for review. Reports shall be reviewed and processed in the same order that they are received. MassHighway endeavors to review and process permit requests in a timely manner.

8.4 EXISTING INVENTORIED ROUTES

The MassHighway Bridge Section performs the analysis for certain routes of travel that may be utilized by Special Permit Vehicles. Consultant engineering firms are to analyze the structures not on these routes and shall determine their adequacy to support the proposed Special Permit Vehicle. The routes that are presently analyzed by MassHighway as a service to the Special Permit Vehicle permit applicants are as follows:

Interstate I-495
Interstate I-295
Interstate I-290
Interstate I-84
Interstate I-395
Interstate I-95
Interstate I-91
Interstate I-190
Interstate I-195 (Wareham to New Bedford)
Interstate I-93 (I-95/128 in Reading to Exit 30, Mystic Ave., in

Medford)

The routes contained in the MassHighway Bridge Section inventory may expand in the future. The Rating Engineer should contact the MassHighway Bridge Section to determine whether additional routes have been added prior to performing the Special Permit Vehicle analysis.

8.5 PRIVATELY OWNED AND OTHER AGENCY OWNED STRUCTURES

MassHighway does not perform structural analysis nor does it review structural analysis performed by Consulting Rating Engineers for bridges not owned by either MassHighway or the various cities and towns of Massachusetts.

2006-2008 MHD BRIDGE SECTION WEIGHTED AVERAGE UNIT PRICES
GUIDELINES FOR THE USE OF THE WEIGHTED AVERAGE UNIT PRICE TABULATION SHEETS

GENERAL

The listed average unit prices are based on the available lowest 2006, 2007, and 2008 bids for each MassHighway project. Please note that data is not available for every item because many items were not used during this timeframe. Please check the Weighted Average Bid Application, available via the MassHighway website, for the latest unit price data. In cases where unit price data is not available, it is recommended that a unit price be estimated using the available data for the next closest size member. It is important to recognize the necessity of varying the Office Estimate unit prices based on the quantity of the item in question. Since the MassHighway Capital Expenditure Program Office (CEPO) determines funding requirements for projects based on the Office Estimates, it is vital that the office estimate be as accurate as possible and in line with the actual contractor bids.

Therefore, the goal shall be to use unit prices that will place the office estimate into the middle third of the bid "pack". This is generally accomplished by adjusting the weighted average unit prices based on the quantity of a particular item. Generally speaking, the larger the quantity of an item the cheaper it will be on a per unit basis. However, there is no hard and fast rule on how to apply this. The adjustment of unit prices is based on experience and judgement. It is better to over estimate (marginally) the unit price of an item than to under estimate it.

Some assistance in estimating unit prices for structural items may be found in the representive graphs of the unit costs of main members, reinforcing steel, concrete items, prestressed concrete beams and structural steel.

Of note is the number of projects listed for each item. The larger the number of projects the more reflective the average prices will be of the cost of the work. Also, unit price data that indicates an apparent reduction of a unit price over time is more likely an indicator of less complicated work or economies of scale.

DEMOLITION OF SUPERSTRUCTURE

Demolition of Superstructure is to be listed in the Office Estimate on a Lump Sum basis. Estimate the cost based on the total deck area in square yards of existing superstructure intended to be demolished. (reference charts for Estimating Cost).

BRIDGE STRUCTURE LUMP SUM ITEM

In general, the Bridge Structure Lump Sum Item is used to pay the Contractor a fixed price for the work done and no measurement of final pay quantity is required. However, the Bridge Structure Lump Sum Item can only be used for those elements of the structure for which the scope of work, the methods of construction, and the type and quantity of materials to be furnished are accurately defined on the plans and/or in the special provisions. All other items must utilize a Unit Price basis of payment since the Contractor's bid is based on estimated quantities that may vary considerably from the actual quantities required during construction.

The breakdown of the Bridge Structure Lump Sum Item shall be provided in the Special Provisions and shall specify for each component part the sub-item number, the sub-item name, the quantity of each sub-item, and the unit of each sub-item quantity. The sub-item numbering, naming, and quantity unit convention shall match that used in the latest Standard Nomenclature as specified herein. Please refer to the sample provided on the next page.

GUIDELINES FOR THE USE OF THE WEIGHTED AVERAGE UNIT PRICE TABULATION SHEETS

SCHEDULE OF BASIS FOR PARTIAL PAYMENT

Within ten (10) days after the award of the Contract, the Contractor shall submit, in duplicate, for the approval of the Engineer, a schedule of unit prices for the major components of the bridge structure as listed below. The bridge structure Lump Sum breakdown quantities provided below are estimated and not guaranteed. The total of all partial payments to the Contractor shall equal the Lump Sum contract price regardless of the accuracy of the quantities furnished by the Engineer for the individual bridge components. The cost of labor and materials for any Item not listed but required to complete the work shall be considered incidental to Item 995.01 and no further compensation will be allowed.

SUB-ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
910.2	STEEL REINFORCEMENT FOR STRUCTURES - COATED	122,000	LB		
922.4	LAM. ELASTOMERIC BEARING W/O ANCHOR - BOLTS (151-200K)	13	EA		
931.03	PRESTRESSED CONCRETE BULB TEE - BEAMS (NEBT 1400)	397	LF		
960.363	STEEL M270 GRADE 36 GALVANIZED - MISCELLANEOUS	2795	LB		
970.	BITUMINOUS DAMP-PROOFING	228	SY		
971.	ASPHALTIC BRIDGE JOINT SYSTEM	59	LF		
975.4	PROTECTIVE SCREEN TYPE II	437	LF		
			TOTAL COST OF ITEM 995.01 =		

The above schedule applies only to the Bridge Structure No. A-01-234(BIN). Payment for similar materials and construction at locations other than at this bridge structure shall not be included under this Item. Sub-Item numbering is presented for information only in coordination with MassHighway Standard Nomenclature.

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
114.1	DEMOLITION OF SUPERSTRUCTURE OF BRIDGE NO.____________	LS	SEE CHARTS FOR ESTIMATING COST			
127.1	REINFORCED CONCRETE EXCAVATION	CY	1,121	5	$341.01	
140.	BRIDGE EXCAVATION	CY	54,933	14	$21.43	$20.00
140.1	BRIDGE EXCAVATION WITHIN COFFERDAM	CY	764	3	$58.34	
143.	CHANNEL EXCAVATION	CY	12,644	30	$36.09	
144.	CLASS B ROCK EXCAVATION	CY	2176.5	7	$134.69	$170.00
151.1	GRAVEL BORROW FOR BRIDGE FOUNDATION	CY	3078	7	$34.66	$50.00
151.2	GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES	CY	5549	7	$23.79	
156.	CRUSHED STONE FOR DRAIN., REVET AND/OR W. WORKS FOUNDATIONS	TON	10	1		$60.00
156.1	CRUSHED STONE FOR BRIDGE FOUNDATIONS	TON	225	2	$37.14	
156.13	CRUSHED STONE FOR INTEGRAL ABUTMENT PILES	TON	176	1	$43.54	
460.	HOT MIX ASPHALT	TON	26486	14	$79.38	$58.00
462.	HOT MIX ASPHALT DENSE BINDER COURSE FOR BRIDGES	TON	1273	13	$89.94	$58.00
901.	4000 PSI, 1.5 IN., 565 CEMENT CONCRETE	CY	SEE CHARTS FOR ESTIMATING COST			
904.	4000 PSI, 3/4 IN., 610 CEMENT CONCRETE	CY	SEE CHARTS FOR ESTIMATING COST			
904.3	5000 PSI, 3/4 IN., 685 HP CEMENT CONCRETE	CY	SEE CHARTS FOR ESTIMATING COST			
904.4	4000 PSI, 3/4 IN., 585 HP CEMENT CONCRETE	CY	SEE CHARTS FOR ESTIMATING COST			
905.2	5000 PSI, 3/8 IN, 710 HP CEMENT CONCRETE	CY	SEE CHARTS FOR ESTIMATING COST			
908.2	CEMENT CONCRETE FORM LINER - FRACTURED FIN	SY	0			$0.00
909.9	UNDERWATER FOUNDATION INSPECTION	UD	0	0		$0.00
910.2	STEEL REINFORCEMENT FOR STRUCTURES - COATED	LB	14,780,917	44		$1.85
912.5	DRILLED AND CHEMICAL ANCHORED #5 DOWELS	EA	0	0	$0.00	$82.46
915.13	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 20 TO 24.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.14	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 20 TO 24.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.15	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 20 TO 24.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.16	ARCH FRAME UNIT (OVER 6 FT. WIDE - 20 TO 24.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.23	ARCH FRAME UNIT (4 FT. OR LRSS WIDE - 25 TO 29.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.24	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 25 TO 29.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.25	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 25 TO 29.99 FT. SPAN)	EA	6	1	$32,500.00	$195,000.00
915.26	ARCH FRAME UNIT (OVER 6 FT. WIDE - 25 TO 29.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.33	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 30 TO 34.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.34	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 30 TO 34.99 FT. SPAN)	EA	0	0	$0.00	$0.00

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
915.35	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 30 TO 34.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.36	ARCH FRAME UNIT (OVER 6 FT. WIDE - 30 TO 34.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.43	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 35 TO 39.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.44	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 35 TO 39.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.45	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 35 TO 39.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.46	ARCH FRAME UNIT (OVER 6 FT. WIDE - 35 TO 39.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.53	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 40 TO 44.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.54	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 40 TO 44.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.55	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 40 TO 44.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.56	ARCH FRAME UNIT (OVER 6 FT. WIDE - 40 TO 44.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.63	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 45 TO 49.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.64	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 45 TO 49.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.65	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 45 TO 49.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.66	ARCH FRAME UNIT (OVER 6 FT. WIDE - 45 TO 49.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.73	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 50 TO 54.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.74	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 50 TO 54.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.75	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 50 TO 54.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.76	ARCH FRAME UNIT (OVER 6 FT. WIDE - 50 TO 54.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.83	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 55 TO 59.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.84	ARCH FRAME UNIT (4.01 TO 5 FT. WIDE - 55 TO 59.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.85	ARCH FRAME UNIT (5.01 TO 6 FT. WIDE - 55 TO 59.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.86	ARCH FRAME UNIT (OVER 6 FT. WIDE - 55 TO 59.99 FT. SPAN)	EA	0	0	$0.00	$0.00
915.93	ARCH FRAME UNIT (4 FT. OR LESS WIDE - 60 OR MORE FT. SPAN)	EA	0	0	$0.00	$0.00
915.94	ARCH FRAME UNIT (4.01 TO 5 FT. OR LESS WIDE - 60 OR MORE FT. SPAN)	EA	0	0	$0.00	$0.00
915.95	ARCH FRAME UNIT (5.01 TO 6 FT. OR LESS WIDE - 60 OR MORE FT. SPAN)	EA	0	0	$0.00	$0.00
915.96	ARCH FRAME UNIT (OVER 6 FT. OR LESS WIDE - 60 OR MORE FT. SPAN)	EA	0	0	$0.00	$0.00
916.42	PRECAST CONCRETE CULVERT (4 FT. SPAN - 2 FT. HEIGHT)	F	0	0		$0.00
916.43	PRECAST CONCRETE CULVERT (4 FT. SPAN - 3 FT. HEIGHT)	F	0	0		$0.00
916.44	PRECAST CONCRETE CULVERT (4 FT. SPAN - 4 FT. HEIGHT)	F	0	0		$0.00

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
916.45	PRECAST CONCRETE CULVERT (4 FT. SPAN - 5 FT. HEIGHT)	F	0	0		$0.00
916.46	PRECAST CONCRETE CULVERT (4 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.52	PRECAST CONCRETE CULVERT (5 FT. SPAN - 2 FT. HEIGHT)	F	0	0		$0.00
916.53	PRECAST CONCRETE CULVERT (5 FT. SPAN - 3 FT. HEIGHT)	F	0	0		$0.00
916.54	PRECAST CONCRETE CULVERT (5 FT. SPAN - 4 FT. HEIGHT)	F	0	0		$0.00
916.55	PRECAST CONCRETE CULVERT (5 FT. SPAN - 5 FT. HEIGHT)	F	0	0		$0.00
916.56	PRECAST CONCRETE CULVERT (5 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.63	PRECAST CONCRETE CULVERT (6 FT. SPAN - 3 FT. HEIGHT)	F	0	0		$0.00
916.64	PRECAST CONCRETE CULVERT (6 FT. SPAN - 4 FT. HEIGHT)	F	0	0		$0.00
916.65	PRECAST CONCRETE CULVERT (6 FT. SPAN - 5 FT. HEIGHT)	F	0	0		$0.00
916.66	PRECAST CONCRETE CULVERT (6 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.73	PRECAST CONCRETE CULVERT (7 FT. SPAN - 3 FT. HEIGHT)	F	0	0		$0.00
916.74	PRECAST CONCRETE CULVERT (7 FT. SPAN - 4 FT. HEIGHT)	F	0	0		$0.00
916.75	PRECAST CONCRETE CULVERT (7 FT. SPAN - 5 FT. HEIGHT)	F	0	0		$0.00
916.76	PRECAST CONCRETE CULVERT (7 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.77	PRECAST CONCRETE CULVERT (7 FT. SPAN - 7 FT. HEIGHT)	F	0	0		$0.00
916.84	PRECAST CONCRETE CULVERT (8 FT. SPAN - 4 FT. HEIGHT)	F	0	0		$0.00
916.85	PRECAST CONCRETE CULVERT (8 FT. SPAN - 5 FT. HEIGHT)	F	0	0		$0.00
916.86	PRECAST CONCRETE CULVERT (8 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.87	PRECAST CONCRETE CULVERT (8 FT. SPAN - 7 FT. HEIGHT)	F	0	0		$0.00
916.88	PRECAST CONCRETE CULVERT (8 FT. SPAN - 8 FT. HEIGHT)	F	0	0		$0.00
916.105	PRECAST CONCRETE CULVERT (10 FT. SPAN - 5 FT. HEIGHT)	F	42	1		$1,280.00
916.106	PRECAST CONCRETE CULVERT (10 FT. SPAN - 6 FT. HEIGHT)	F	0	0		$0.00
916.107	PRECAST CONCRETE CULVERT (10 FT. SPAN - 7 FT. HEIGHT)	F	0	0		$0.00
916.108	PRECAST CONCRETE CULVERT (10 FT. SPAN - 8 FT. HEIGHT)	F	0	0		$0.00
916.109	PRECAST CONCRETE CULVERT (10 FT. SPAN - 9 FT. HEIGHT)	F	0	0		$0.00
916.11	PRECAST CONCRETE CULVERT (10 FT. SPAN - 10 FT. HEIGHT)	F	77	1		$1,605.00
920.	PLAIN ELASTOMERIC BEARING	EA	77	4		$311.56
921.1	LAM. ELASTOMERIC BEARING W/ ANCHOR BOLTS (0 TO 50K)	EA	0	0	$0.00	$0.00
921.2	LAM. ELASTOMERIC BEARING W/ ANCHOR BOLTS (51 TO 100K)	EA	0	0	$0.00	$0.00
921.3	LAM. ELASTOMERIC BEARING W/ ANCHOR BOLTS (101 TO 150K)	EA	32	1		$2,305.00
921.4	LAM. ELASTOMERIC BEARING W/ANCHOR BOLTS (151 TO 200K)	EA	0	0	$0.00	$0.00
921.5	LAM. ELASTOMERIC BEARING W/ANCHOR BOLTS (OVER 200K)	EA	32	1		$4,062.50
922.1	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (0 TO 50K)	EA	47	3		$330.85

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
922.2	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (51 TO 100K)	EA	280	5		$800.55
922.3	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (101 TO 150K)	EA	114	3		$776.25
922.4	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (151 TO 200K)	EA	0	0	$0.00	$0.00
922.5	LAM. ELASTOMERIC BEARING W/O ANCHOR BOLTS (OVER 200K)	EA	58	4		$1,810.79
923.1	LAM. SLIDING ELASTOMERIC BEARING W/ ANCHOR BOLTS (0 TO 50K)	EA	34	1		$280.00
923.2	LAM. SLIDING ELASTOMERIC BEARING W/ ANCHOR BOLTS (51 TO 100K)	EA	0	0	$0.00	$0.00
923.3	LAM. SLIDING ELASTOMERIC BEARING W/ ANCHOR BOLTS (101 TO 150K)	EA	0	0	$0.00	$0.00
923.4	LAM. SLIDING ELASTOMERIC BEARING W/ ANCHOR BOLTS (151 TO 200K)	EA	0	0	$0.00	$0.00
923.5	LAM. SLIDING ELASTOMERIC BEARING W/ ANCHOR BOLTS (OVER 200K)	EA	12	1		$991.00
924.1	LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (0 TO 50K)	EA	0	0	$0.00	$0.00
924.2	LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (51 TO 100K)	EA	0	0	$0.00	$0.00
924.3	LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (101 TO 150K)	EA	0	0	$0.00	$0.00
924.4	LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (151 TO 200K)	EA	0	0	$0.00	$0.00
924.5	LAM. SLIDING ELASTOMERIC BEARING W/O ANCHOR BOLTS (OVER 200K)	EA	0	0	$0.00	$0.00
925.1	HIGH LOAD MULTI ROTATIONAL BEARING (0-500K)	EA	50	6		$9,050.24
925.2	HIGH LOAD MULTI ROTATIONAL BEARING (501-1000K)	EA	107	6		$8,830.06
925.3	HIGH LOAD MULTI ROTATIONAL BEARING (1001-1500K)	EA	21	1		$8,338.67
925.4	HIGH LOAD MULTI ROTATIONAL BEARING (1501-2000K)	EA	0	0		$0.00
925.5	HIGH LOAD MULTI ROTATIONAL BEARING (>2000K)	EA	0	0		$0.00
930.XXX	PRESTRESSED CONCRETE XXX BEAMS	F	SEE CHARTS FOR ESTIMATING COST			
940.	UNTREATED TIMBER PILES	F	0	0		$0.00
941.	TREATED TIMBER PILES	F	0	0		$0.00
942.101	STEEL PILE HP 10 X 42	F	0	0	$0.00	$0.00
942.102	STEEL PILE HP 10 X 57	F	755	1	$132.59	$0.00
942.121	STEEL PILE HP 12 X 53	F	11,600	1		$95.00
942.122	STEEL PILE HP 12 X 63	F	0	0		$0.00
942.123	STEEL PILE HP 12 X 74	F	7,041	4	$119.44	$212.04
942.124	STEEL PILE HP 12 X 84	F	2,700	1		$578.00
942.141	STEEL PILE HP 14 X 73	F	14,252	2	$150.88	$75.00
942.142	STEEL PILE HP 14 X 89	F	7,130	2		$82.99
942.143	STEEL PILE HP 14 X 102	F	1,329	1	$115.82	
942.144	STEEL PILE HP 14 X 117	F	0	0		$0.00
943.09	STEEL PIPE PILE 8-5/8 INCH OUTSIDE DIAMETER	F	0	0		$0.00

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
943.1	STEEL PIPE PILE 10 INCH OUTSIDE DIAMETER	F	0	0		$0.00
943.11	STEEL PIPE PILE 10-3/4 INCH OUTSIDE DIAMETER	F	0	0		$0.00
943.12	STEEL PIPE PILE 12 INCH OUTSIDE DIAMETER	F	0	0		$0.00
943.13	STEEL PIPE PILE 12-3/4 INCH OUTSIDE DIAMETER	F	0	0		$0.00
943.14	STEEL PIPE PILE 14 INCH OUTSIDE DIAMETER	F	196,000	1		$106.88
943.16	STEEL PIPE PILE 16 INCH OUTSIDE DIAMETER	F	77,600	1		$154.13
944.2	PRE-DRILLING FOR PILES	F	138	1	$250.39	
944.3	DRILLED ROCK SOCKET FOR PILES	F	0	0		$0.00
945.1	DRILLED SHAFT EXCAVATION 2.0 FEET DIAMETER	F	1,286	2	$517.85	
945.101	DRILLED SHAFT EXCAVATION 3.0 FEET DIAMETER	F	815	2	$1,066.80	$466.43
945.102	DRILLED SHAFT EXCAVATION 3.5 FEET DIAMETER	F	476	2	$603.29	
945.103	DRILLED SHAFT EXCAVATION 4.0 FEET DIAMETER	F	2,657	6	$793.99	$311.06
945.104	DRILLED SHAFT EXCAVATION 4.5 FEET DIAMETER	F	75	1	$525.78	$373.56
945.105	DRILLED SHAFT EXCAVATION 5 FEET DIAMETER	F	623	1	$670.56	
945.106	DRILLED SHAFT EXCAVATION 5.5 FEET DIAMETER	F	0	0	$0.00	
945.107	DRILLED SHAFT EXCAVATION 6.0 FEET DIAMETER	F	89	1		$420.00
945.108	DRILLED SHAFT EXCAVATION 6.5 FEET DIAMETER	F	0	0		
945.109	DRILLED SHAFT EXCAVATION 7.0 FEET DIAMETER	F	0	0		
945.11	DRILLED SHAFT EXCAVATION 7.5 FEET DIAMETER	F	0	0		
945.111	DRILLED SHAFT EXCAVATION 8.0 FEET DIAMETER	F	0	0		
945.112	DRILLED SHAFT EXCAVATION 8.5 FEET DIAMETER	F	0	0		
945.113	DRILLED SHAFT EXCAVATION 9.0 FEET DIAMETER	F	0	0		
945.2	ROCK SOCKET EXCAVATION 2.0 FEET DIAMETER	F	295	2	$1,833.54	
945.201	ROCK SOCKET EXCAVATION 3.0 FEET DIAMETER	F	407	4	$961.31	$3,732.13
945.202	ROCK SOCKET EXCAVATION 3.5 FEET DIAMETER	F	52	1	$1,981.20	
945.203	ROCK SOCKET EXCAVATION 4.0 FEET DIAMETER	F	788	6	$1,943.58	$4,622.22
945.204	ROCK SOCKET EXCAVATION 4.5 FEET DIAMETER	F	3,836	1		$2,639.00
945.205	ROCK SOCKET EXCAVATION 5.0 FEET DIAMETER	F	118	1	$2,407.92	
945.206	ROCK SOCKET EXCAVATION 5.5 FEET DIAMETER	F	0	0		
945.207	ROCK SOCKET EXCAVATION 6.0 FEET DIAMETER	F	0	0		
945.208	ROCK SOCKET EXCAVATION 6.5 FEET DIAMETER	F	0	0		
945.209	ROCK SOCKET EXCAVATION 7.0 FEET DIAMETER	F	0	0		
945.21	ROCK SOCKET EXCAVATION 7.5 FEET DIAMETER	F	0	0		
945.211	ROCK SOCKET EXCAVATION 8.0 FEET DIAMETER	F	0	0		
945.212	ROCK SOCKET EXCAVATION 8.5 FEET DIAMETER	F	0	0		
945.213	ROCK SOCKET EXCAVATION 9.0 FEET DIAMETER	F	0	0		
945.3	OBSTRUCTION EXCAVATION 2.0 FEET DIAMETER	F	95	1	$1,524.00	
945.301	OBSTRUCTION EXCAVATION 3.0 FEET DIAMETER	F	156	2	$1,981.20	$2,818.75
945.302	OBSTRUCTION EXCAVATION 3.5 FEET DIAMETER	F	56	2	$953.84	

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
945.303	OBSTRUCTION EXCAVATION 4.0 FEET DIAMETER	F	356	5	$1,145.54	$2,495.00
945.304	OBSTRUCTION EXCAVATION 4.5 FEET DIAMETER	F	130	2	$525.78	$2,716.67
945.305	OBSTRUCTION EXCAVATION 5.0 FEET DIAMETER	F	898	2	$1,828.80	$825.00
945.306	OBSTRUCTION EXCAVATION 5.5 FEET DIAMETER	F	0	0		
945.307	OBSTRUCTION EXCAVATION 6.0 FEET DIAMETER	F	0	0		
945.308	OBSTRUCTION EXCAVATION 6.5 FEET DIAMETER	F	0	0		
945.309	OBSTRUCTION EXCAVATION 7.0 FEET DIAMETER	F	0	0		
945.31	OBSTRUCTION EXCAVATION 7.5 FEET DIAMETER	F	0	0		
945.311	OBSTRUCTION EXCAVATION 8.0 FEET DIAMETER	F	0	0		
945.312	OSTRUCTION EXCAVATION 8.5 FEET DIAMETER	F	0	0		
945.313	OSTRUCTION EXCAVATION 9.0 FEET DIAMETER	F	0	0		
945.4	TRIAL SHAFT 2.0 FEET DIAMETER	F	0	0		
945.401	TRIAL SHAFT 3.0 FEET DIAMETER	F	0	0		
945.402	TRIAL SHAFT 3.5 FEET DIAMETER	F	0	0		
945.403	TRIAL SHAFT 4.0 FEET DIAMETER	F	128	2	$2,133.60	$1,050.00
945.404	TRIAL SHAFT 4.5 FEET DIAMETER	F	0	0		
945.405	TRIAL SHAFT 5.0 FEET DIAMETER	F	0	0		
945.406	TRIAL SHAFT 5.5 FEET DIAMETER	F	0	0		
945.407	TRIAL SHAFT 6.0 FEET DIAMETER	F	0	0		
945.408	TRIAL SHAFT 6.5 FEET DIAMETER	F	0	0		
945.409	TRIAL SHAFT 7.0 FEET DIAMETER	F	0	0		
945.410*	TRIAL SHAFT 7.5 FEET DIAMETER	F	0	0		
945.411	TRIAL SHAFT 8.0 FEET DIAMETER	F	0	0		
945.412	TRIAL SHAFT 8.5 FEET DIAMETER	F	0	0		
945.413	TRIAL SHAFT 9.0 FEET DIAMETER	F	0	0		
945.5	DRILLED SHAFT 2.0 FEET DIAMETER	F	1,378	1	$182.88	
945.501	DRILLED SHAFT 3.0 FEET DIAMETER	F	1,287	3	$576.47	$674.29
945.502	DRILLED SHAFT 3.5 FEET DIAMETER	F	528	2	$433.72	
945.503	DRILLED SHAFT 4.0 FEET DIAMETER	F	4,114	7	$422.48	$634.22
945.504	DRILLED SHAFT 4.5 FEET DIAMETER	F	1,215	2	$320.04	$802.94
945.505	DRILLED SHAFT 5.0 FEET DIAMETER	F	13,618	2	$228.60	$580.00
945.506	DRILLED SHAFT 5.5 FEET DIAMETER	F	0	0		
945.507	DRILLED SHAFT 6.0 FEET DIAMETER	F	88	1	$1,000.00	
945.508	DRILLED SHAFT 6.5 FEET DIAMETER	F	0	0		
945.509	DRILLED SHAFT 7.0 FEET DIAMETER	F	0	0		
945.51	DRILLED SHAFT 7.5 FEET DIAMETER	F	0	0		
945.511	DRILLED SHAFT 8.0 FEET DIAMETER	F	0	0		
945.512	DRILLED SHAFT 8.5 FEET DIAMETER	F	0	0		
945.513	DRILLED SHAFT 9.0 FEET DIAMETER	F	0	0		

*Items are non-standard

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
945.6	PERMANENT CASING 2.0 FEET DIAMETER	F	0	0	$0.00	
945.601	PERMANENT CASING 3.0 FEET DIAMETER	F	171	1	$241.40	
945.602	PERMANENT CASING 3.5 FEET DIAMETER	F	394	1	$152.40	
945.603	PERMANENT CASING 4.0 FEET DIAMETER	F	760	1		$486.88
945.604	PERMANENT CASING 4.5 FEET DIAMETER	F	875	1	$167.64	$382.00
945.605	PERMANENT CASING 5.0 FEET DIAMETER	F	722	1	$109.73	
945.606	PERMANENT CASING 5.5 FEET DIAMETER	F	0	0		
945.607	PERMANENT CASING 6.0 FEET DIAMETER	F	0	0		
945.608	PERMANENT CASING 6.5 FEET DIAMETER	F	0	0		
945.609	PERMANENT CASING 7.0 FEET DIAMETER	F	0	0		
945.610*	PERMANENT CASING 7.5 FEET DIAMETER	F	0	0		
945.611	PERMANENT CASING 8.0 FEET DIAMETER	F	0	0		
945.612	PERMANENT CASING 8.5 FEET DIAMETER	F	0	0		
945.613	PERMANENT CASING 9.0 FEET DIAMETER	F	0	0		
945.71	CROSS HOLE SONIC TESTING ACCESS PIPES	F	74,850	10	$6.51	$7.38
945.72	CROSS HOLE SONIC TEST	EA	422	9	$584.65	$1,350.01
945.81	OSTERBERG LOAD CELL AXIAL LOAD TEST	EA	15	3	$220,000.00	$126,381.35
945.82	CONVENTIONAL AXIAL LOAD TEST	EA	1	1	$57,000.00	
946.12	PRECAST-PRESTRESSED CONC. PILE (12 IN.)	F	0	0		
946.14	PRECAST-PRESTRESSED CONC. PILE (14 IN.)	F	0	0		$0.00
946.16	PRECAST-PRESTRESSED CONC. PILE (16 IN.)	F	0	0		$0.00
946.18	PRECAST-PRESTRESSED CONC. PILE (18 IN.)	F	0	0		$0.00
946.2	PRECAST-PRESTRESSED CONC. PILE (20 IN.)	F	0	0		$0.00
947.	TEST PILE	F	0	0		$0.00
947.1	TIMBER TEST PILE	EA	0	0		$0.00
948.1	SHORT DURATION LOAD TEST	EA	0	0		$0.00
948.2	MAINTAINED LOAD TEST	EA	2	1		$192,867.50
948.3	QUICK LOAD TEST	EA	0	0		$0.00
948.31	STATIC - CYCLIC (EXPRESS) LOAD TEST	EA	2	1		$15,000.00
948.4	DYNAMIC LOAD TEST PREPARATION	EA	6	2		$161.33
948.41	DYNAMIC LOAD TEST BY CONTRACTOR	EA	231	6	$3,666.67	$3,690.84
948.5	PILE SHOES	EA	3878	4		$213.96
952.	STEEL SHEETING	LB	948,536	4		$2.38
953.	PERMANENT STEEL SHEETING	SY	0	0		$0.00
953.1	TEMPORARY STEEL SHEETING	SY	354	2		$105.00
953.2	INTERIM STEEL SHEETING	SY	0	0		$0.00
953.3	EXCAVATION SUPPORT SYSTEM	SY	0	0		$0.00
954.	COFFERDAM	EA	0	0		$0.00
954.1	TEMPORARY WATERWAY DIVERSION STRUCTURE	EA	0	0		$0.00

*Items are non-standard

WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

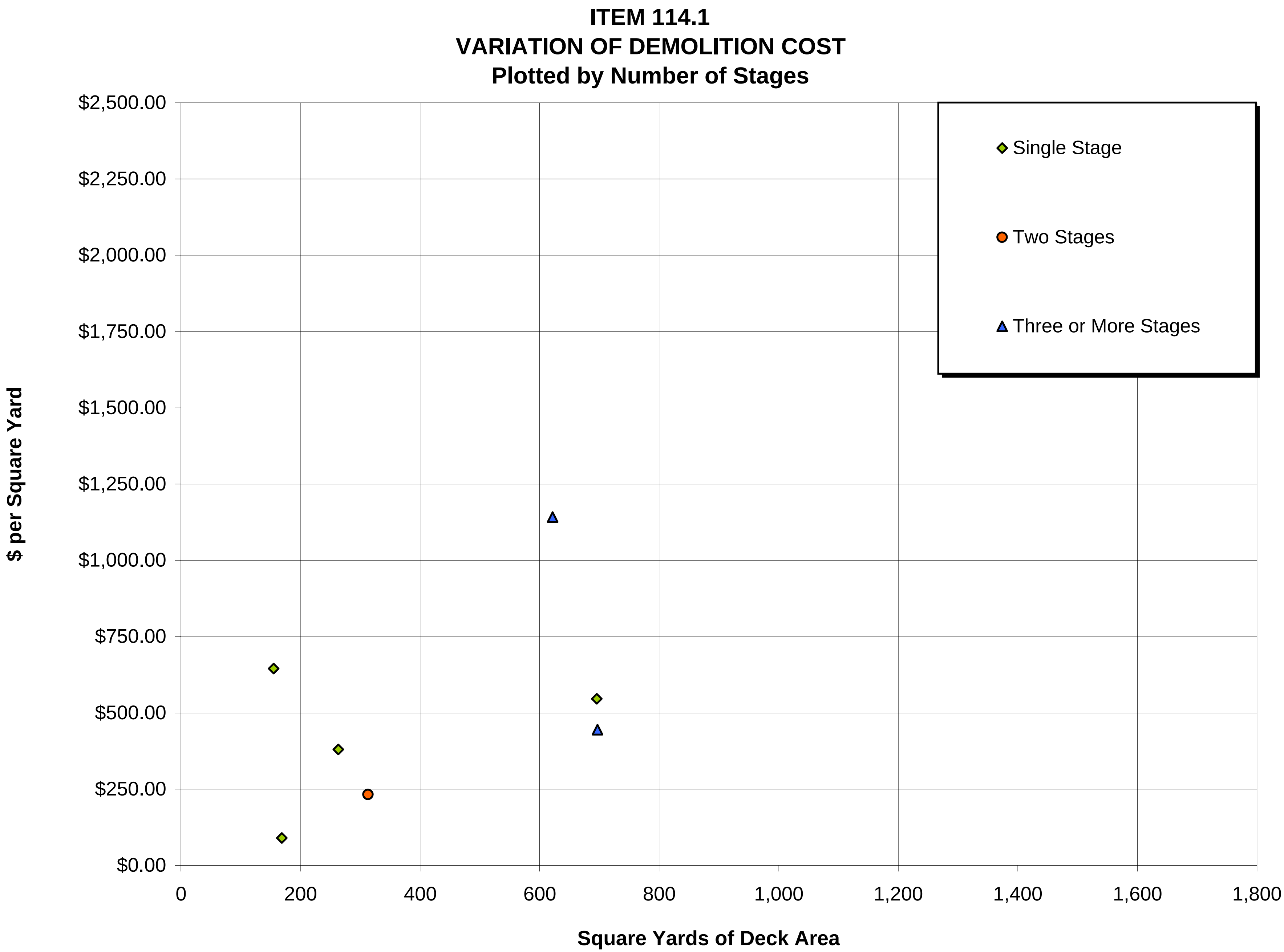
ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
955.1	MSE WALL - NO COLOR - PLAIN SURFACE	SY	1,133	5		$1,314.85
955.2	MSE WALL - NO COLOR - FORM LINER SURFACE	SY	0	0		$0.00
955.3	MSE WALL - INTEGRAL COLOR - PLAIN SURFACE	SY	0	0		$0.00
955.4	MSE WALL - INTEGRAL COLOR - FORM LINER SURFACE	SY	0	0		$0.00
960.362	STRUCTURAL STEEL M270 GRADE 36 PAINTED-MISCELLANEOUS	LB	0	0		$0.00
960.363	STRUCTURAL STEEL M270 GRADE 36 GALVANIZED-MISCELLANEOUS	LB	SEE CHARTS FOR ESTIMATING COST			
960.501	STEEL M270 GRADE 50W UNCOATED ROLLED BEAM BRIDGE	LB	SEE CHARTS FOR ESTIMATING COST			
960.502	STEEL M270 GRADE 50W UNCOATED PLATE GIRDER BRIDGE	LB	SEE CHARTS FOR ESTIMATING COST			
960.503	STEEL M270 GRADE 50W UNCOATED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.504	STEEL M270 GRADE 50W UNCOATED TRUSS BRIDGE	LB	0	0		$0.00
960.505	STEEL M270 GRADE 50W UNCOATED BASCULE	LB	0	0		$0.00
960.506	STEEL M270 GRADE 50 PAINTED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.507	STEEL M270 GRADE 50 PAINTED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.508	STEEL M270 GR 50 PAINTED BOX GIRDER BRIDGE	LB	SEE CHARTS FOR ESTIMATING COST			
960.509	STEEL M270 GR 50 PAINTED TRUSS BRIDGE	LB	0	0		$0.00
960.510	STEEL 270 GRADE 50 PAINTED BASCULE	LB	SEE CHARTS FOR ESTIMATING COST			
960.511	STEEL 270 GRADE 50 GALVANIZED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.512	STEEL 270 GRADE 50 GALVANIZED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.513	STEEL 270 GRADE 50 GALVANIZED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.514	STEEL 270 GRADE 50 GALVANIZED TRUSS BRIDGE	LB	0	0		$0.00
960.515	STEEL 270 GRADE 50 GALVANIZED BASCULE	LB	0	0		$0.00
960.516	STEEL 270 GRADE 50 GALVANIZED PAINTED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.517	STEEL 270 GRADE 50 GALVANIZED PAINTED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.518	STEEL 270 GRADE 50 GALVANIZED PAINTED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.519	STEEL 270 GRADE 50 GALVANIZED PAINTED TRUSS BRIDGE	LB	0	0		$0.00
960.520	STEEL 270 GRADE 50 GALVANIZED PAINTED BASCULE	LB	0	0		$0.00
960.521	STEEL 270 GRADE HPS50W UNCOATED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.522	STEEL 270 GRADE HPS50W UNCOATED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.523	STEEL 270 GRADE HPS50W UNCOATED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.524	STEEL 270 GRADE HPS50W UNCOATED TRUSS BRIDGE	LB	0	0		$0.00
960.525	STEEL 270 GRADE HPS50W UNCOATED BASCULE BRIDGE	LB	0	0		$0.00
960.531	STEEL 270 GRADE HPS50W PAINTED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.532	STEEL 270 GRADE HPS50W PAINTED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.533	STEEL 270 GRADE HPS50W PAINTED BOX GIRDER BRIDGE	LB	0	0		$0.00

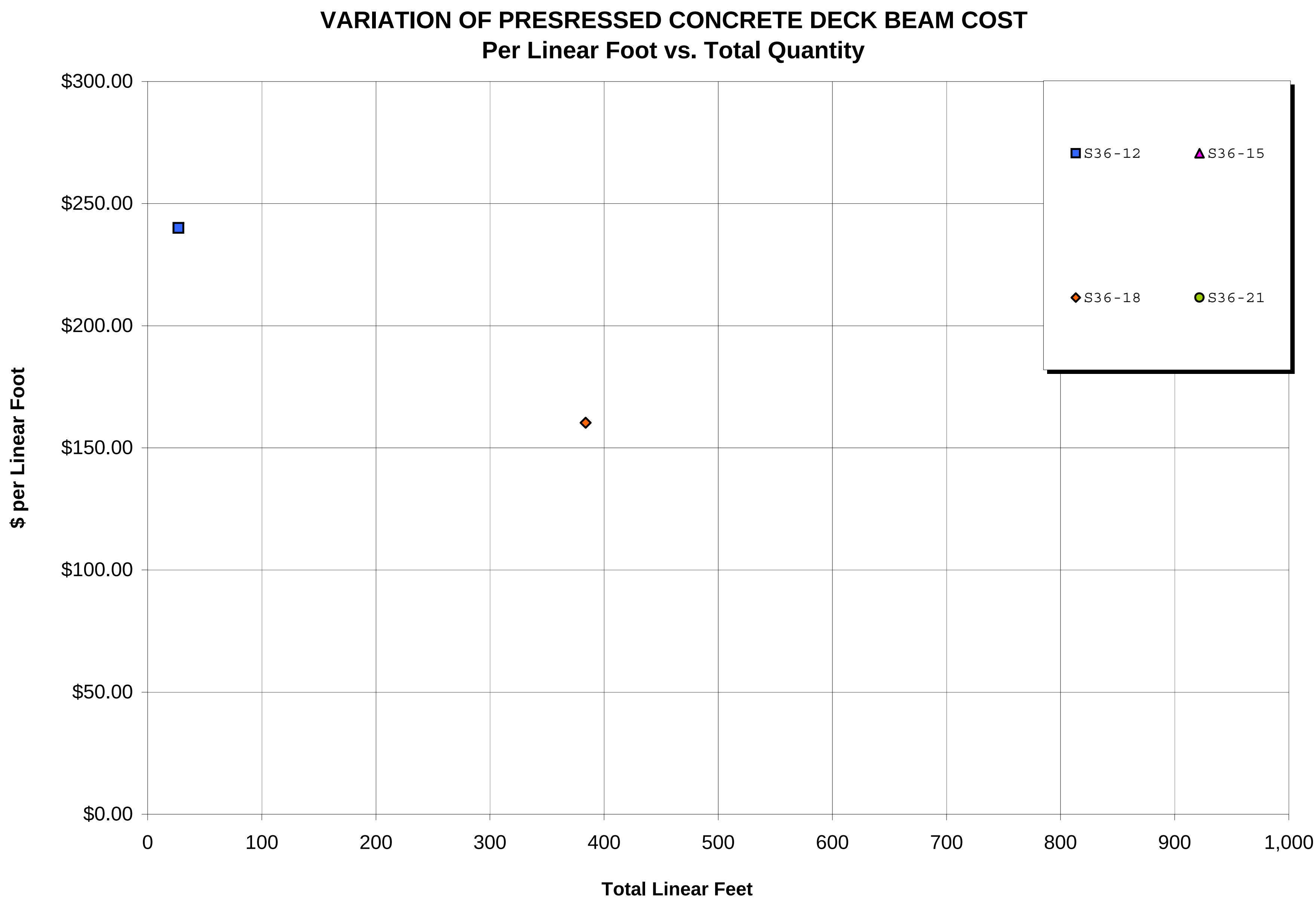
WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

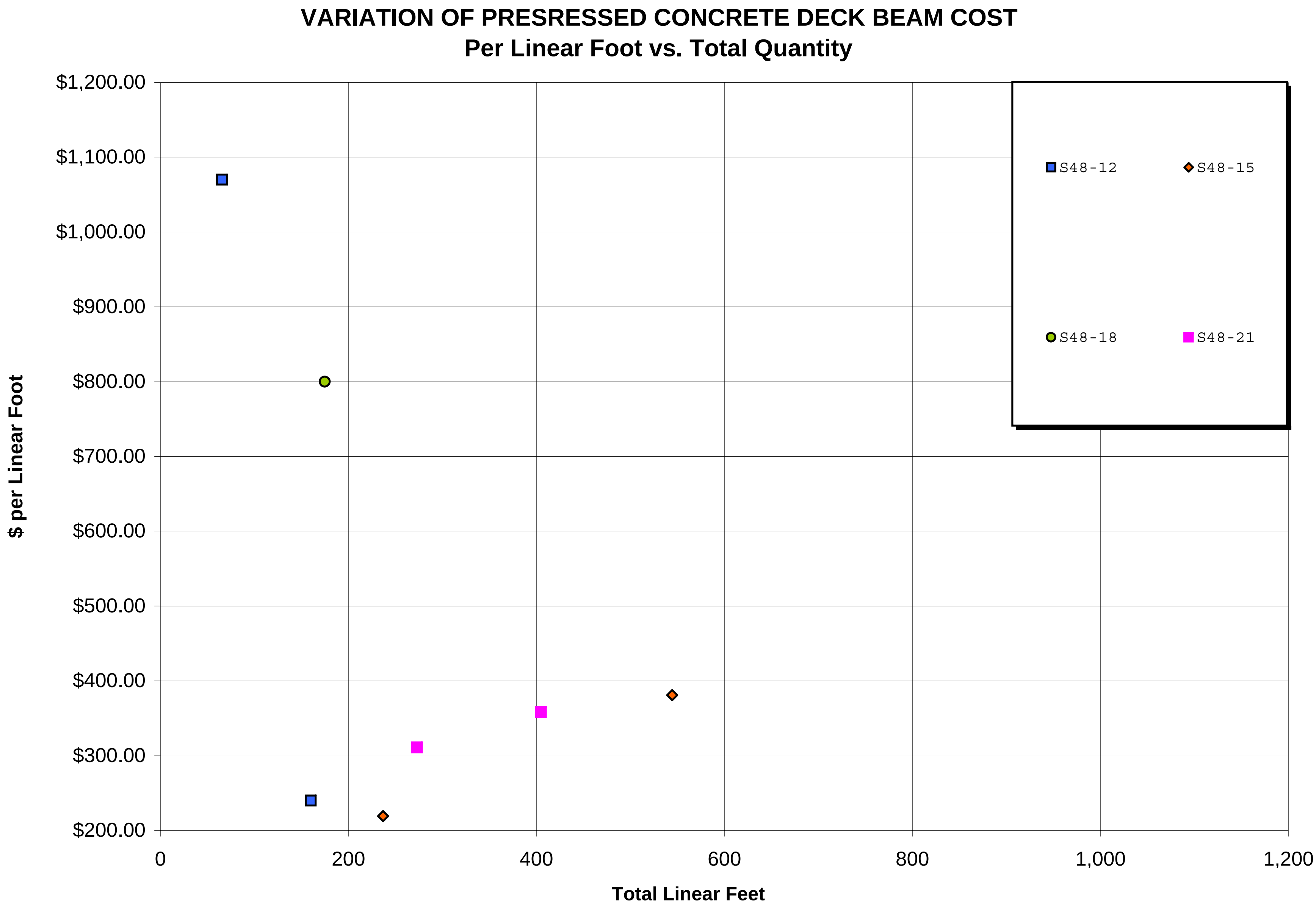
ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
960.534	STEEL 270 GRADE HPS50W PAINTED TRUSS BRIDGE	LB	0	0		$0.00
960.535	STEEL 270 GRADE HPS50W PAINTED BASCULE BRIDGE	LB	0	0		$0.00
960.701	STEEL 270 GRADE HPS50W AND 70W UNCOATED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.702	STEEL 270 GRADE HPS50W AND 70W UNCOATED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.703	STEEL 270 GRADE HPS50W AND 70W UNCOATED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.704	STEEL 270 GRADE HPS50W AND 70W UNCOATED TRUSS BRIDGE	LB	0	0		$0.00
960.705	STEEL 270 GRADE HPS50W AND 70W UNCOATED BASCULE BRIDGE	LB	0	0		$0.00
960.711	STEEL 270 GRADE HPS50W AND 70W PAINTED ROLLED BEAM BRIDGE	LB	0	0		$0.00
960.712	STEEL 270 GRADE HPS50W AND 70W PAINTED PLATE GIRDER BRIDGE	LB	0	0		$0.00
960.713	STEEL 270 GRADE HPS50W AND 70W PAINTED BOX GIRDER BRIDGE	LB	0	0		$0.00
960.714	STEEL 270 GRADE HPS50W AND 70W PAINTED TRUSS BRIDGE	LB	0	0		$0.00
960.715	STEEL 270 GRADE HPS50W AND 70W PAINTED BASCULE BRIDGE	LB	0	0		$0.00
960.9	STUD SHEAR CONNECTORS	EA	85,132	13		$4.40
965.	MEMBRANE WATERPROOFING FOR BRIDGE DECKS	SY	143,881	53	$18.88	$21.81
965.1	MEMBRANE WATERPROOFING (RUBBERIZED ASPHALT)	SY	0	0		$0.00
965.2	MEMBRANE WATERPROOFING FOR BRIDGE DECKS - SPRAY APPLIED	SY	505	3	$94.46	
966.	WATERPROOFING PROTECTIVE COURSE	SY	1,887	15	$45.83	$77.49
967.	MEMBRANE WATERPROOFING	SY	3,132	5		$18.45
968.	SCUPPER	EA	28	2		$4,695.00
968.1	SCUPPER AND DOWNSPOUT	EA	0	0	$0.00	$0.00
970.	BITUMINOUS DAMP-PROOFING	SY	10,375	43	$8.95	$16.03
971.	ASPHALTIC BRIDGE JOINT SYSTEM	F	282	20	$104.13	$218.13
972.	STRIP SEAL BRIDGE JOINT SYSTEM	F	1,442	9		$460.37
973.	FINGER PLATE BRIDGE JOINT SYSTEM	F	202	2		$2,564.00
973.1	MODULAR BRIDGE JOINT SYSTEM	F	693	7		$1,300.59
975.1	METAL BRIDGE RAILING (3 RAIL), STEEL (TYPE S3-TL4)	F	9,168	9	$287.81	$314.32
975.3	PROTECTIVE SCREEN TYPE I	F	540	1		$125.00
975.4	PROTECTIVE SCREEN TYPE II	F	844	3	$247.41	
975.5	ALUMINUM HANDRAIL	F	141	1	$60.96	
975.6	PROTECTIVE SCREEN ELECTRIFICATION BARRIER	F	0	0		$0.00
976.	TEMPORARY CONCRETE BRIDGE BARRIER	F	1,660	4	$89.96	
977.	TEMPORARY CONCRETE BRIDGE BARRIER REMOVE AND RESET	F	591	1	$99.06	
983.	DUMPED RIPRAP	TON	5,907	5	$51.65	
983.1	RIPRAP	TON	712	4	$47.21	

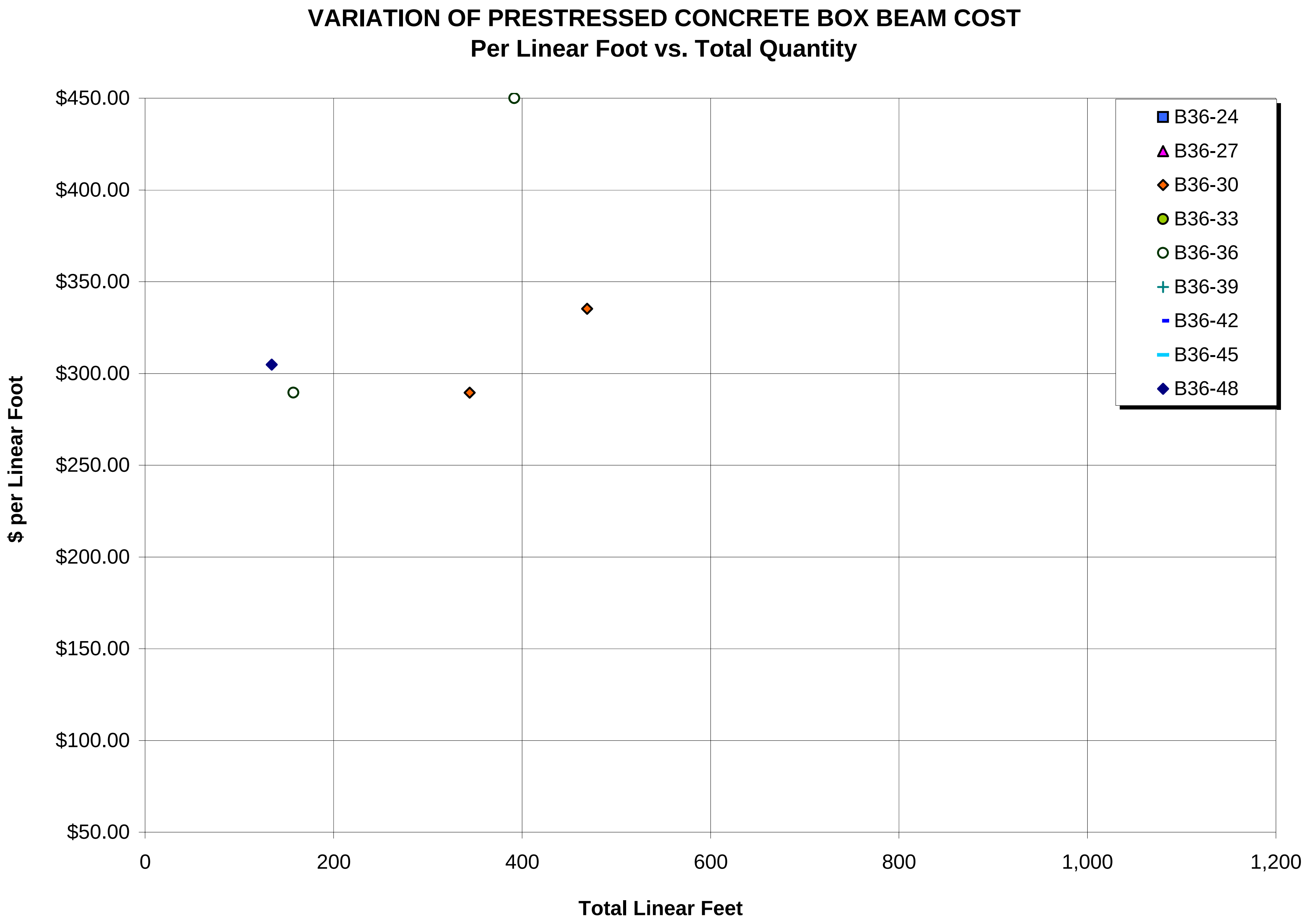
WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006-2008 STATEWIDE WEIGHTED AVERAGE BID PRICES AND BRIDGE STRUCTURE LUMP SUM BREAKDOWNS

ITEM NO.		UNITS	TOTAL QUANTITY	NO PROJECTS	AVG. BID PRICE 2006	AVG. BID PRICE 2007+2008
983.41	ROCK FILL	TON	69	1		$58.32
986.	MODIFIED ROCKFILL	TON	12,655	1		$50.94
988.	CHANNEL PAVING	SY	100	1		$64.00
991.1	CONTROL OF WATER - STRUCTURE NO. _________	LS	1	6		$36,933.00


ITEM 114.1
VARIATION OF DEMOLITION COST
Plotted by Number of Stages
$2,500.00
$2,250.00
$2,000.00
$1,750.00
$1,500.00
$1,250.00
$1,000.00
$750.00
$500.00
$250.00
$0.00
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
$ per Square Yard
Square Yards of Deck Area
Single Stage
Two Stages
Three or More Stages

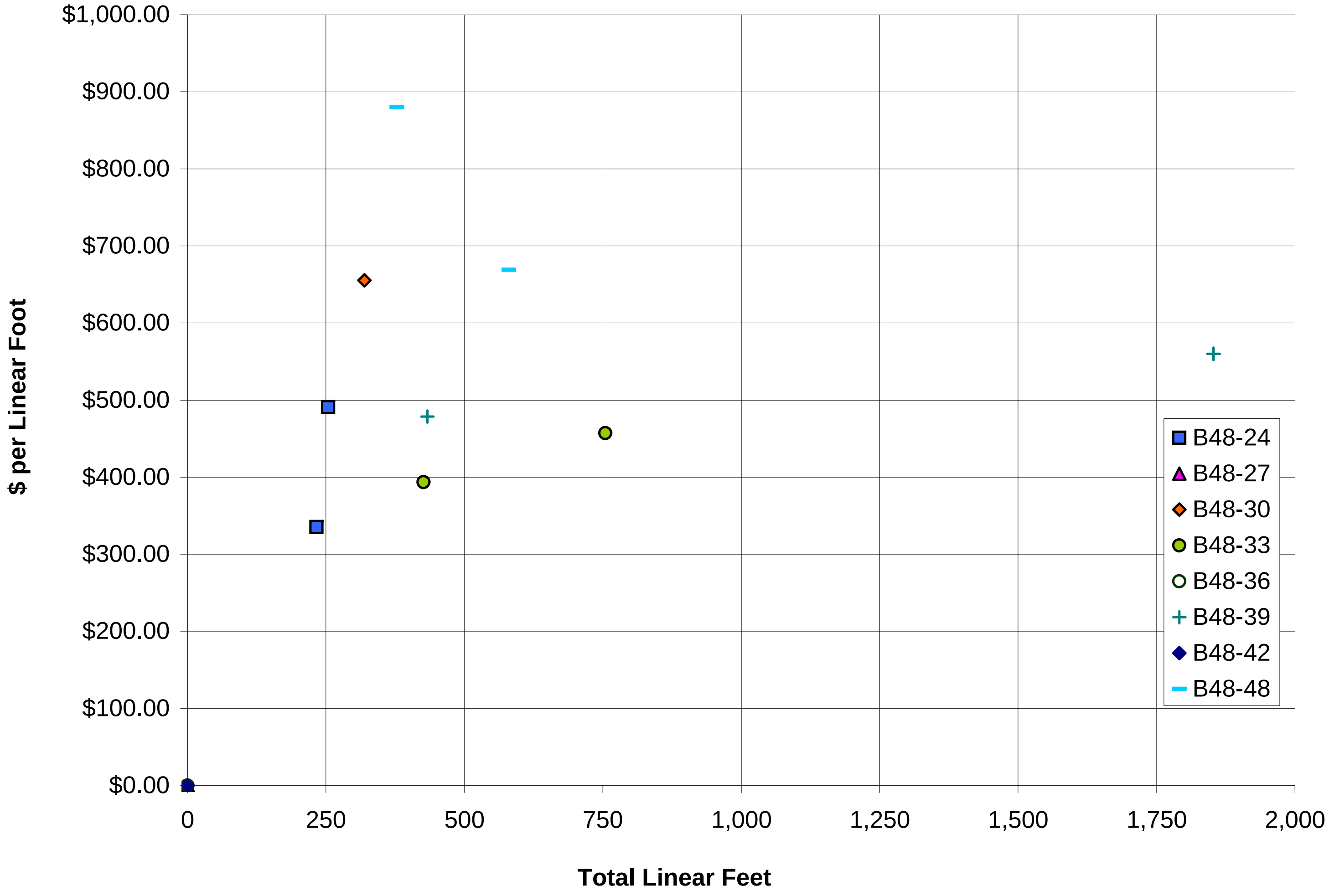

VARIATION OF PRESRESSED CONCRETE DECK BEAM COST
Per Linear Foot vs. Total Quantity
$300.00
$250.00
$200.00
$150.00
$100.00
$50.00
$0.00
$ per Linear Foot
0
100
200
300
400
500
600
700
800
900
1,000
Total Linear Feet
S36-12
S36-15
S36-18
S36-21

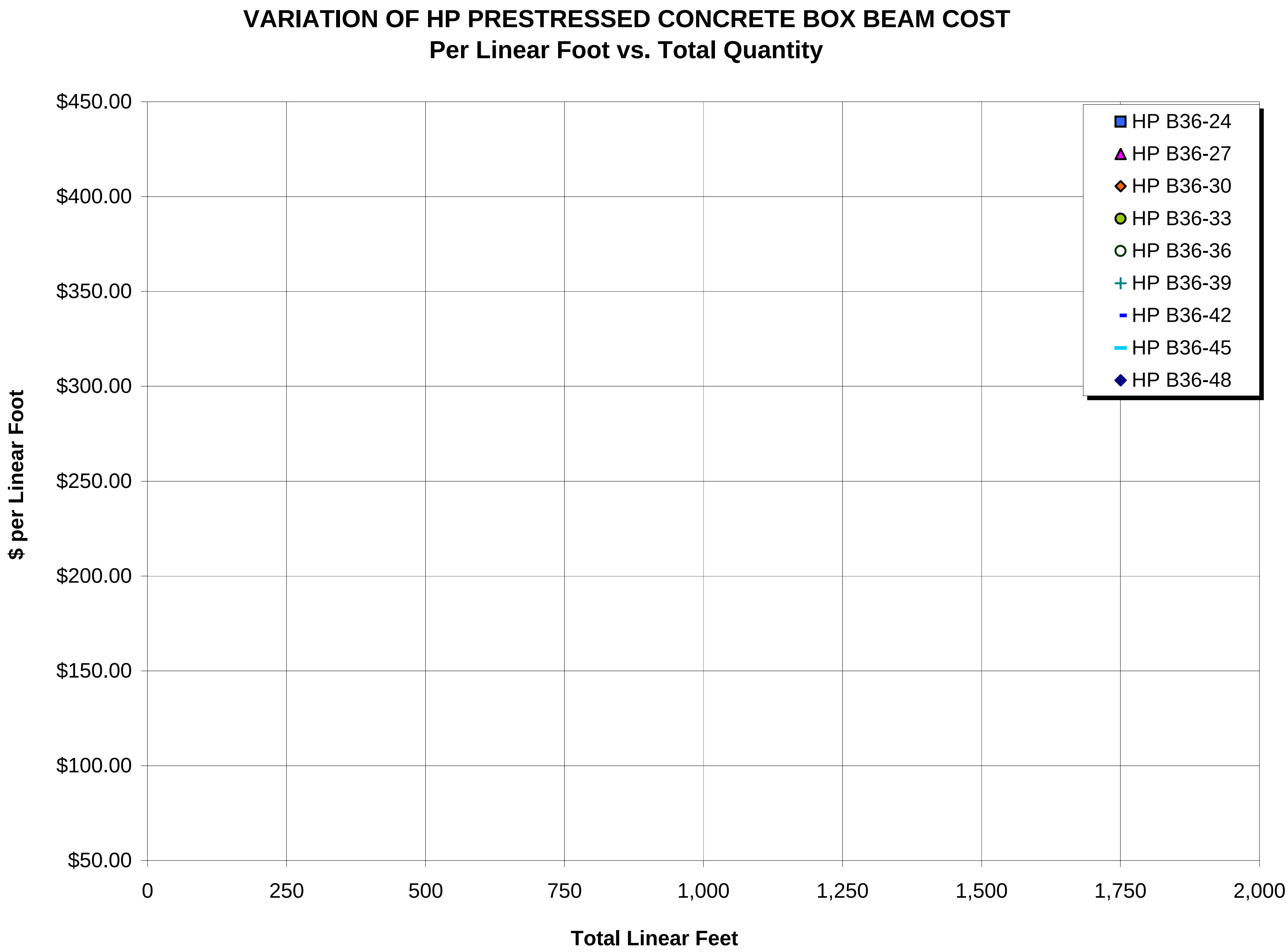

VARIATION OF PRESRESSED CONCRETE DECK BEAM COST
Per Linear Foot vs. Total Quantity
$1,200.00
$1,100.00
$1,000.00
$900.00
$800.00
$700.00
$600.00
$500.00
$400.00
$300.00
$200.00
$ per Linear Foot
0
200
400
600
800
1,000
1,200
Total Linear Feet
S48-12
S48-15
S48-18
S48-21

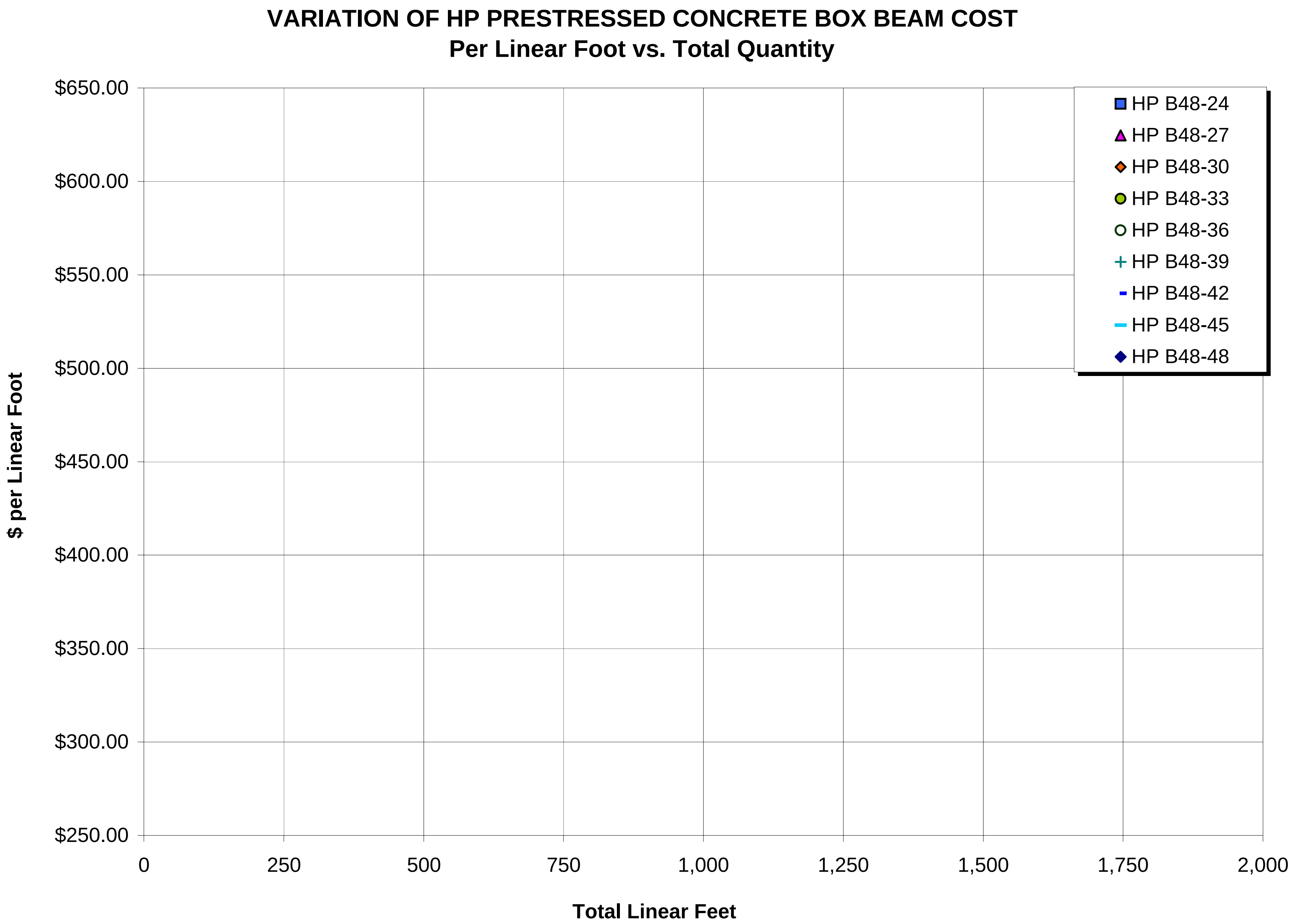


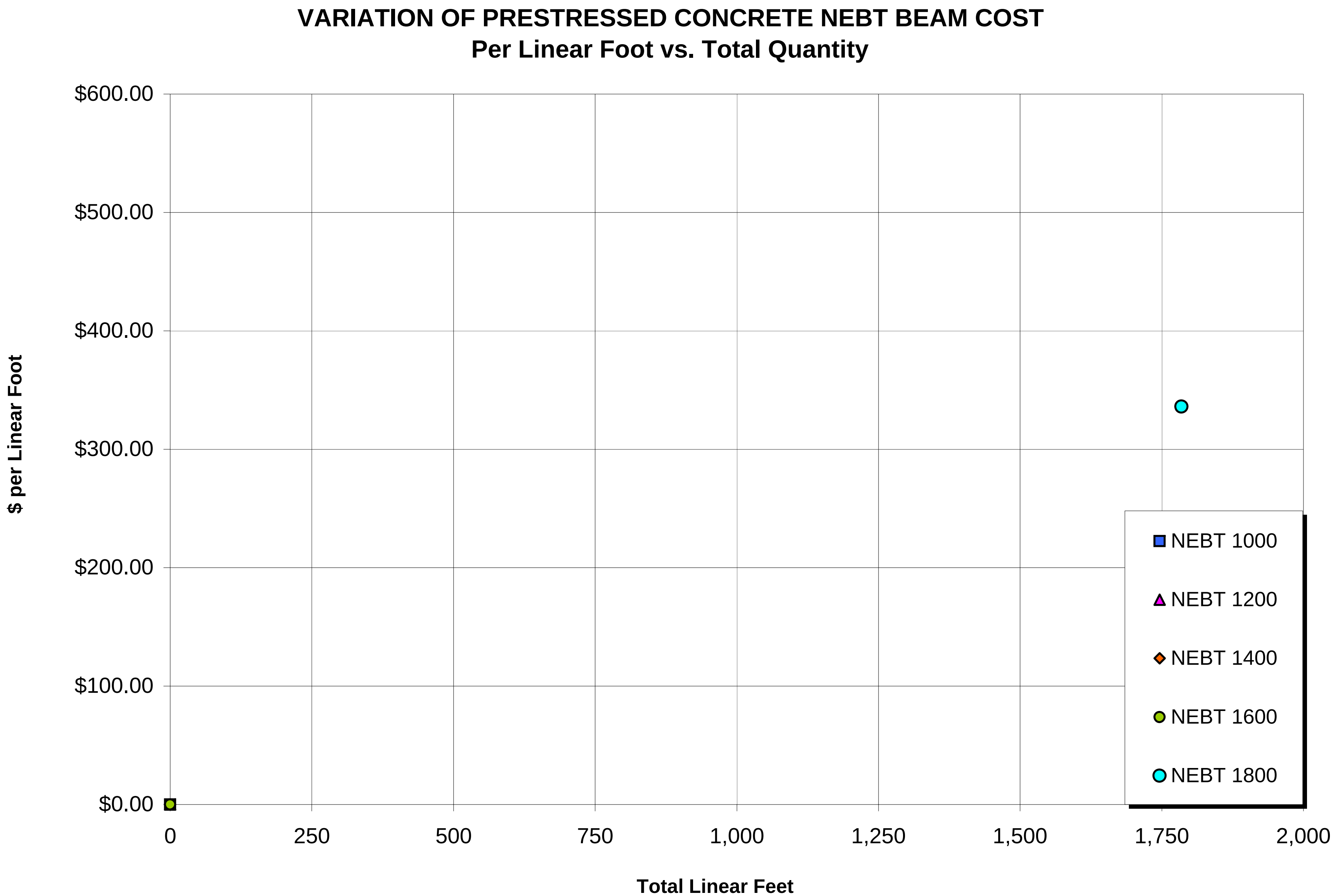
VARIATION OF PRESTRESSED CONCRETE BOX BEAM COST
Per Linear Foot vs. Total Quantity
$450.00
$400.00
$350.00
$300.00
$250.00
$200.00
$150.00
$100.00
$50.00
$ per Linear Foot
0
200
400
600
800
1,000
1,200
Total Linear Feet
B36-24
B36-27
B36-30
B36-33
B36-36
B36-39
B36-42
B36-45
B36-48

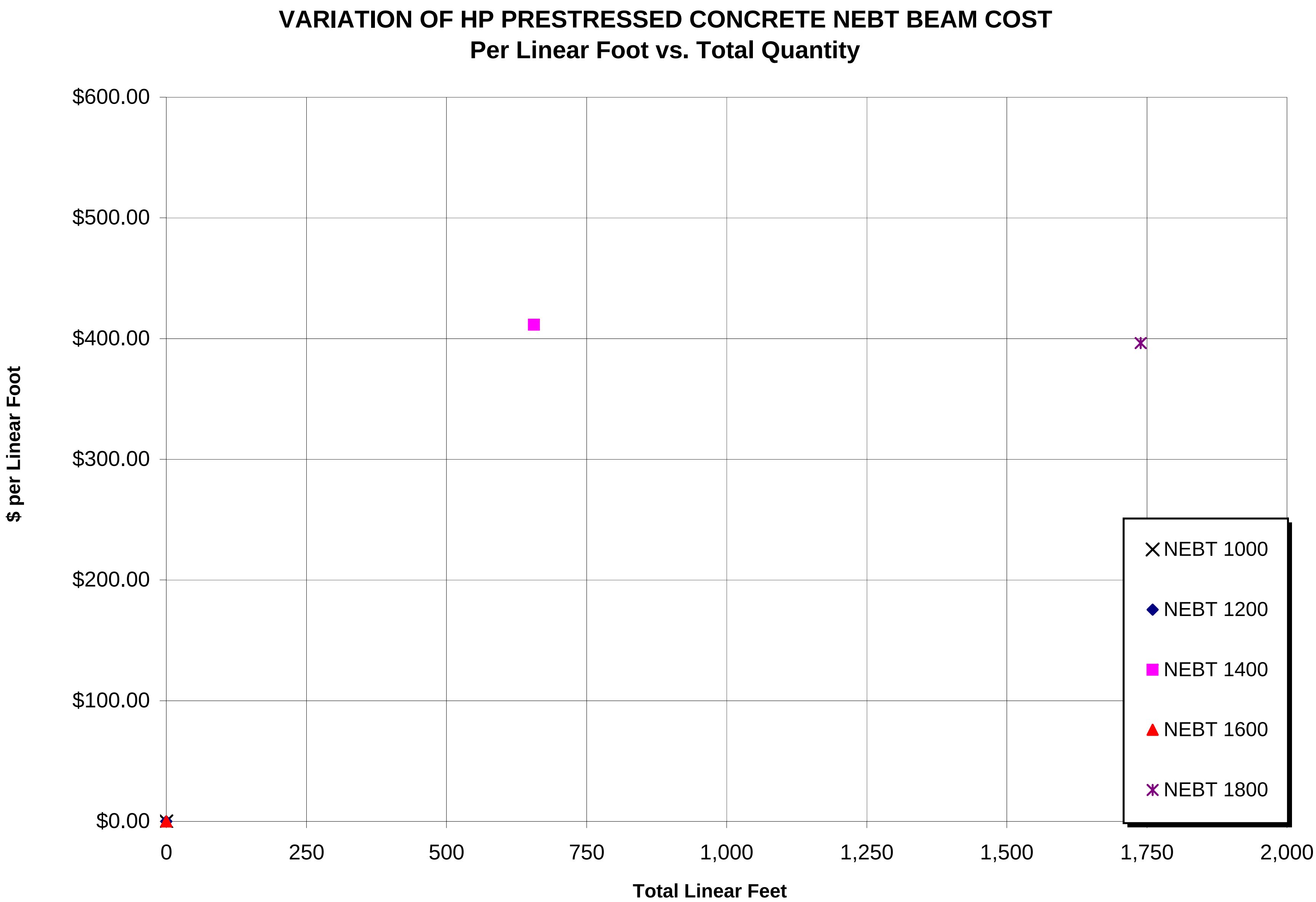
VARIATION OF PRESTRESSED CONCRETE BOX BEAM COST
Per Linear Foot vs. Total Quantity

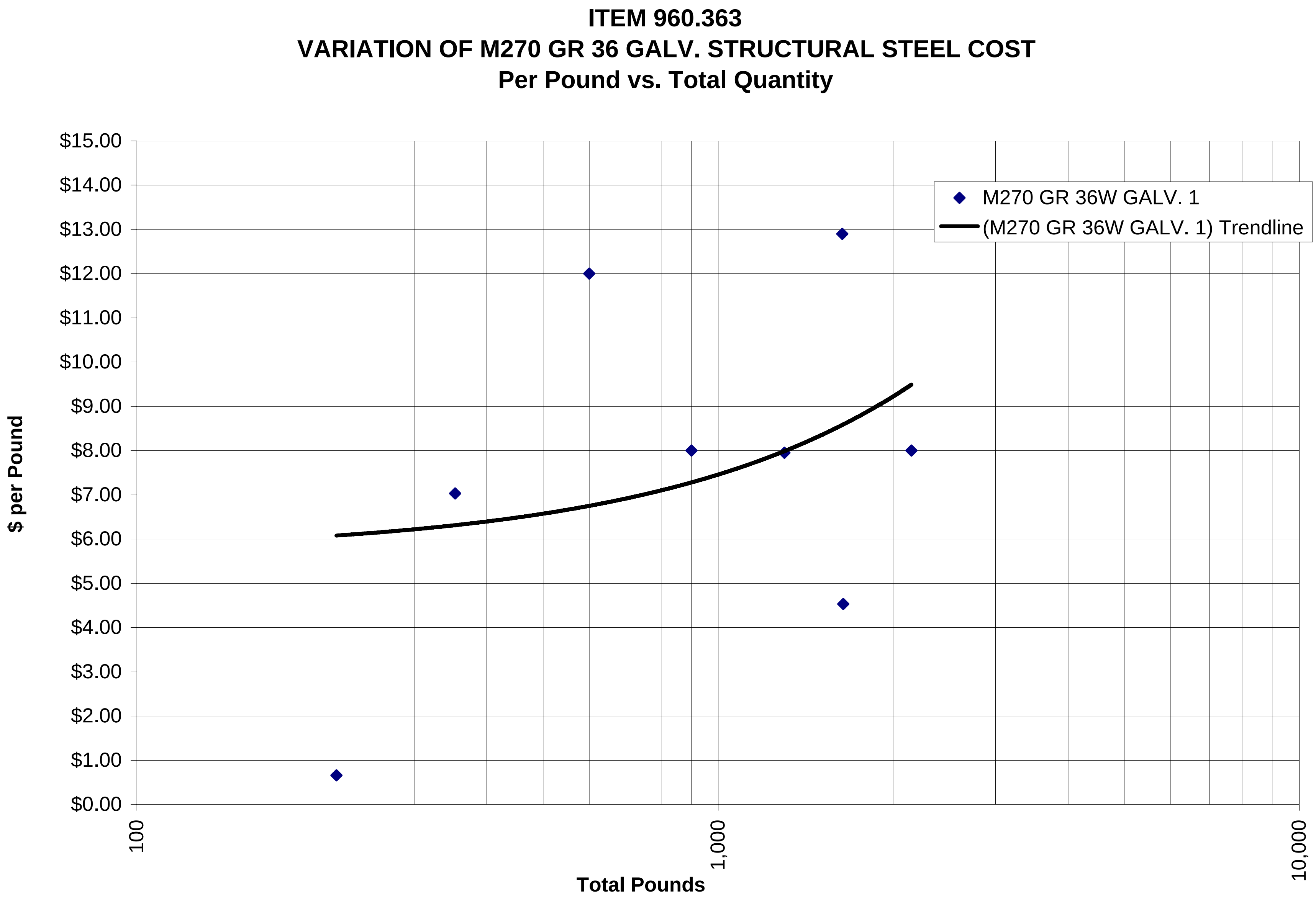



VARIATION OF HP PRESTRESSED CONCRETE BOX BEAM COST
Per Linear Foot vs. Total Quantity
$ per Linear Foot
$450.00
$400.00
$350.00
$300.00
$250.00
$200.00
$150.00
$100.00
$50.00
0
250
500
750
1,000
1,250
1,500
1,750
2,000
Total Linear Feet
HP B36-24
HP B36-27
HP B36-30
HP B36-33
HP B36-36
HP B36-39
HP B36-42
HP B36-45
HP B36-48

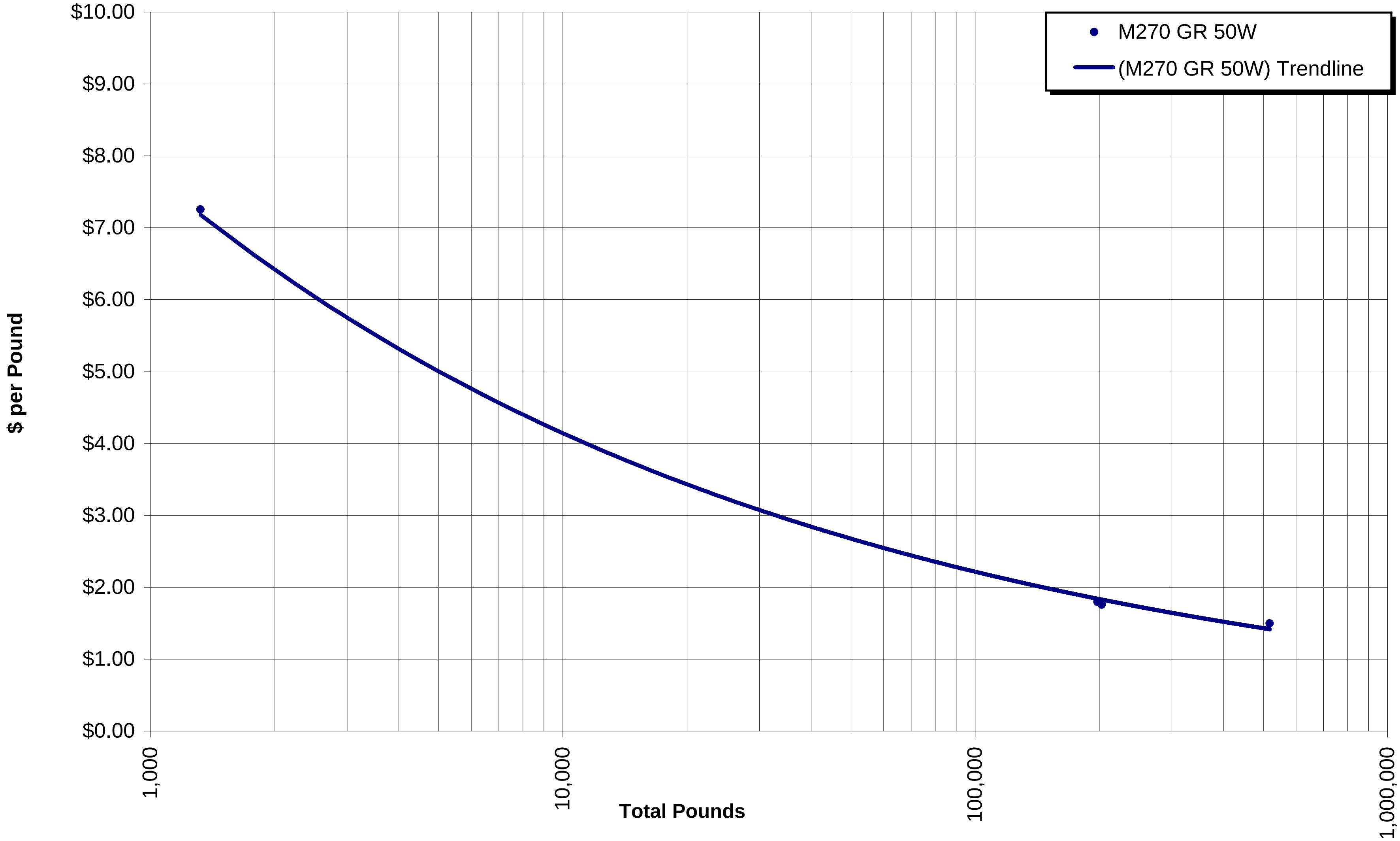

VARIATION OF HP PRESTRESSED CONCRETE BOX BEAM COST
Per Linear Foot vs. Total Quantity
$ per Linear Foot
$650.00
$600.00
$550.00
$500.00
$450.00
$400.00
$350.00
$300.00
$250.00
0
250
500
750
1,000
1,250
1,500
1,750
2,000
Total Linear Feet
HP B48-24
HP B48-27
HP B48-30
HP B48-33
HP B48-36
HP B48-39
HP B48-42
HP B48-45
HP B48-48

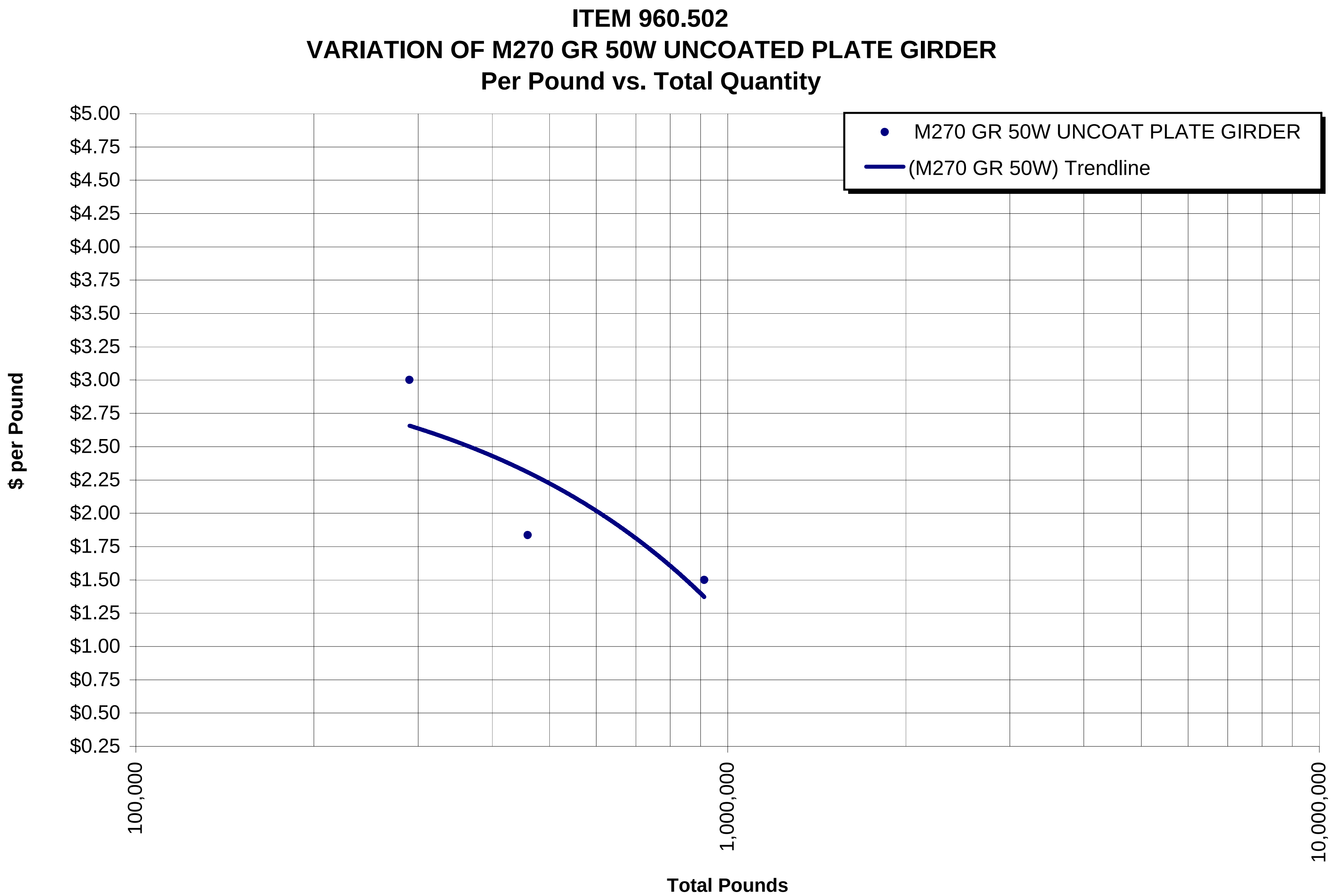

VARIATION OF PRESTRESSED CONCRETE NEBT BEAM COST
Per Linear Foot vs. Total Quantity
$600.00
$500.00
$400.00
$300.00
$200.00
$100.00
$0.00
$ per Linear Foot
0
250
500
750
1,000
1,250
1,500
1,750
2,000
Total Linear Feet
NEBT 1000
NEBT 1200
NEBT 1400
NEBT 1600
NEBT 1800

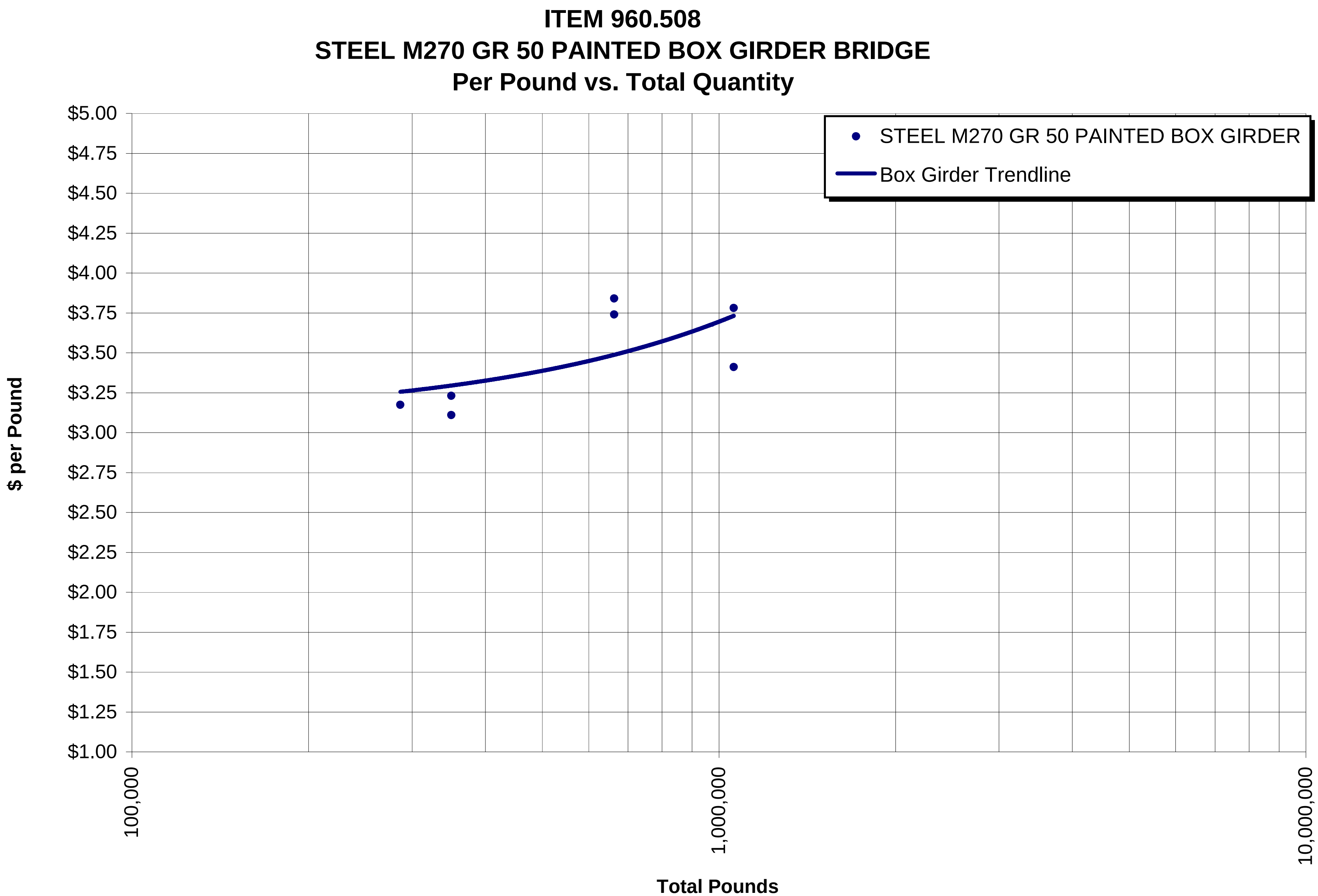

VARIATION OF HP PRESTRESSED CONCRETE NEBT BEAM COST
Per Linear Foot vs. Total Quantity
$ per Linear Foot
$600.00
$500.00
$400.00
$300.00
$200.00
$100.00
$0.00
0
250
500
750
1,000
1,250
1,500
1,750
2,000
Total Linear Feet
NEBT 1000
NEBT 1200
NEBT 1400
NEBT 1600
NEBT 1800

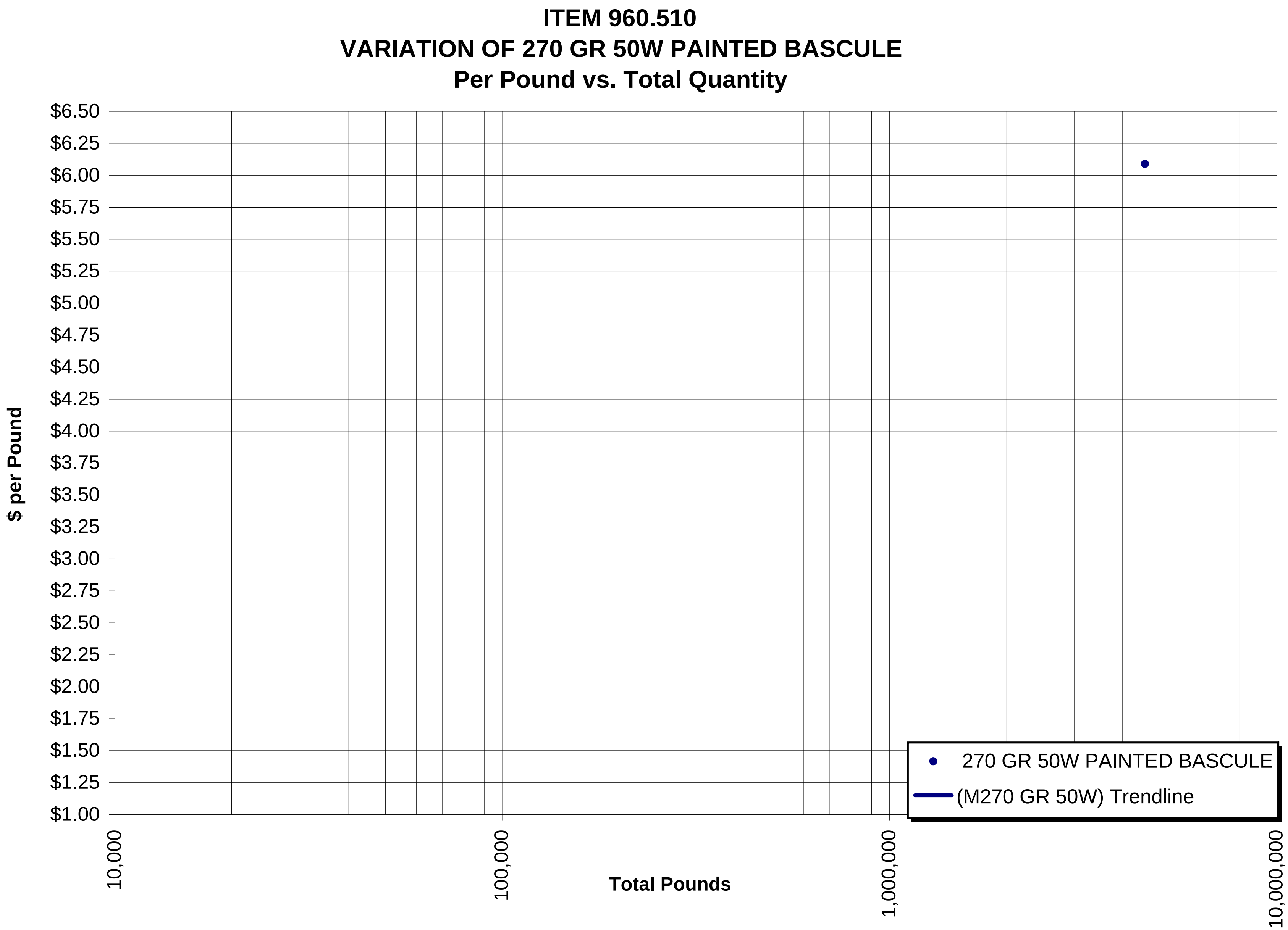

ITEM 960.363
VARIATION OF M270 GR 36 GALV. STRUCTURAL STEEL COST
Per Pound vs. Total Quantity
$ per Pound
$0.00
$1.00
$2.00
$3.00
$4.00
$5.00
$6.00
$7.00
$8.00
$9.00
$10.00
$11.00
$12.00
$13.00
$14.00
$15.00
100
1,000
10,000
Total Pounds
M270 GR 36W GALV. 1
(M270 GR 36W GALV. 1) Trendline

ITEM 960.501
VARIATION OF M270 GR 50W UNCOATED ROLLED BEAM BRIDGE
Per Pound vs. Total Quantity

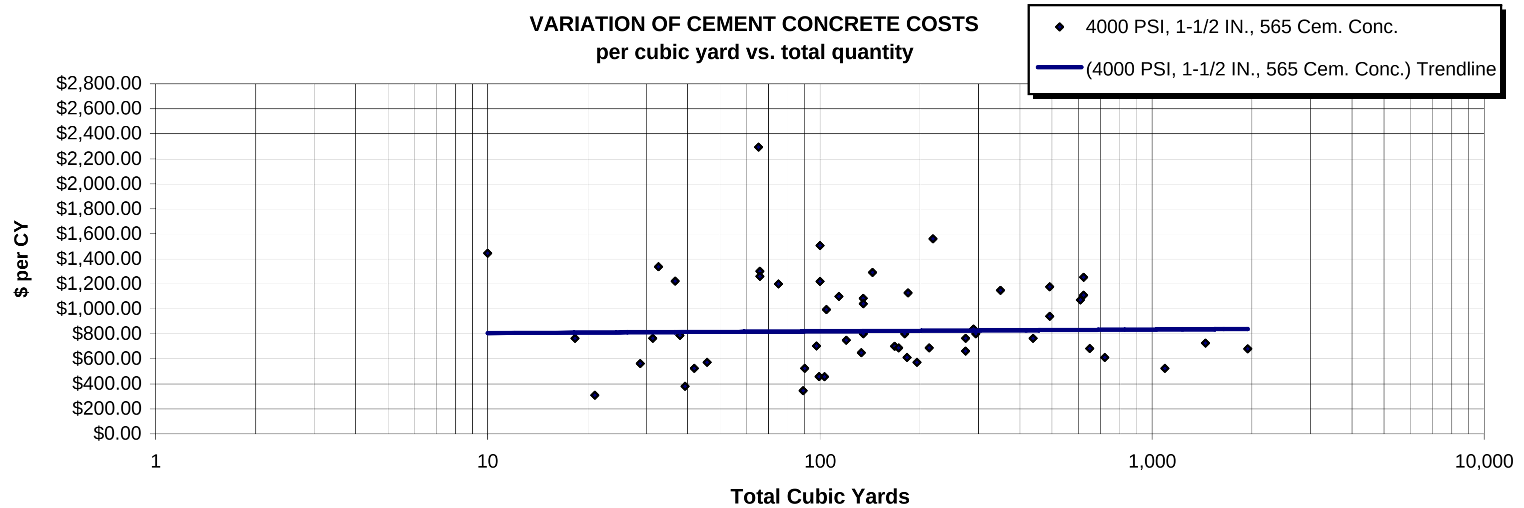



ITEM 960.502
VARIATION OF M270 GR 50W UNCOATED PLATE GIRDER
Per Pound vs. Total Quantity
$5.00
$4.75
$4.50
$4.25
$4.00
$3.75
$3.50
$3.25
$3.00
$2.75
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
$0.75
$0.50
$0.25
$ per Pound
M270 GR 50W UNCOAT PLATE GIRDER
(M270 GR 50W) Trendline
100,000
1,000,000
10,000,000
Total Pounds

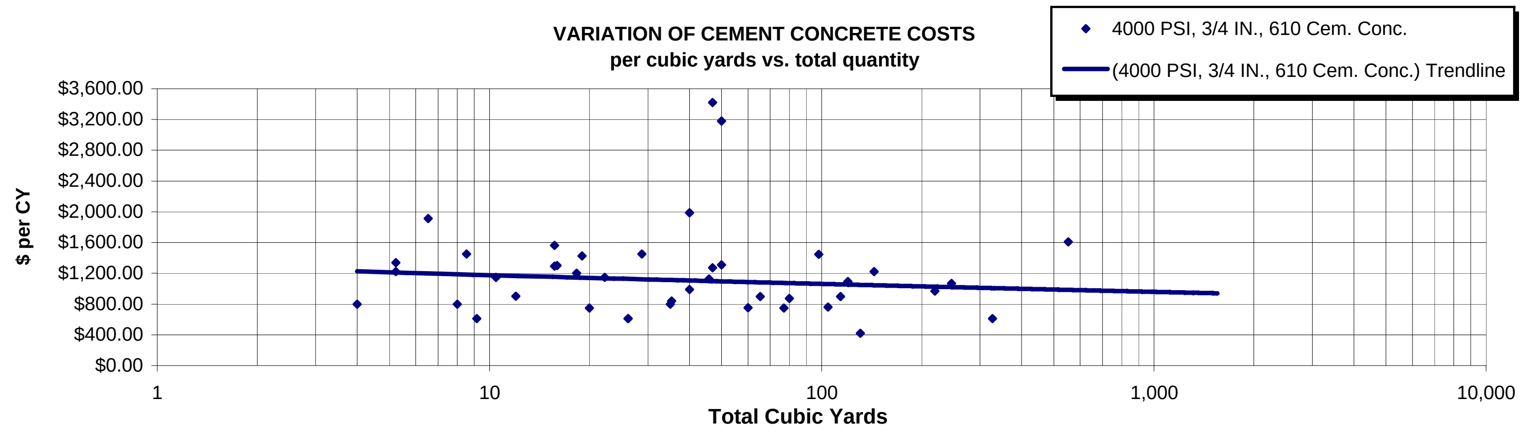

ITEM 960.508
STEEL M270 GR 50 PAINTED BOX GIRDER BRIDGE
Per Pound vs. Total Quantity
STEEL M270 GR 50 PAINTED BOX GIRDER
Box Girder Trendline
$ per Pound
$5.00
$4.75
$4.50
$4.25
$4.00
$3.75
$3.50
$3.25
$3.00
$2.75
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
100,000
1,000,000
10,000,000
Total Pounds


ITEM 960.510
VARIATION OF 270 GR 50W PAINTED BASCULE
Per Pound vs. Total Quantity
$ per Pound
$6.50
$6.25
$6.00
$5.75
$5.50
$5.25
$5.00
$4.75
$4.50
$4.25
$4.00
$3.75
$3.50
$3.25
$3.00
$2.75
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
10,000
100,000
1,000,000
10,000,000
Total Pounds
270 GR 50W PAINTED BASCULE
(M270 GR 50W) Trendline

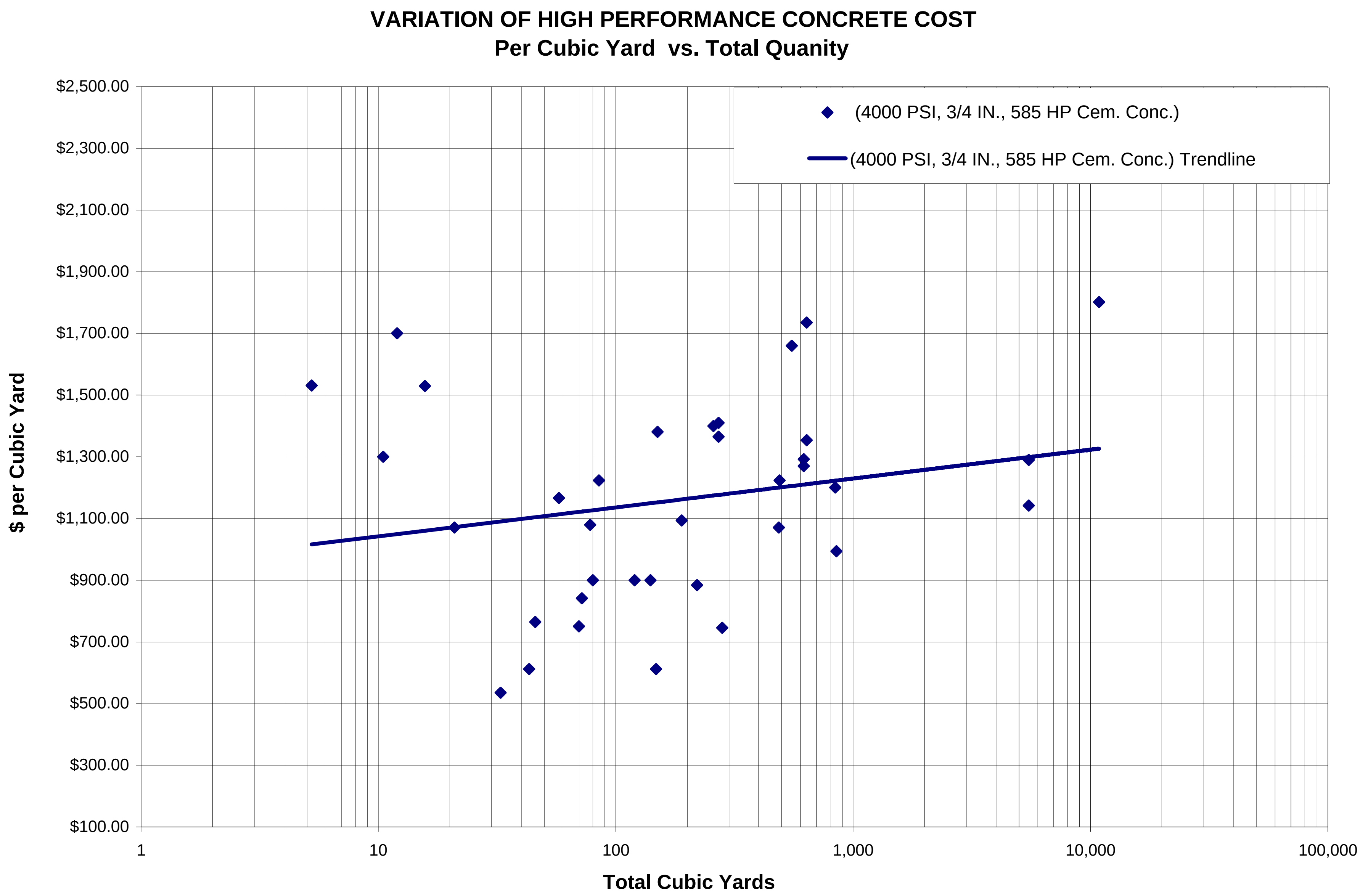
WEIGHTED AVERAGE UNIT PRICES TAKEN FROM 2006 - 2007 STATEWIDE WEIGHTED AVERAGE BID PRICES

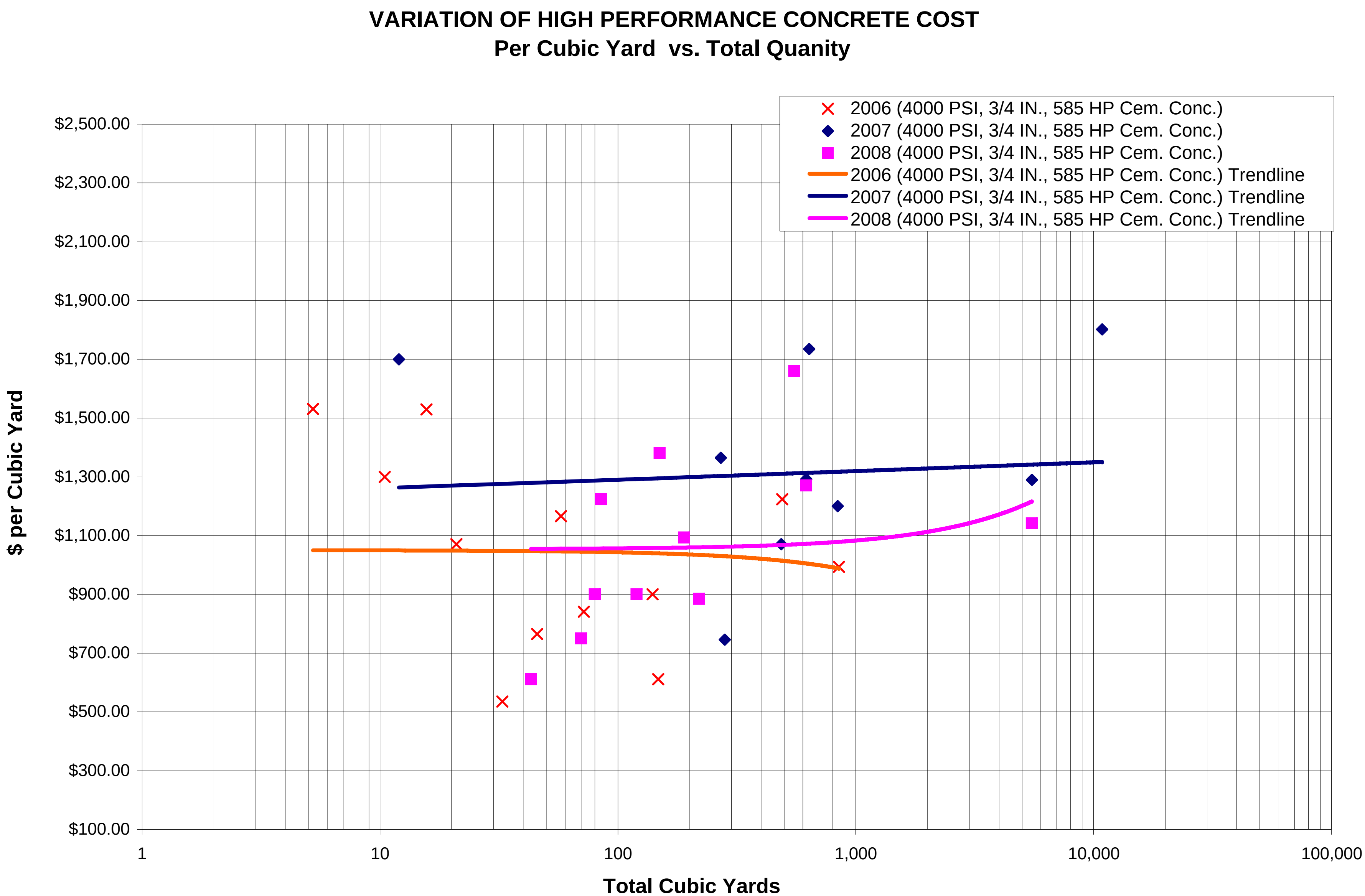


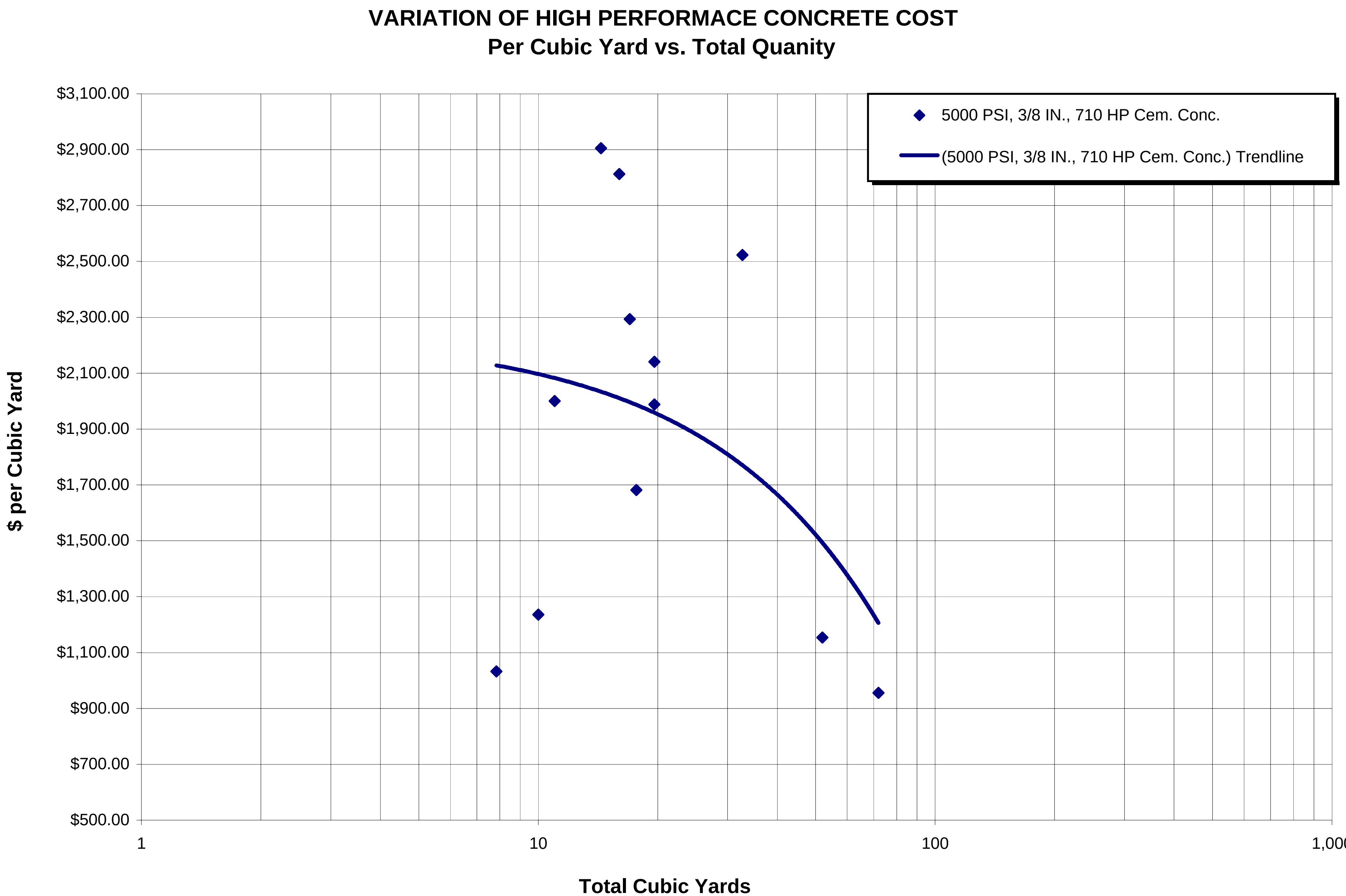
ITEM 901.

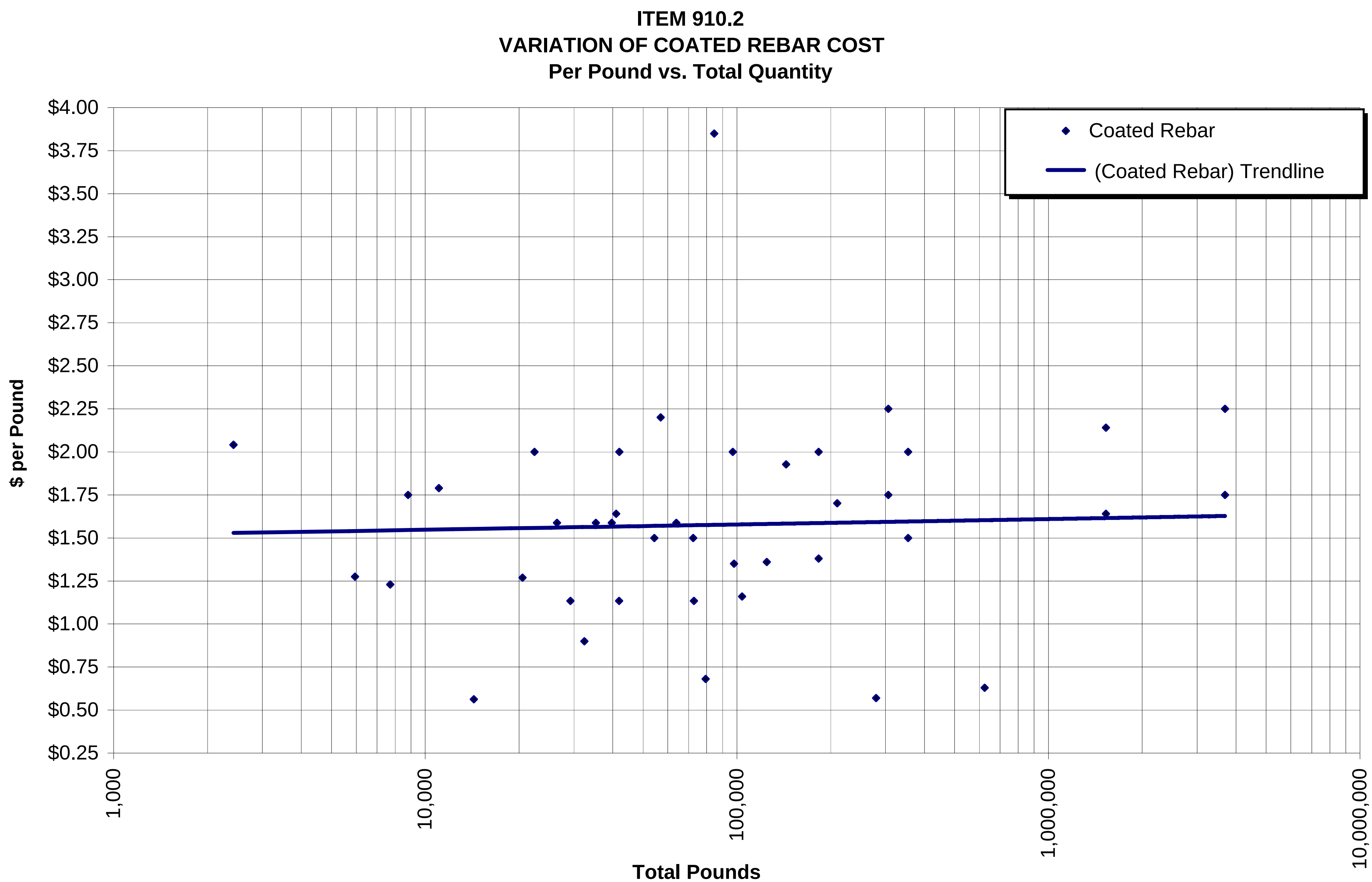


ITEM 904.


VARIATION OF HIGH PERFORMANCE CONCRETE COST
Per Cubic Yard vs. Total Quanity
$ per Cubic Yard
$2,500.00
$2,300.00
$2,100.00
$1,900.00
$1,700.00
$1,500.00
$1,300.00
$1,100.00
$900.00
$700.00
$500.00
$300.00
$100.00
1
10
100
1,000
10,000
100,000
Total Cubic Yards
(4000 PSI, 3/4 IN., 585 HP Cem. Conc.)
(4000 PSI, 3/4 IN., 585 HP Cem. Conc.) Trendline


VARIATION OF HIGH PERFORMANCE CONCRETE COST
Per Cubic Yard vs. Total Quanity
2006 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.)
2007 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.)
2008 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.)
2006 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.) Trendline
2007 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.) Trendline
2008 (4000 PSI, 3/4 IN., 585 HP Cem. Conc.) Trendline
$ per Cubic Yard
$2,500.00
$2,300.00
$2,100.00
$1,900.00
$1,700.00
$1,500.00
$1,300.00
$1,100.00
$900.00
$700.00
$500.00
$300.00
$100.00
1
10
100
1,000
10,000
100,000
Total Cubic Yards


VARIATION OF HIGH PERFORMACE CONCRETE COST
Per Cubic Yard vs. Total Quanity
$ per Cubic Yard
$3,100.00
$2,900.00
$2,700.00
$2,500.00
$2,300.00
$2,100.00
$1,900.00
$1,700.00
$1,500.00
$1,300.00
$1,100.00
$900.00
$700.00
$500.00
1
10
100
1,000
Total Cubic Yards
5000 PSI, 3/8 IN., 710 HP Cem. Conc.
(5000 PSI, 3/8 IN., 710 HP Cem. Conc.) Trendline


ITEM 910.2
VARIATION OF COATED REBAR COST
Per Pound vs. Total Quantity
$ per Pound
$4.00
$3.75
$3.50
$3.25
$3.00
$2.75
$2.50
$2.25
$2.00
$1.75
$1.50
$1.25
$1.00
$0.75
$0.50
$0.25
1,000
10,000
100,000
1,000,000
10,000,000
Total Pounds
Coated Rebar
(Coated Rebar) Trendline

BRIDGE MANUAL
PART II: STANDARD DETAILS
DRAWING NUMBER, DESCRIPTION, DATE OF ISSUE

CHAPTER 1: PREPARATION OF PLANS

CHAPTER 2: BRIDGE GEOMETRY

CHAPTER 3: BRIDGE SUBSTRUCTURES

CHAPTER 4: ADJACENT BEAM BRIDGES

CHAPTER 5: STRINGER BRIDGES – STEEL BEAMS

CHAPTER 6: STRINGER BRIDGES – CONCRETE BEAMS

CHAPTER 7: DECK DETAILS

CHAPTER 8: BRIDGE BEARINGS

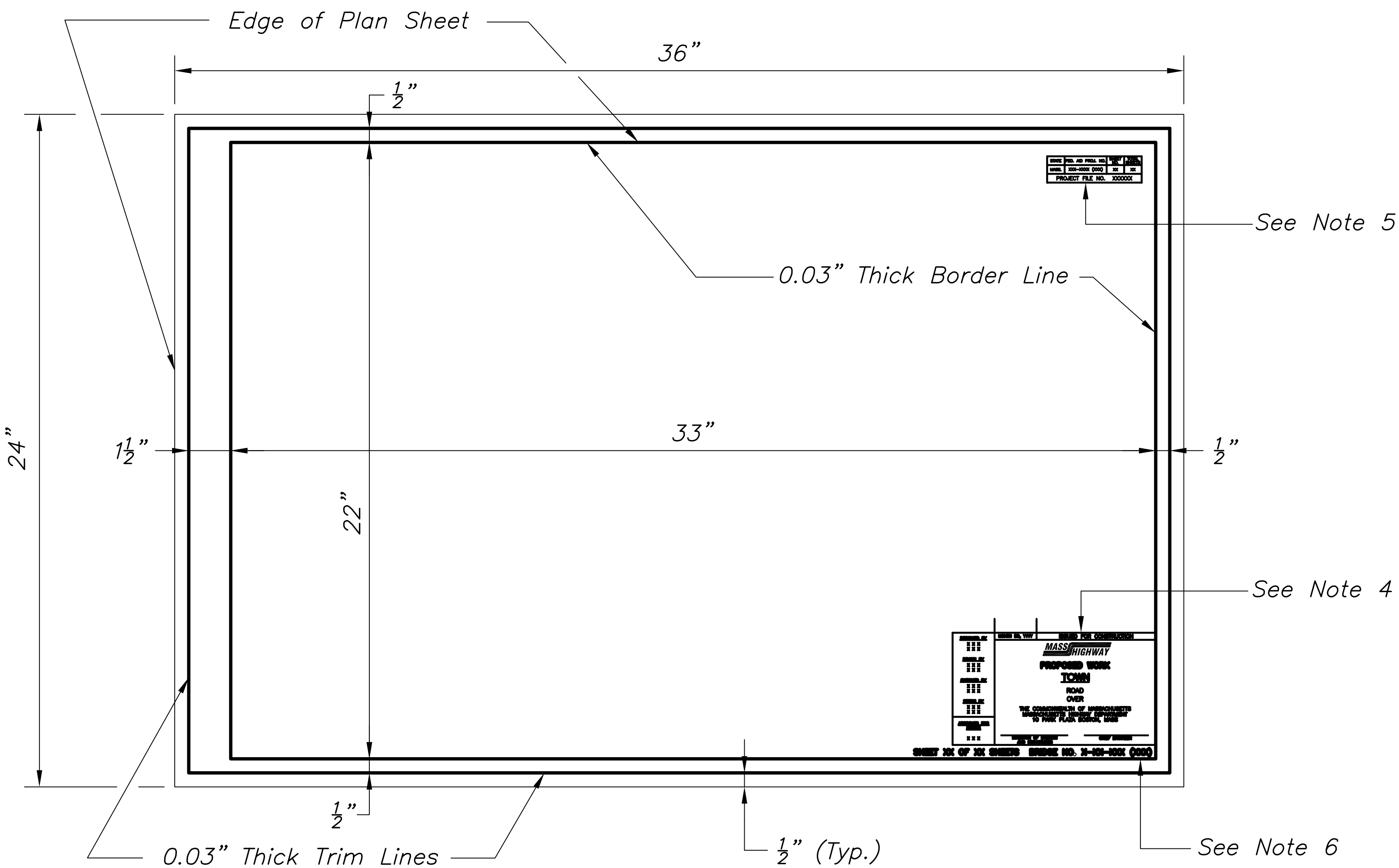
CHAPTER 9: RAILING/TRAFFIC BARRIER SYSTEMS

CHAPTER 10: EXPANSION JOINTS

CHAPTER 11: CULVERTS

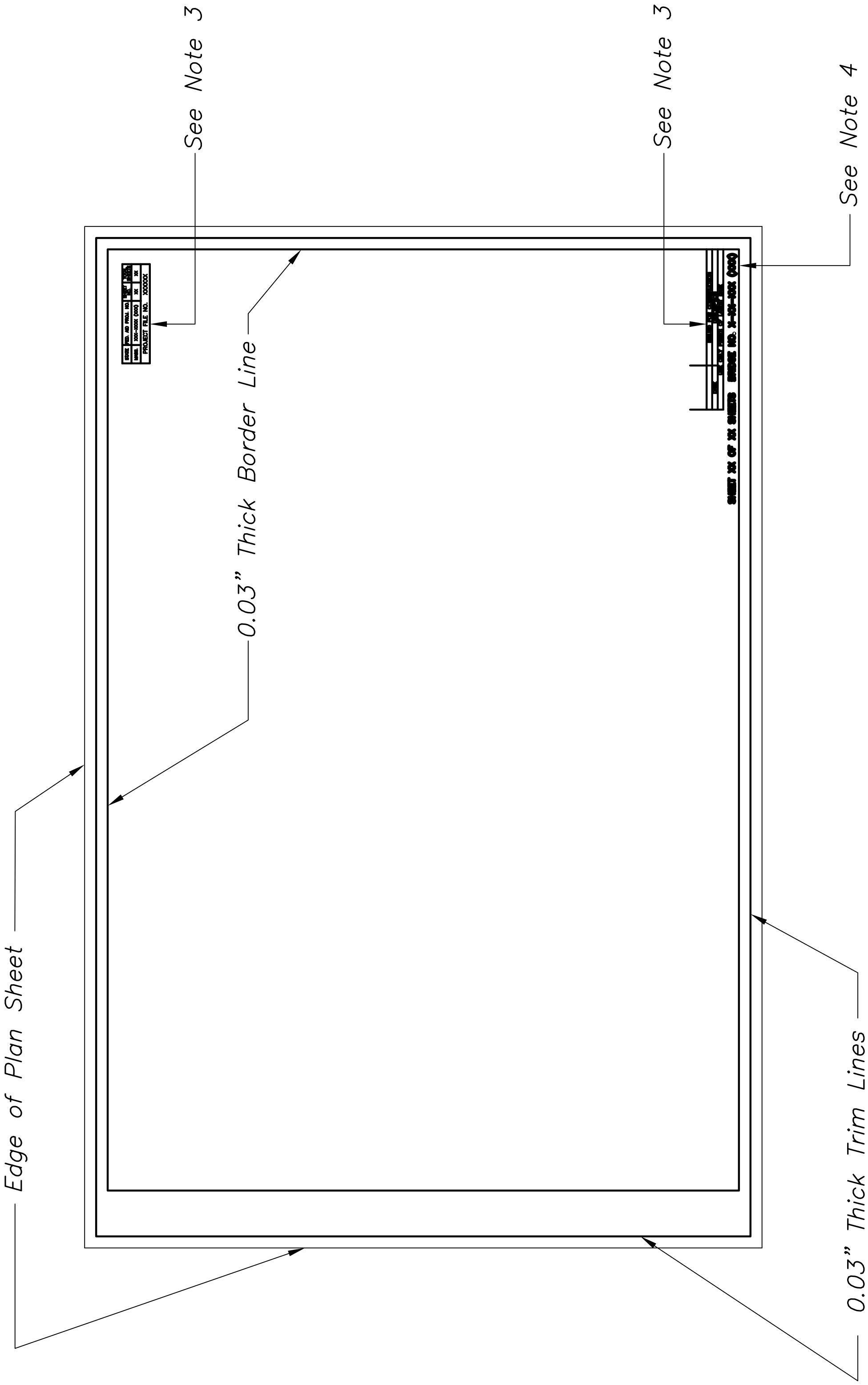
CHAPTER 12: INTEGRAL ABUTMENTS

STANDARD RAILING, SCREEN, AND GUARDRAIL TRANSITION SHEETS



NOTES:

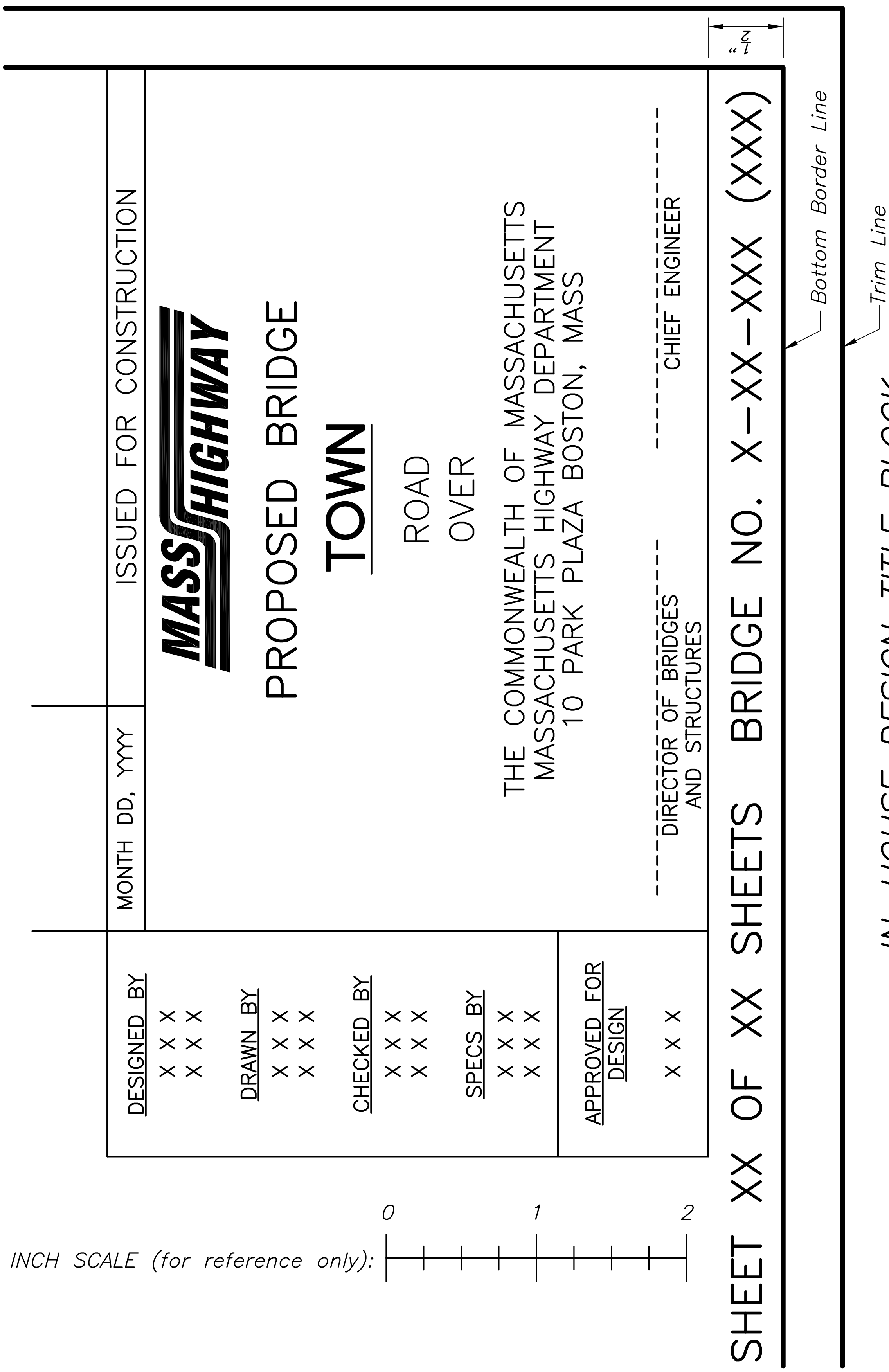
1. The above drawing is not drawn to scale.
2. The Drawing Frame is sized to work with plotters regardless of media orientation.
3. See Dwg. No. 1.1.2 for Standard Subsequent Sheets.
4. See Dwg. No. 1.1.3 for In–House Design Title Block.
   See Dwg. No. 1.1.4 for Consultant Design Title Block.
5. See Dwg. No. 1.1.5 for Federal Aid Block.
6. Bridge with single Bridge Identification Number (B.I.N) shown.
   For bridges with multiple B.I.N’s see Dwg. No. 1.1.5.



NOTES:

1. The above drawing is not drawn to scale.
2. The size and dimensions for subsequent sheets are the same as for the Standard First Sheet (See Dwg. No. 1.1.1).
3. See Dwg. No. 1.1.5 for the Federal Aid Block and for the Subsequent Sheets Title Block.
4. Bridge with single Bridge Identification Number (B.I.N) shown. For bridges with multiple B.I.N.'s see Dwg. No. 1.1.5.

MASS HIGHWAY BRIDGE MANUAL	STANDARD SUBSEQUENT SHEETS CONSTRUCTION DRAWINGS/SKETCH PLANS	DATE OF ISSUE JANUARY 2009 DRAWING NUMBER **1.1.2**

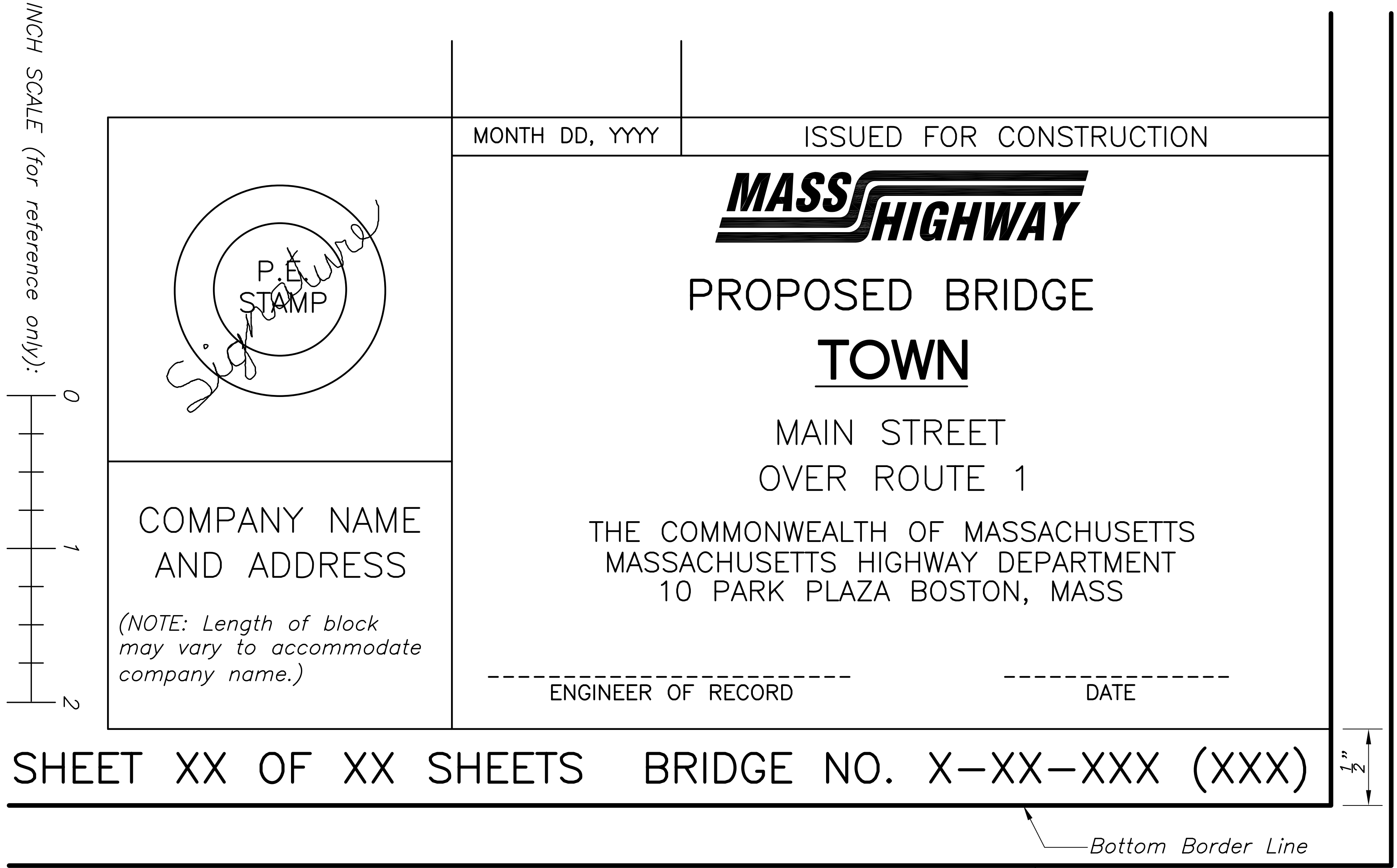


IN-HOUSE DESIGN TITLE BLOCK

SCALE: FULL SIZE

NOTE:
For other types of construction projects, replace the "PROPOSED BRIDGE" title with the correct project description (for example, "PROPOSED SUPERSTRUCTURE REPLACEMENT" and "PROPOSED BRIDGE REHABILITATION"). See Part I Section 4.2.2.2 for complete listing of standard project descriptions. The character size of the project description may have to be reduced to fit the longer titles.

MASS HIGHWAY BRIDGE MANUAL	IN-HOUSE DESIGN TITLE BLOCK CONSTRUCTION DRAWINGS	DATE OF ISSUE: FEBRUARY 2007 DRAWING NUMBER: **1.1.3**

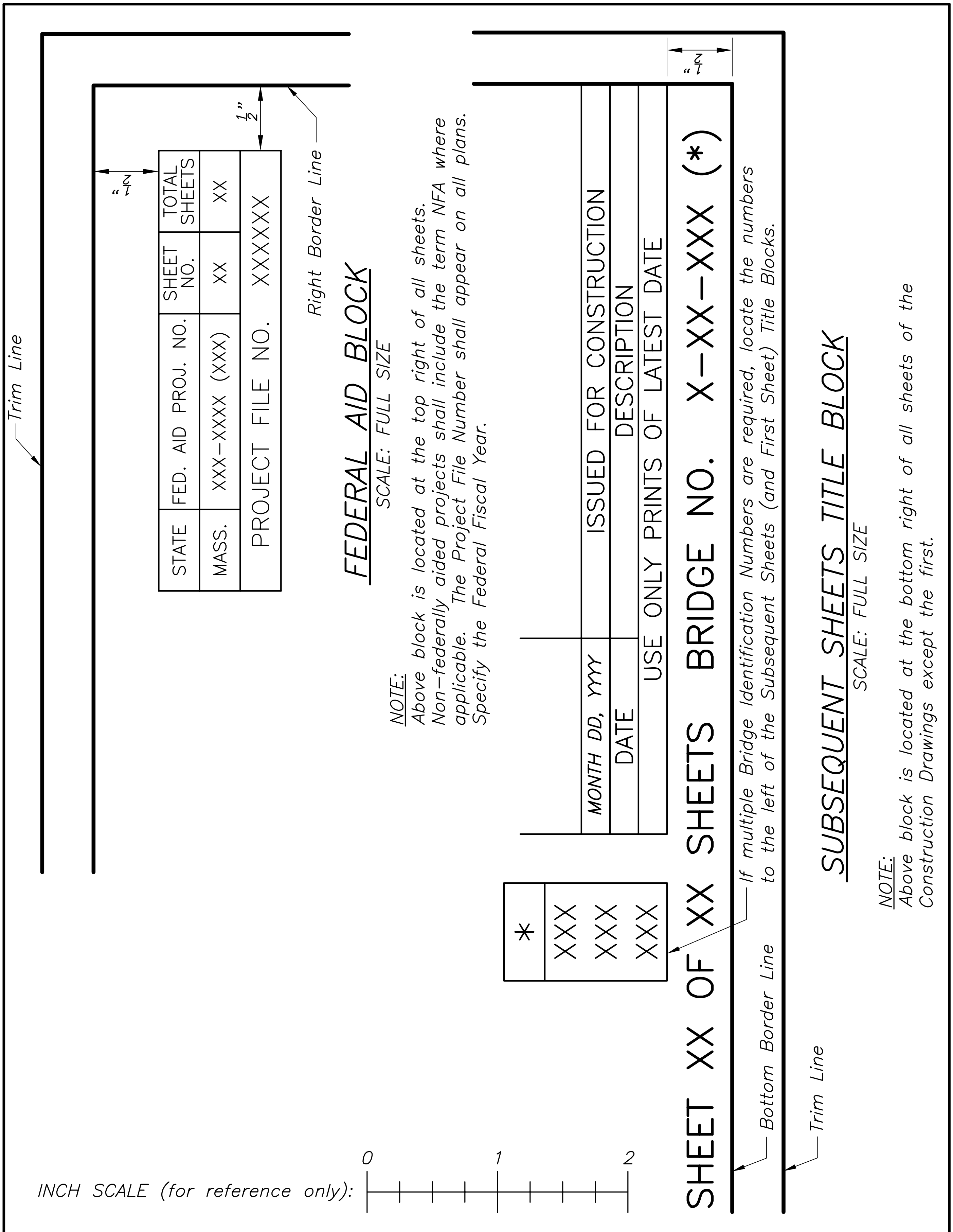


CONSULTANT DESIGN TITLE BLOCK

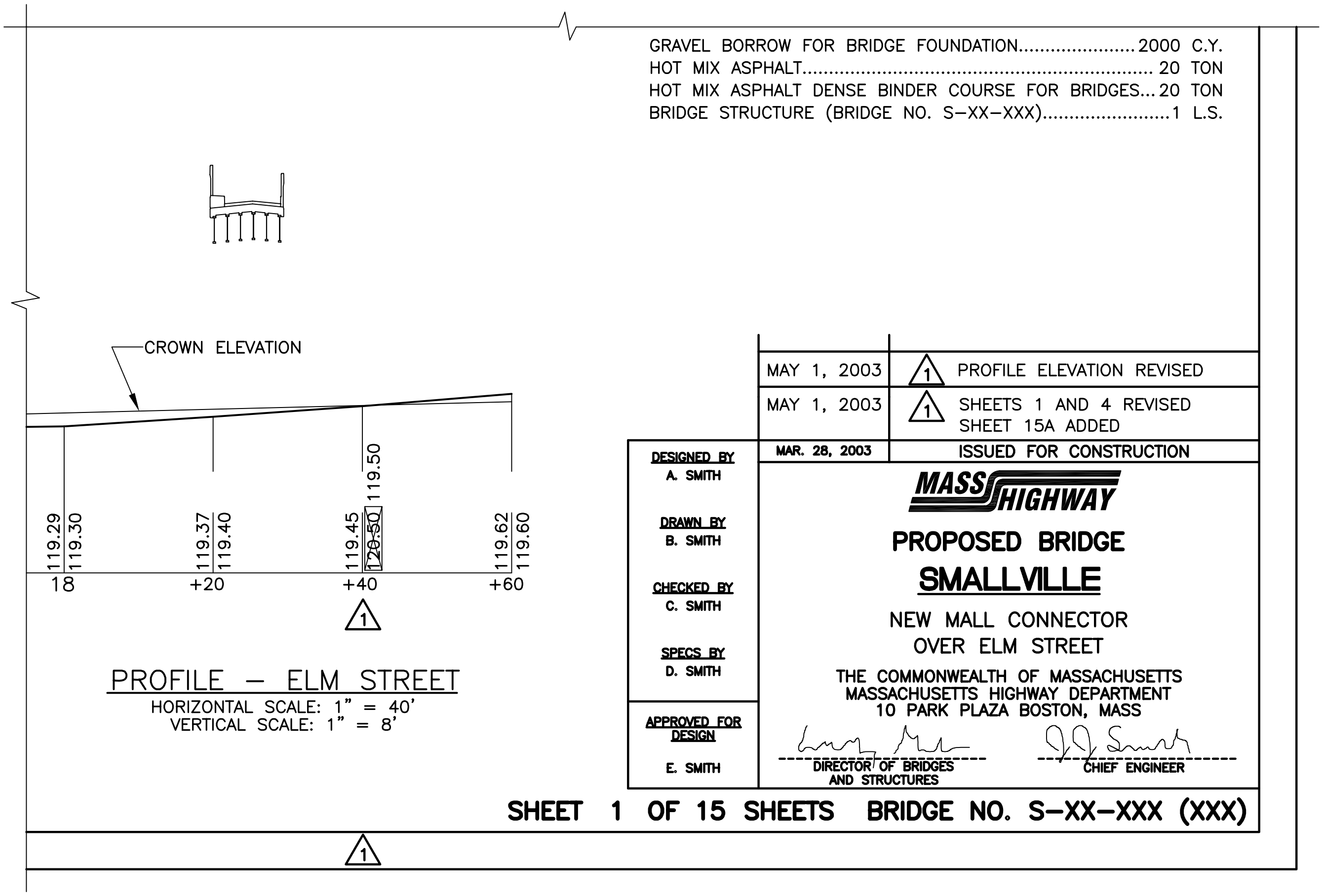
SCALE: FULL SIZE

NOTE:

For other types of construction projects, replace the "PROPOSED BRIDGE" title with the correct project description (for example, "PROPOSED SUPERSTRUCTURE REPLACEMENT" and "PROPOSED BRIDGE REHABILITATION"). See Part I Section 4.2.2.2 for complete listing of standard project descriptions. The character size of the project description may have to be reduced to fit the longer titles.



MASS HIGHWAY BRIDGE MANUAL	MISCELLANEOUS BLOCKS CONSTRUCTION DRAWINGS	DATE OF ISSUE JANUARY 2009 DRAWING NUMBER **1.1.5**

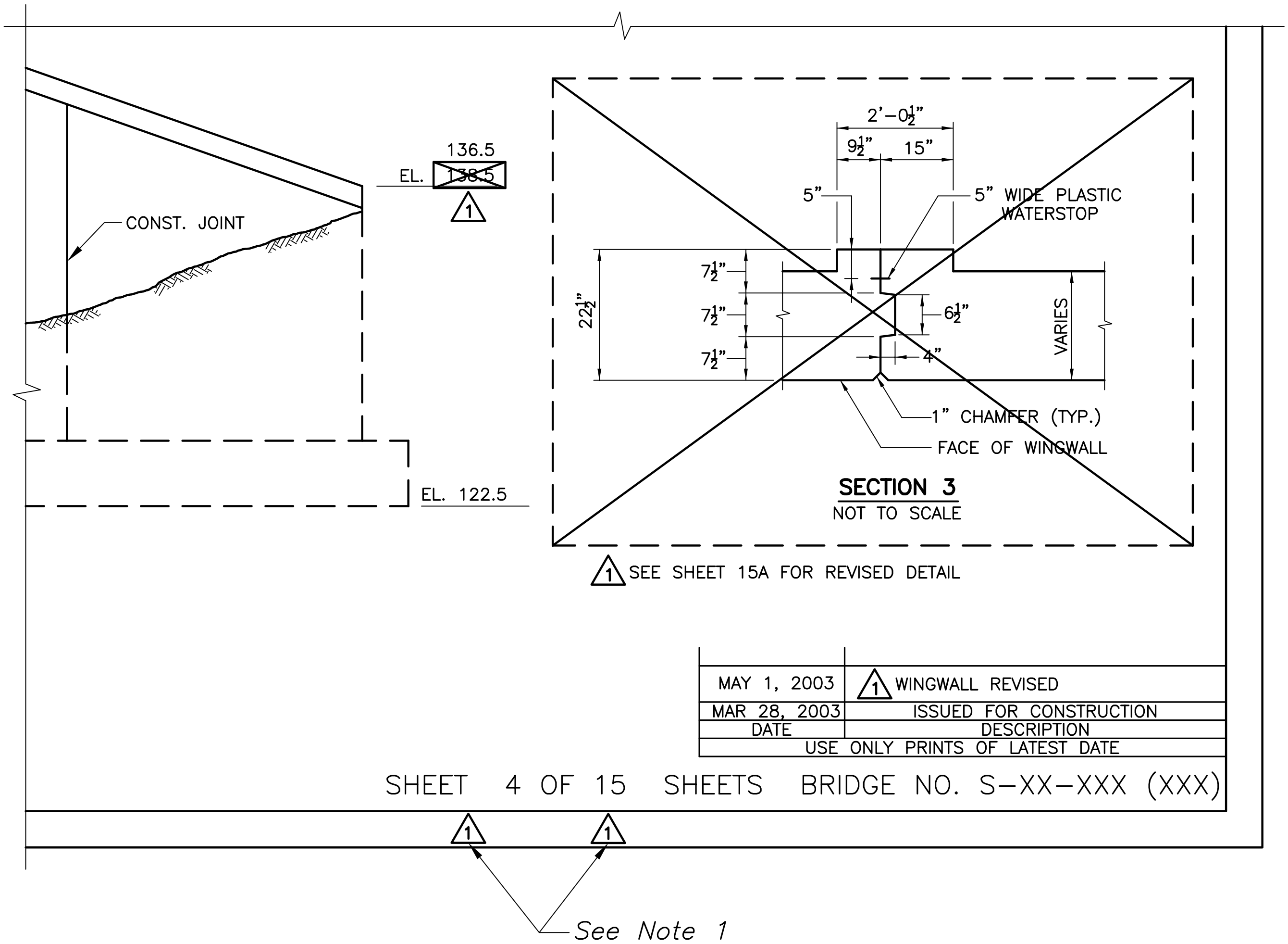


FIRST SHEET OF CONSTRUCTION PLANS

NOT TO SCALE

NOTES:

1. *A revision symbol (△) shall be located in the lower, upper or right hand margin closest to the revision to facilitate locating revisions.*
2. *Revisions made on the same date shall have the same number in the revision symbol.*
3. *When revising the construction plans, erasures of existing details are not permitted. The correct method for revisions is shown above.*
4. *Indicate the sheet numbers of all revised, added and/or deleted sheets over the title block. If there are any revisions on the first sheet, provide a description of the revisions as well.*



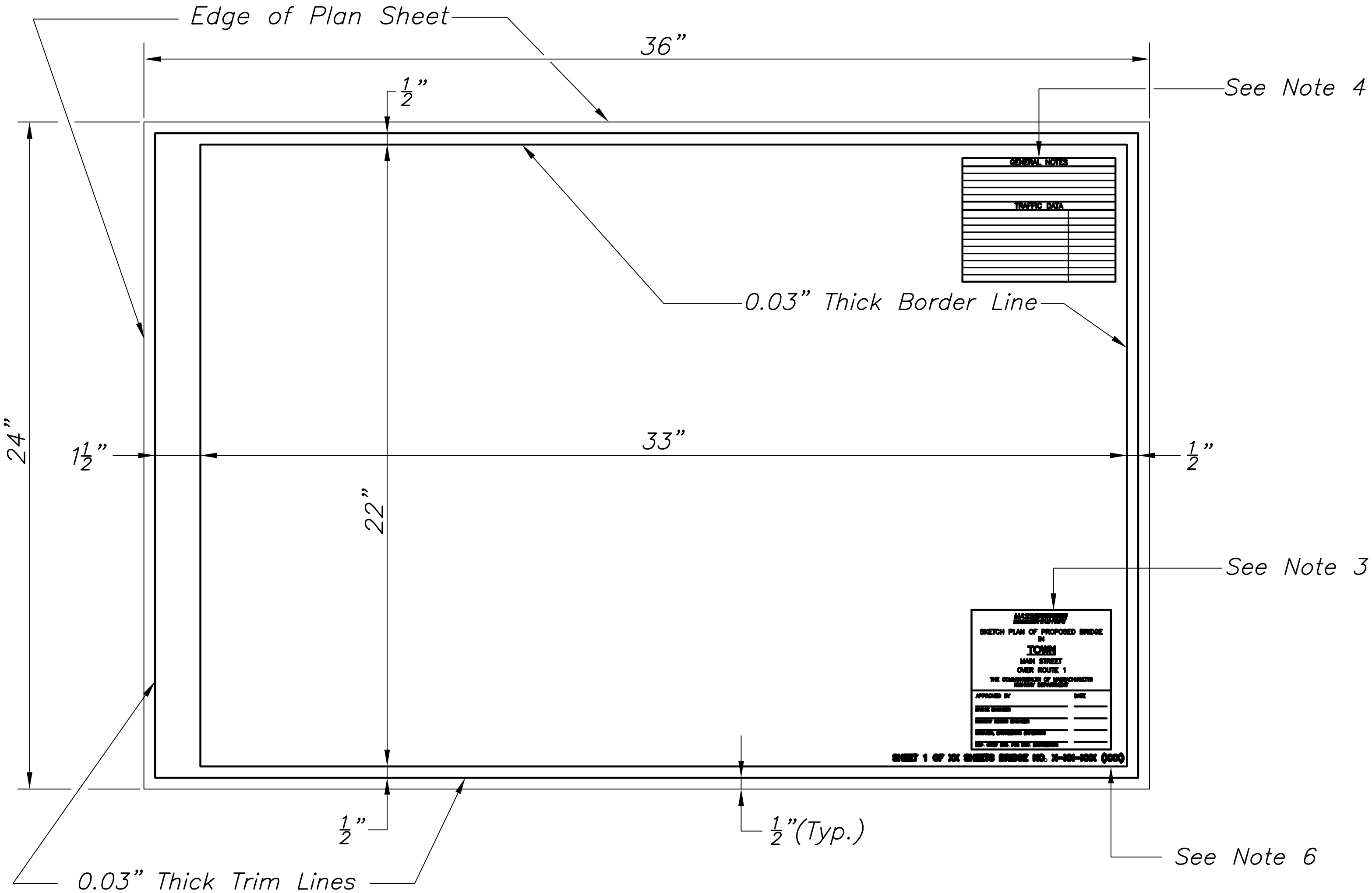
TYPICAL SUBSEQUENT SHEET OF CONSTRUCTION PLANS

NOT TO SCALE

NOTES:

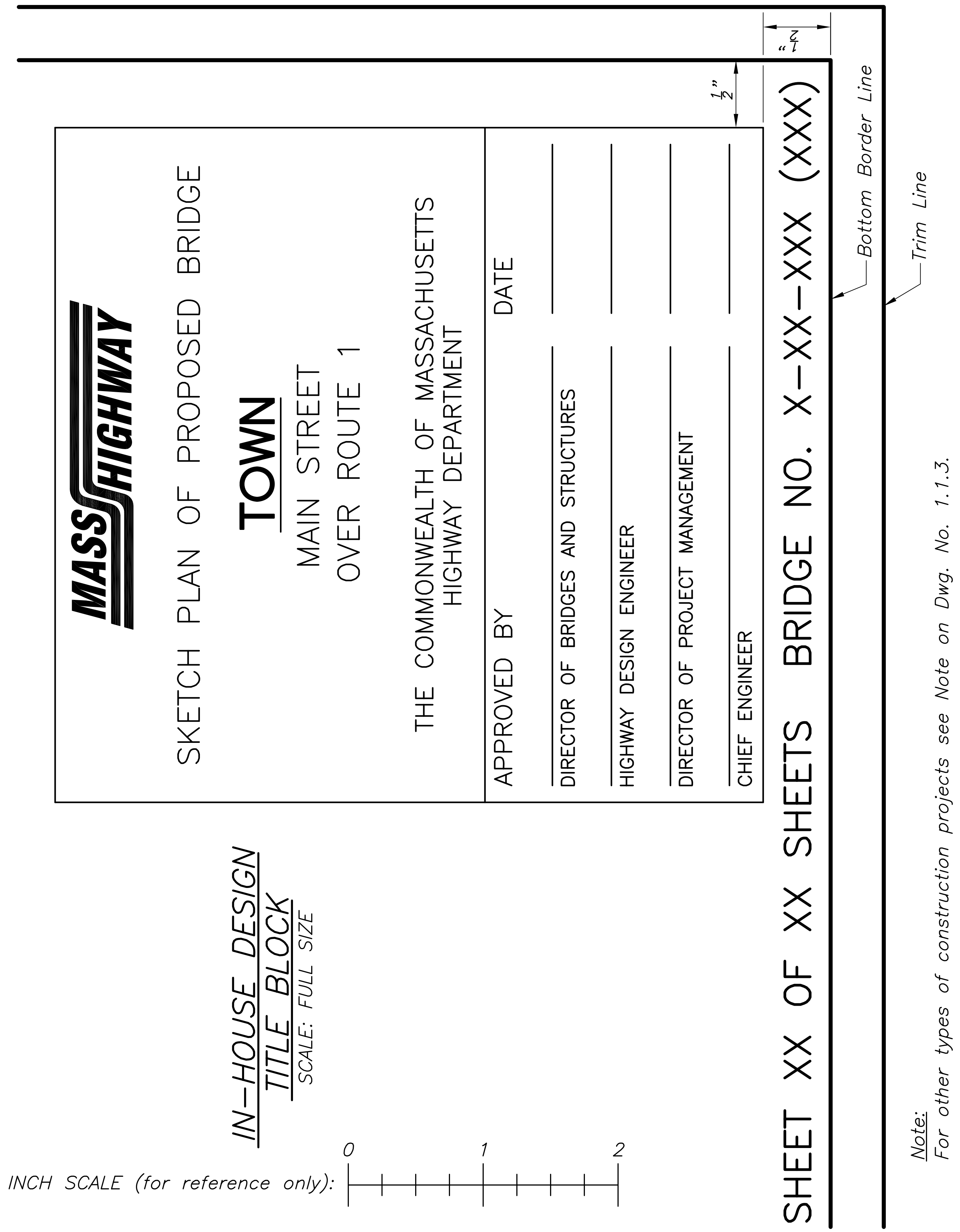
1. *A revision symbol (△) shall be located in the lower, upper or right hand margin closest to the revision to facilitate locating revisions.*
2. *Revisions made on the same date shall have the same number in the revision symbol.*
3. *When revising the construction plans, erasures of existing details are not permitted. The correct method for revisions is shown above.*

MASS HIGHWAY BRIDGE MANUAL	REVISIONS TO SUBSEQUENT SHEETS CONSTRUCTION DRAWINGS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **1.1.7**

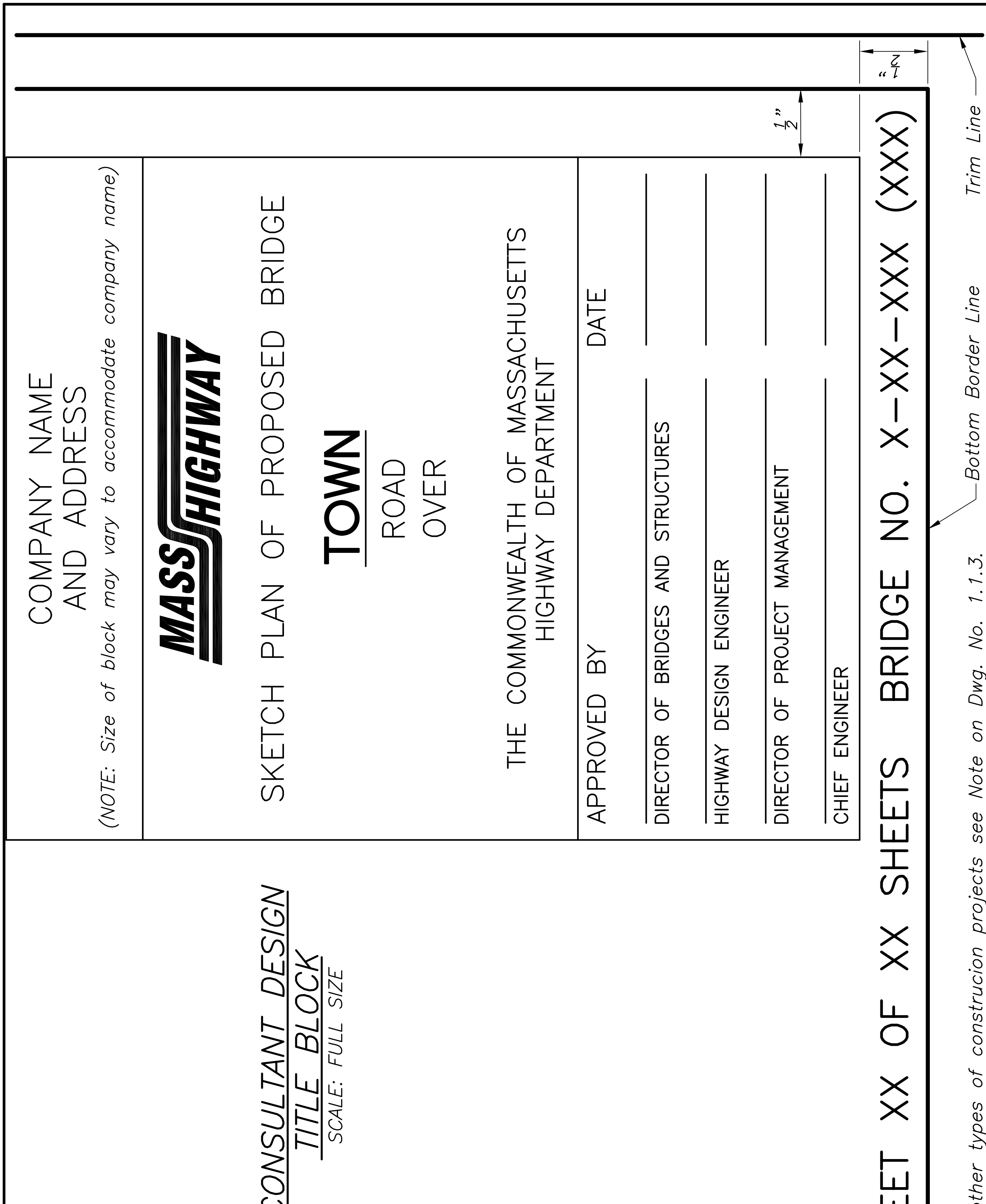


NOTES:

1. The above drawing is not drawn to scale.
2. The Drawing Frame is sized to work with plotters regardless of media orientation.
3. See Dwg. No. 1.2.2 for the In-House Design Title Block or Dwg. 1.2.3 for the Consultant Design Title Block.
4. See Dwg. 1.2.4 for the Standard Data Block.
5. Subsequent Sheets are the same size and dimension as the first sheet. Omit Data Block and Title Block on subsequent sheets. Retain sheet and Bridge Number at bottom right corner of all sheets.
6. For bridges with multiple Bridge Identification Numbers, locate numbers in a box to the left of the Title Block (or above the Bridge Number on subsequent sheets) similar to Dwg. 1.1.5.



MASS HIGHWAY BRIDGE MANUAL	IN-HOUSE DESIGN TITLE BLOCK SKETCH PLANS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **1.2.2**



INCH SCALE (for reference only): 0 1 2

MASS HIGHWAY BRIDGE MANUAL	CONSULTANT DESIGN TITLE BLOCK SKETCH PLANS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **1.2.3**

Trim Line

Top Border Line

1/2"

GENERAL NOTES		
PROJECT FILE NO.:		
TYPE OF PROJECT: *(Same description as in Title Block)*		
BRIDGE DESIGN LOADING: HS25		
SURVEY:		
ELEVATION REFERENCE: NAVD of 1988		

1/2"

TRAFFIC DATA	ROADWAY OVER	ROADWAY UNDER
DESIGN YEAR		
AVERAGE DAILY TRAFFIC–PRESENT		
AVERAGE DAILY TRAFFIC–DESIGN YEAR		
DESIGN HOURLY VOLUME		
DIRECTIONAL DISTRIBUTION		
TRUCK PERCENTAGE–AVERAGE DAY		
TRUCK PERCENTAGE–PEAK HOUR		
DESIGN SPEED		
DIRECTIONAL DESIGN HOURLY VOLUME		

BENCH MARK: *(Description of the Bench Mark, its location and elevation shall be noted here)*

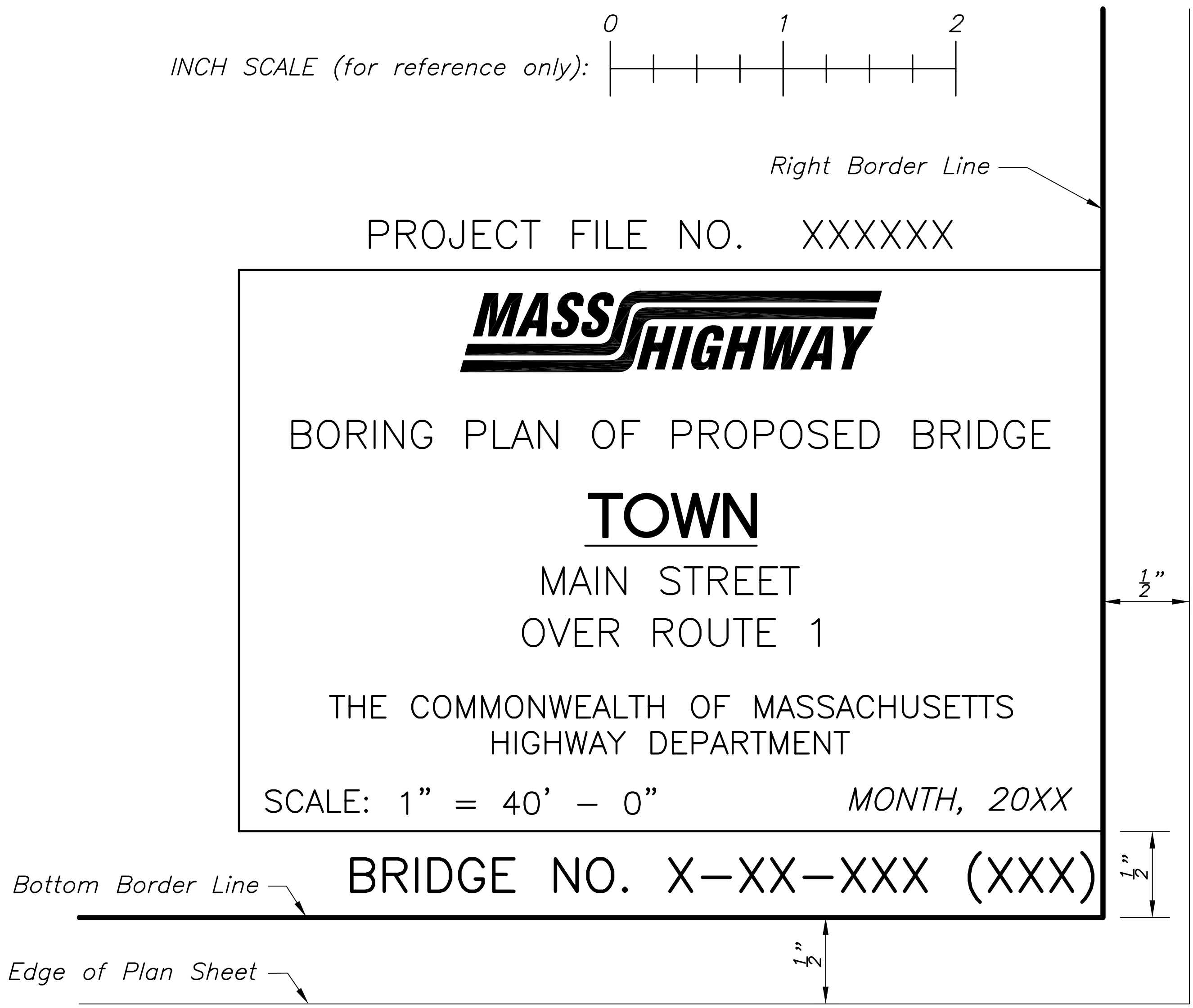
STANDARD DATA BLOCK

SCALE: FULL SIZE

NOTES:

1. *If any of the information in the above blocks is unknown or is not available then note "N/A" in the space provided.*
2. *If there will not be a road under the proposed bridge then draw an "X" over the entire column labeled "ROADWAY UNDER".*
3. *Under "SURVEY", if electronic data collection was used, indicate "ELECTRONIC SURVEY BY company name". Otherwise, specify survey note book numbers.*

INCH SCALE (for reference only): 0 1 2

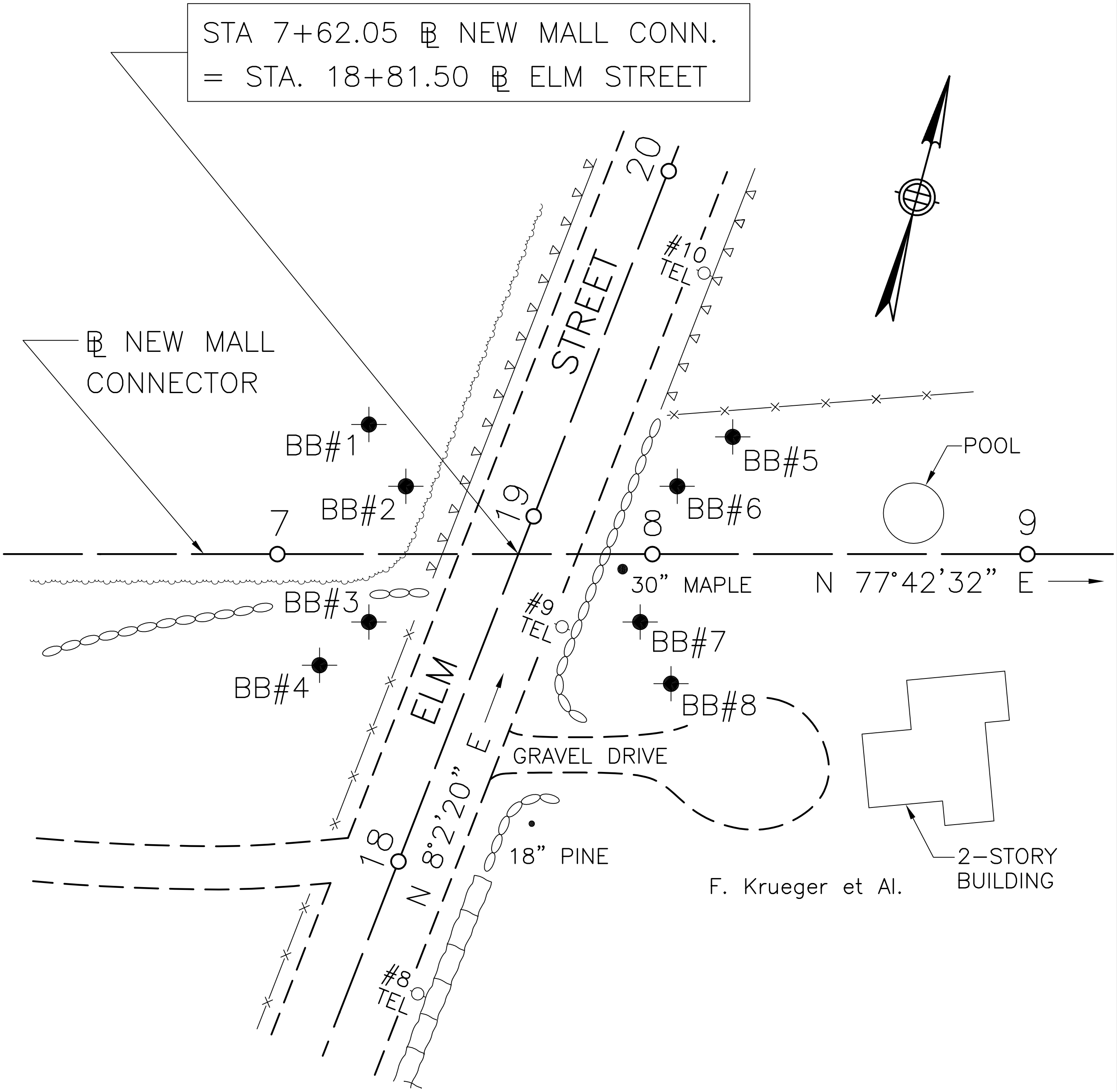


TITLE BLOCK

SCALE: FULL SIZE

NOTE:

Size of Boring Plans may vary to accomodate the plan view, boring locations, and notes. However, the maximum size should not exceed the size of the standard construction plans shown on Dwg. No. 1.1.1.



BORING LOCATIONS (FEET)

BORING	NORTHING	EASTING	STATION	OFFSET	SURFACE EL.	H.B.E.
BB#1	2,927,742	589,413	7+23	35' LT	175.0	104.0
BB#2	2,927,725	589,422	7+34	18' LT	175.0	104.0
BB#3	2,927,691	589,412	7+23	18' RT	175.2	104.0
BB#4	2,927,680	589,400	7+10	30' RT	175.1	104.0
BB#5	2,927,738	589,506	8+19	31' LT	173.0	92.5
BB#6	2,927,726	589,492	8+05	18' LT	173.5	92.5
BB#7	2,927,691	589,482	7+95	18' RT	173.2	92.5
BB#8	2,927,675	589,490	8+03	34' RT	173.4	92.5

MASS HIGHWAY
BRIDGE MANUAL

SAMPLE PLAN

BORING PLANS

DATE OF ISSUE
MAY 2005

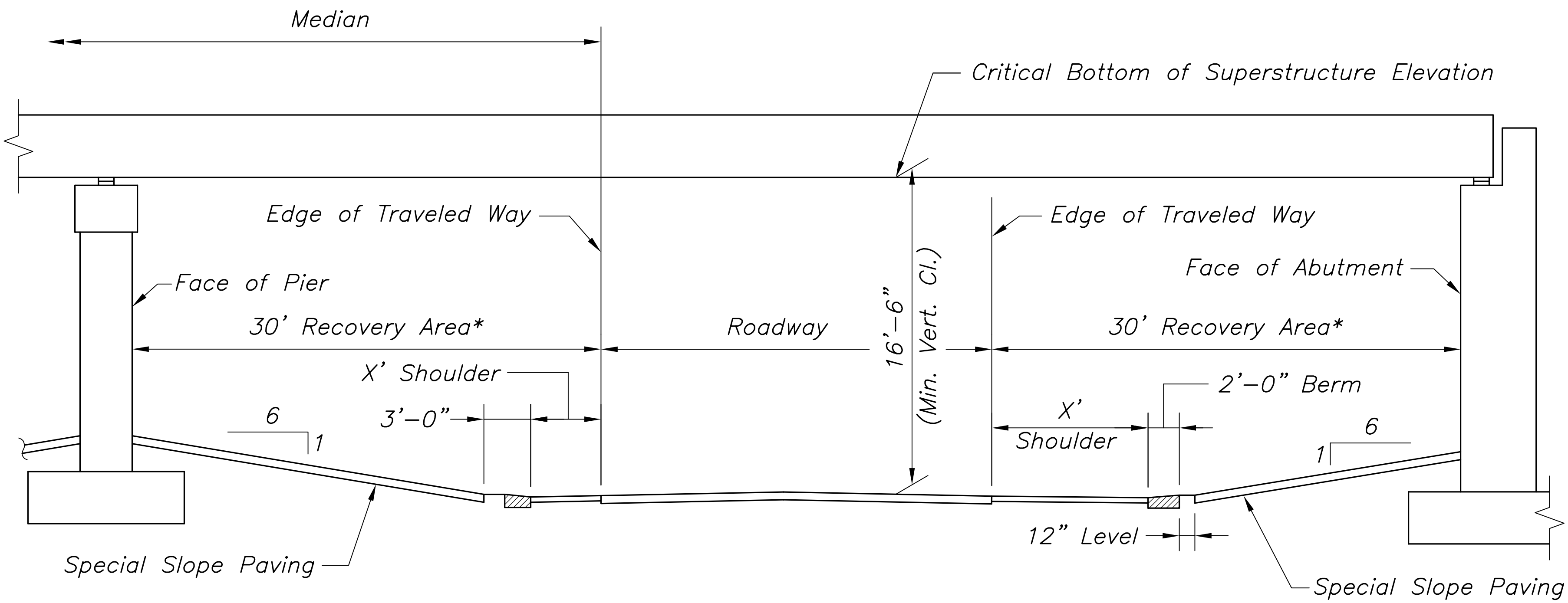
DRAWING NUMBER
1.3.2

NOTES:

1. LOCATION OF DRIVE SAMPLE BORINGS ARE SHOWN THUS: *(See Notes 1 and 2)*
2. SEE THE BORING LOCATIONS TABLE FOR THE SPECIFIED HIGHEST BOTTOM ELEVATION (H.B.E.) OF EACH BORING. *(See Note 3)*
3. BORINGS SHALL EXTEND TO THE SPECIFIED HIGHEST BOTTOM ELEVATION OR TO REFUSAL BELOW THE H.B.E., WHICHEVER IS DEEPER. *(See Note 4)*
4. SHOULD BEDROCK BE ENCOUNTERED AT OR ABOVE THE SPECIFIED HIGHEST BOTTOM ELEVATION, THE BORING SHALL BE CONTINUED AS A ROCK CORE BORING FOR A DEPTH OF 10' THEN TERMINATED. *(See Note 5)*
5. BENCH MARK: *(Description of the Bench Mark, its location, and its elevation to be noted here.)*
6. BORINGS ARE LOCATED FROM THE BASELINE OF THE NEW MALL CONNECTOR. *(Edit as required.)*
7. ADDITIONAL BORINGS MAY BE REQUESTED BY THE ENGINEER IF NECESSARY.

NOTES:

1. *The type of subsurface investigation shall be determined by the Designer and shall be proper for the site conditions and the type of the proposed bridge. (Refer to the latest edition of the AASHTO Manual on Subsurface Investigations.)*
2. *If complimentary borings are required, then the boring locations shall be shown thus:*
   (Control)
   (Complimentary)
3. *The specified highest bottom elevation (H.B.E.) shall be determined by the Designer and shall be adequate to assess the foundation bearing capacity and settlement in conformance with the latest edition of the AASHTO Standard Specifications for Highway Bridges.*
4. *Where accurate information of the proposed bridge site indicates that refusal occurs far below the H.B.E. the designer may consider reducing the number of borings which extend to refusal depending on the complexity of the proposed structure. However, at least one boring shall extend deeper than the H.B.E. to refusal.*
5. *For the depth of rock core borings at drilled shaft locations, refer to the latest edition of the AASHTO Standard Specifications for Highway Bridges. Specify on the plans a minimum of 2" inside diameter NX rock core to be taken at drilled shaft locations socketed into rock.*
6. *For wall structures, boring locations are shown thus:* WB#1
7. *Testpits are shown thus:*
8. *Observation wells are shown thus:* OW
9. *Probes are shown thus:*



LONGITUDINAL SECTION

SCALE: $\frac{3}{32}$" = 1'–0"

NOTES:

1. * If an additional lane is anticipated in Recovery Area, set bottom of footing to provide sufficient cover for future use.
2. Show all dimensions on Sketch Plans and Construction Drawings.
3. Minimum vertical clearance shall be measured wherever critical within the roadway or shoulder.

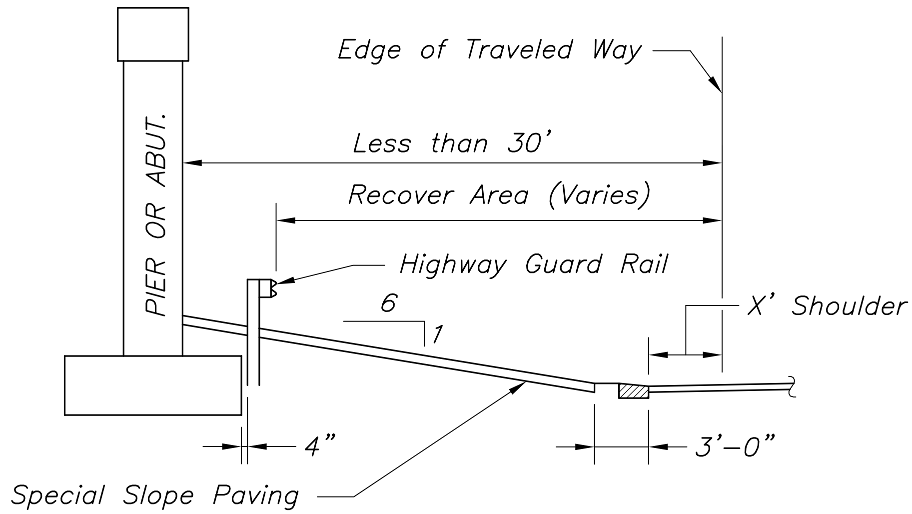
MASS HIGHWAY
BRIDGE MANUAL

LIMITED ACCESS HIGHWAY (30' RECOVERY AREA)

CLEARANCES UNDER BRIDGE

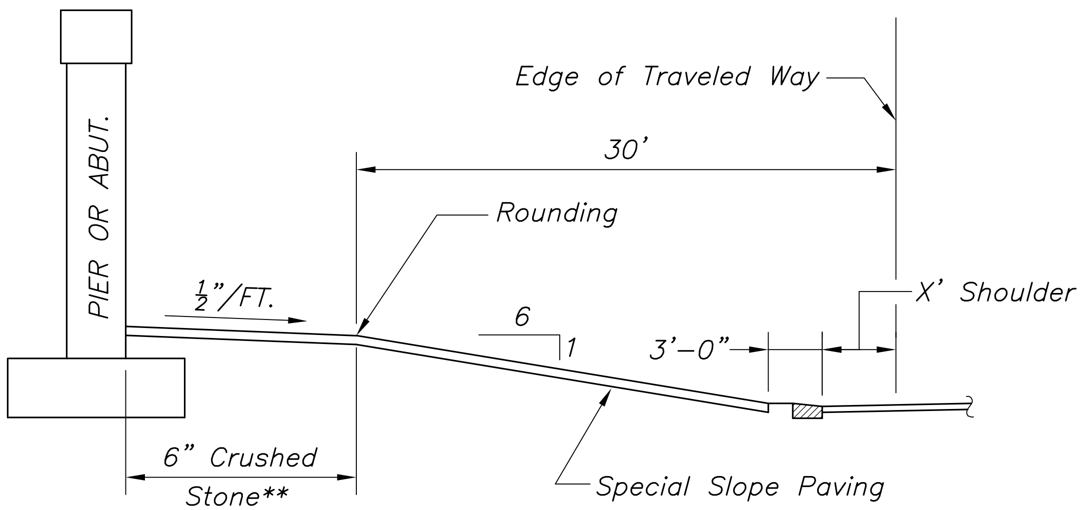
DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.1



SUBSTRUCTURE WITHIN STANDARD RECOVERY AREA

SCALE: $\frac{3}{32}$" = 1'-0"



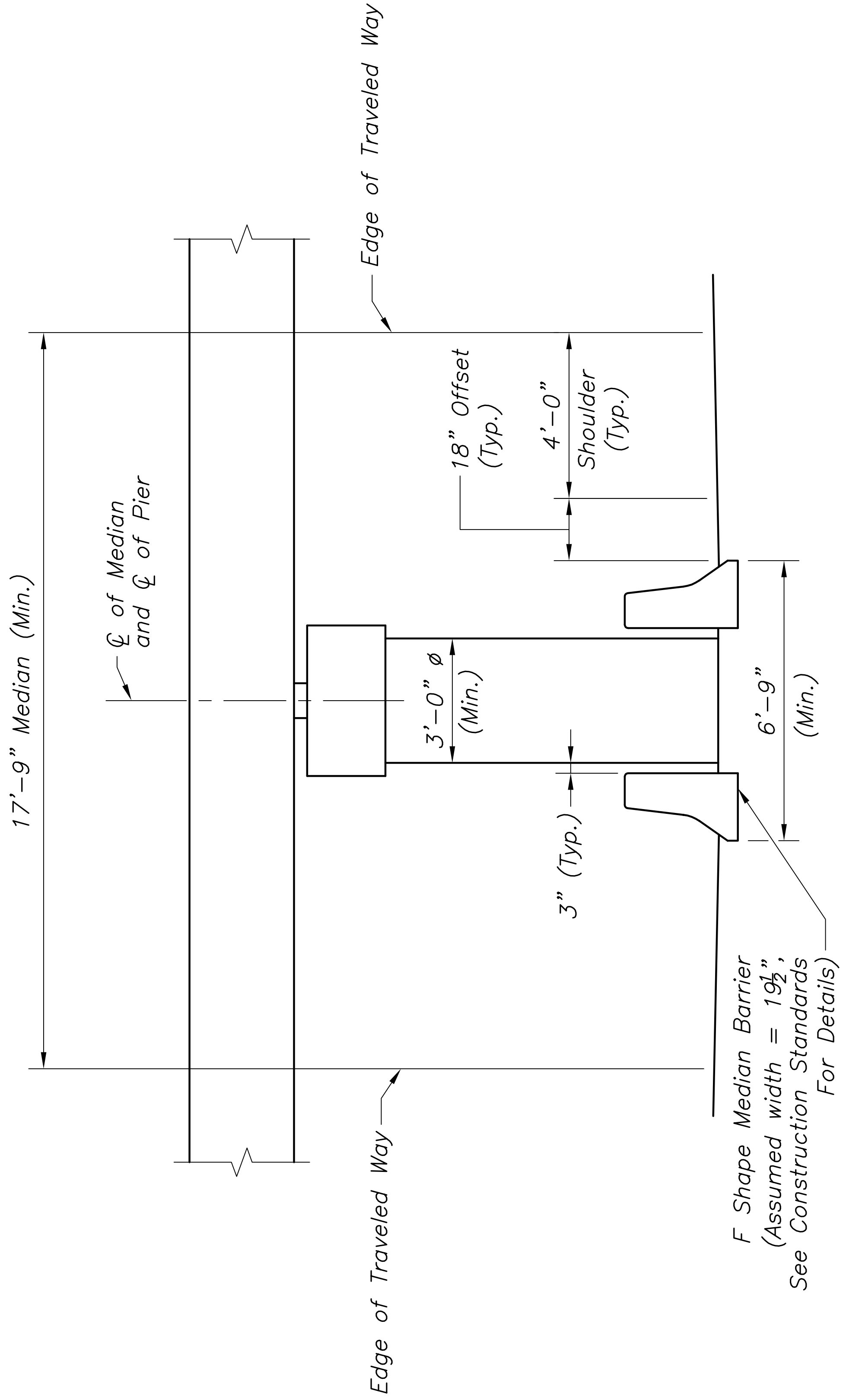
SUBSTRUCTURE OUTSIDE OF STANDARD RECOVERY AREA

SCALE: $\frac{3}{32}$" = 1'-0"

NOTES:

1. ** 4" Cement Concrete over 6" Gravel is to be substituted for the above in urban areas and locations that may be accessible to pedestrians.
2. Show all dimensions on Sketch Plans and Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	LIMITED ACCESS HIGHWAY (VARIOUS RECOVERY AREAS) CLEARANCES UNDER BRIDGE	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **2.1.2**



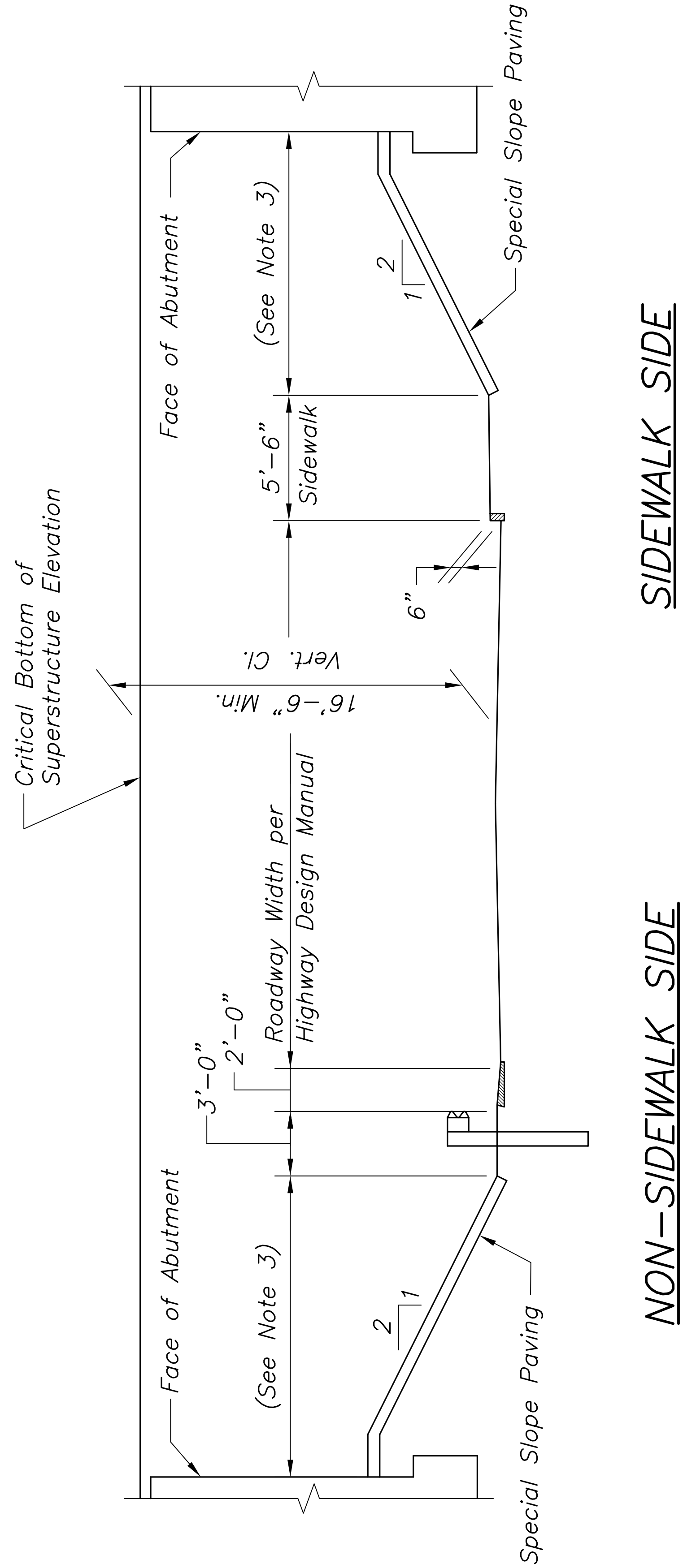
LONGITUDINAL SECTION

SCALE: ¼" = 1'–0"

NOTES:

1. All dimensions are for square section.
2. Show all dimensions on Sketch Plans and Construction Drawings.
3. Refer to the Highway Design Manual for complete instructions regarding shoulder widths.

MASS HIGHWAY BRIDGE MANUAL	MINIMUM LATERAL CLEARANCES AT PIER CLEARANCES UNDER BRIDGE	DATE OF ISSUE MAY 2005 DRAWING NUMBER 2.1.3



LONGITUDINAL SECTION

SCALE: $\frac{1}{8}$" = 1'-0"

NOTES:

1. Show all dimensions on Sketch Plans and Construction Drawings.
2. Vertical underclearances less than 16'-6" require an approved design exception.
3. Distance approximately equal to Vertical Clearance for Cantilever Abutments only.

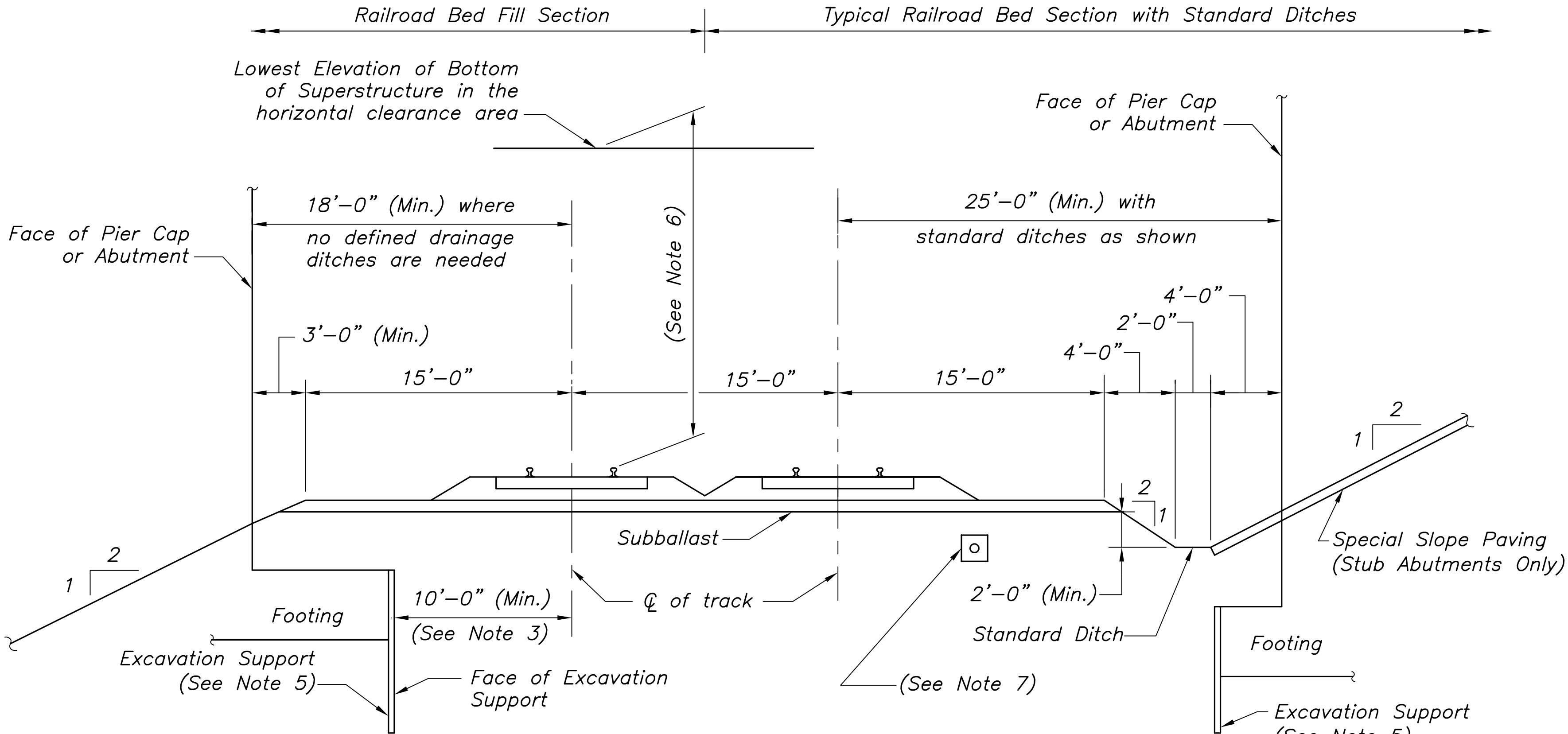
MASS HIGHWAY BRIDGE MANUAL

LOCAL ROAD

CLEARANCES UNDER BRIDGE

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.4



LONGITUDINAL SECTION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. The clearances shown are for guide purposes and are subject to CSX approval. Provide actual distance between track centerlines.
2. Single track R.R. lines are to be treated similarly.
3. Minimum distance from footing to ℄ of main line track is 11'–0".
4. Provide standard ditches when they currently exist or are required by CSX.
5. See Dwg. No. 2.1.9 for excavation support details and requirements.
6. For vertical clearance, consult Bridge Engineer.
7. Existing buried utilities must be accommodated.
8. All horizontal clearances to be inceased $1\frac{1}{2}$" per degree of curvature. When track is superelevated clearances on inside of the curve shall be increased $3\frac{1}{2}$" per each 1" of superelevation.

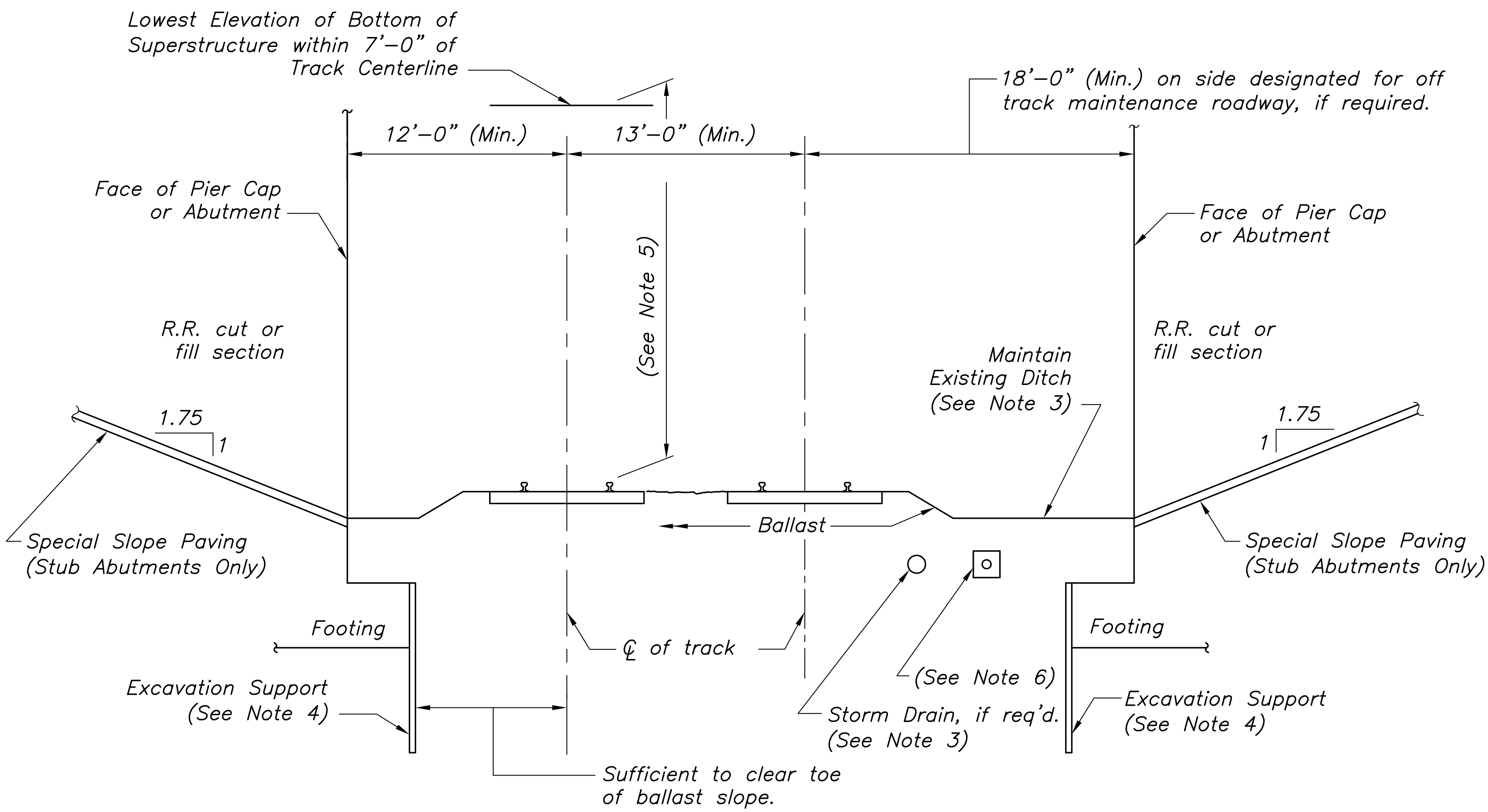
MASS HIGHWAY BRIDGE MANUAL

CSX TRANSPORTATION, INC.

CLEARANCES UNDER BRIDGE

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.5



LONGITUDINAL SECTION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. The clearances shown are for guide purposes and are subject to MBTA approval. Provide actual distance between track centerlines.
2. Single track R.R. lines are to be treated similarly.
3. Survey the existing ditch so that the grade of the proposed ditch under bridge matches. If ditch can not be provided, provide storm drains sized to have flow capacity equal to adjacent R.O.W. ditches, 12" diameter minimum.
4. See Dwg. No. 2.1.10 for excavation support details and requirements.
5. For vertical clearance, consult Bridge Engineer.
6. Existing buried utilities must be accommodated. Horizontal side clearances shall be increased 1" per degree of curvature.

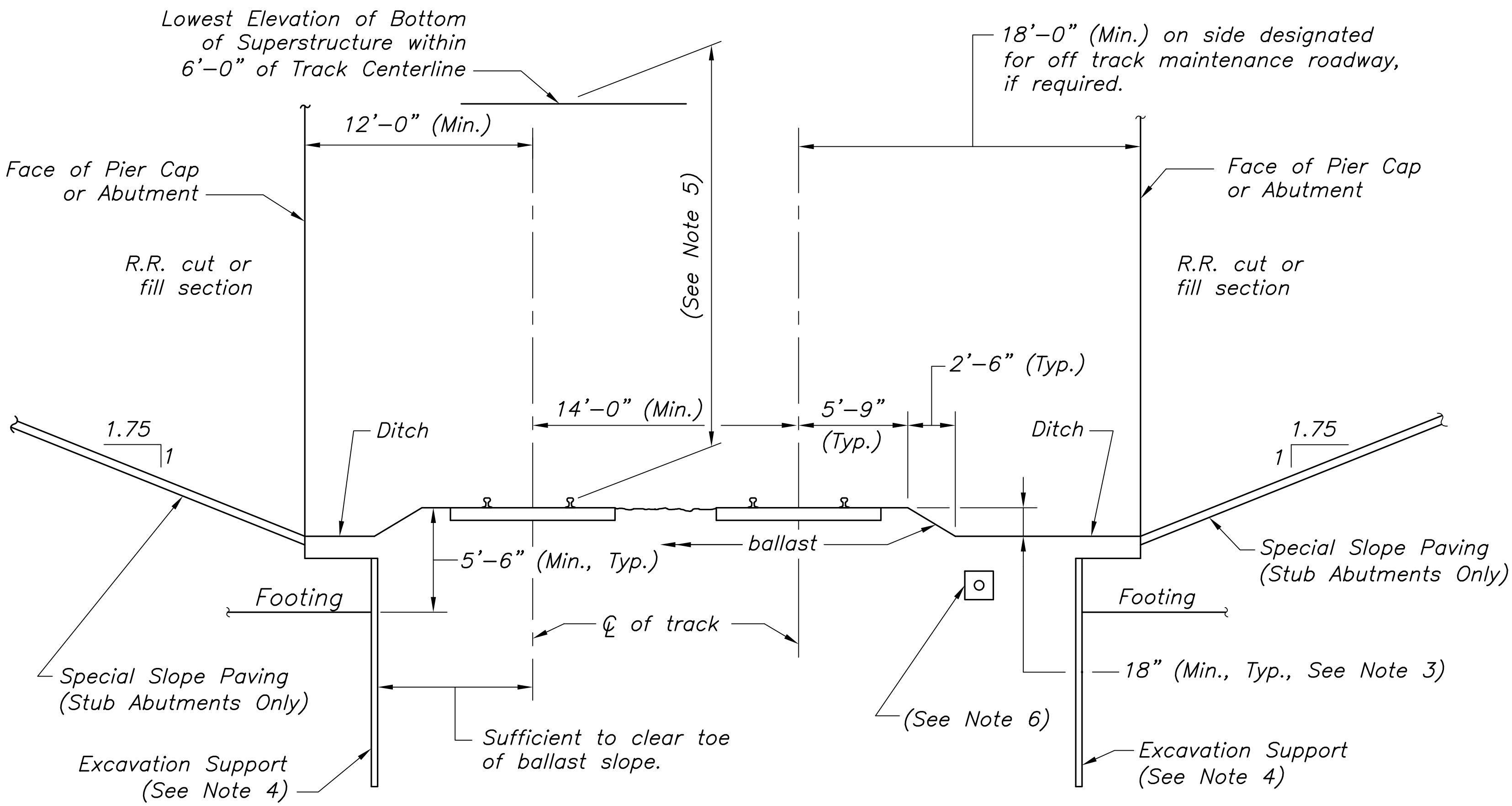
MASS HIGHWAY
BRIDGE MANUAL

MBTA COMMUTER RAIL

CLEARANCES UNDER BRIDGE

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.6



LONGITUDINAL SECTION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. The clearances shown are for guide purposes and are subject to R.R. approval. Provide actual distance between track centerlines.
2. Single track R.R. lines are to be treated similarly.
3. Survey the existing ditch so that the grade of the proposed ditch under bridge matches.
4. See Dwg. 2.1.11 for excavation support details and requirements.
5. For vertical clearance, consult Bridge Engineer.
6. Existing buried utilities must be accommodated.
7. Horizontal side clearances shall be increased 1" per degree of curvature.

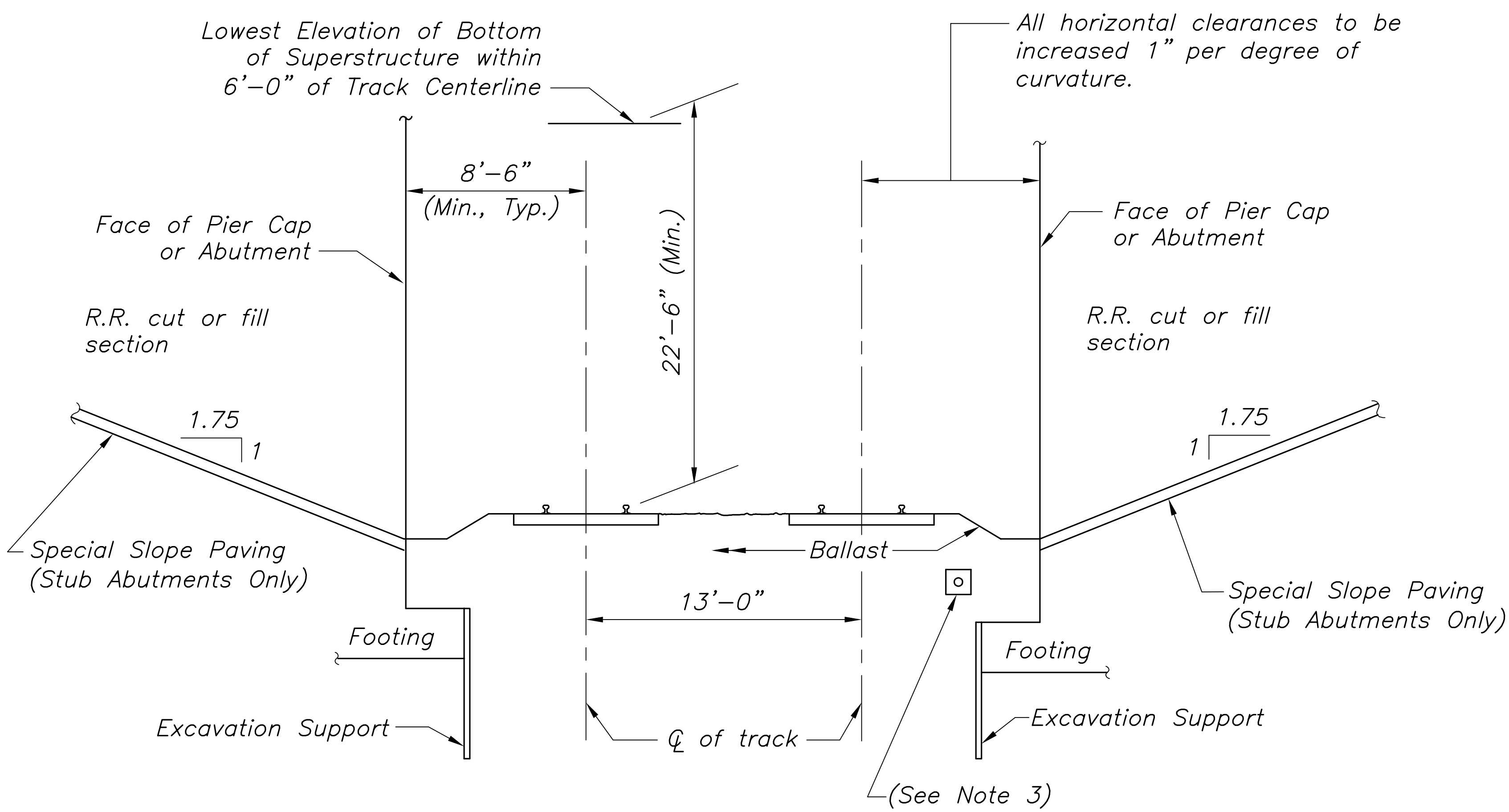
MASS HIGHWAY BRIDGE MANUAL

B&M CORPORATION

CLEARANCES UNDER BRIDGE

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.7



LONGITUDINAL SECTION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. The clearances shown are for new bridges on new roads in accordance with MGL Chapter 160, Section 134A and may be modified by other legal requirements, such as MGL Chapter 634.
2. Single track R.R. lines are to be treated similarly.
3. Existing buried utilities must be accomodated.

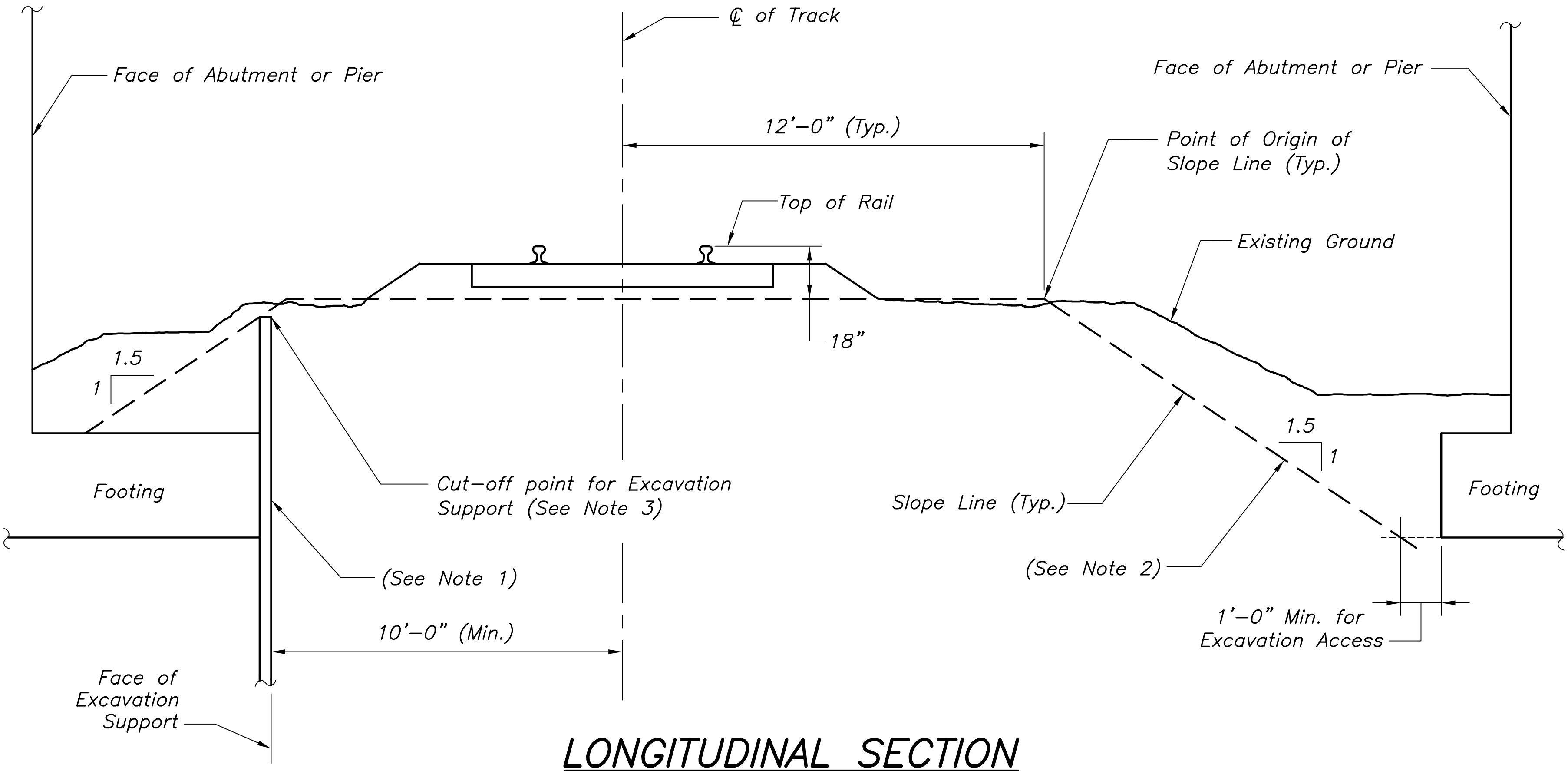
MASS HIGHWAY BRIDGE MANUAL

LEGAL MINIMUM RAILROAD CLEARANCES

CLEARANCES UNDER BRIDGE

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
2.1.8



LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. Provide excavation support whenever the 1.5:1 slope line would be disturbed in the placement of the structure or when track is on embankment and excavation of embankment toe would be required.
2. If elevation of Bottom of Footing falls at or above the 1:5:1 slope line, and track is on level ground or in a cut section and on stable soil, excavation support is not required.
3. Excavation Support shall be cut off at top of footing or intersection with the slope line, which ever is higher.
4. Excavation Support for the protection of railroad shall be designed in accordance with provisions of AREMA specifications. Extent of excavation support shall be dimensioned on plan view of bridge.
5. Excavation Support is to be designed for a lateral earth pressure from E–80 vertical loading surcharge plus 50% impact in addition to active earth pressure. The 80 kips surcharge shall be uniformly distributed over the tie length (8'–6") and axle spacing (5'–0"). Horizontal pressure on the excavation support due to the E–80 surcharge shall be determined using the strip load formula shown in the AREMA specifications. Allowable stresses for materials shall be in accordance with AREMA.

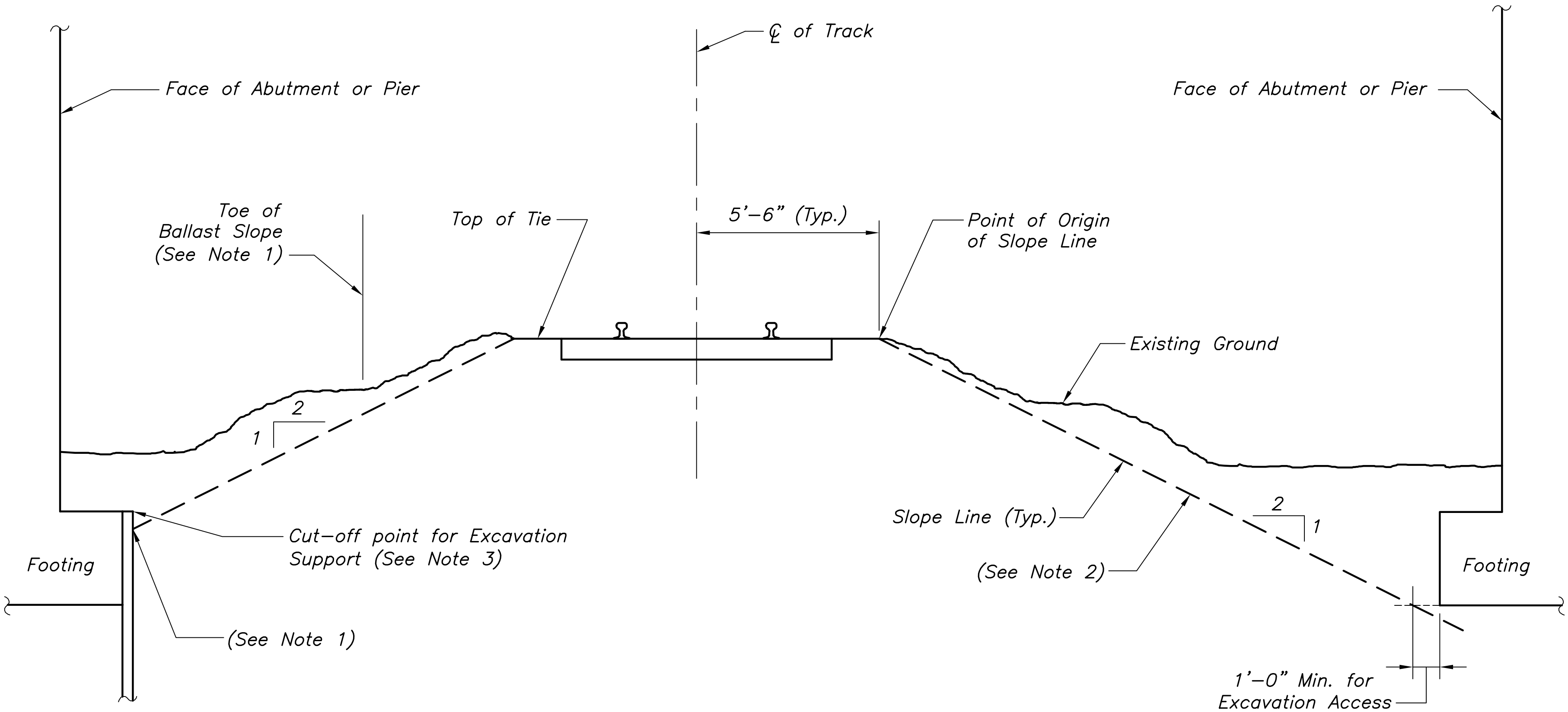
MASS HIGHWAY BRIDGE MANUAL

EXCAVATION SUPPORT REQ'S
CSX TRANSPORTATION, INC.

CLEARANCES UNDER BRIDGE

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: 2.1.9

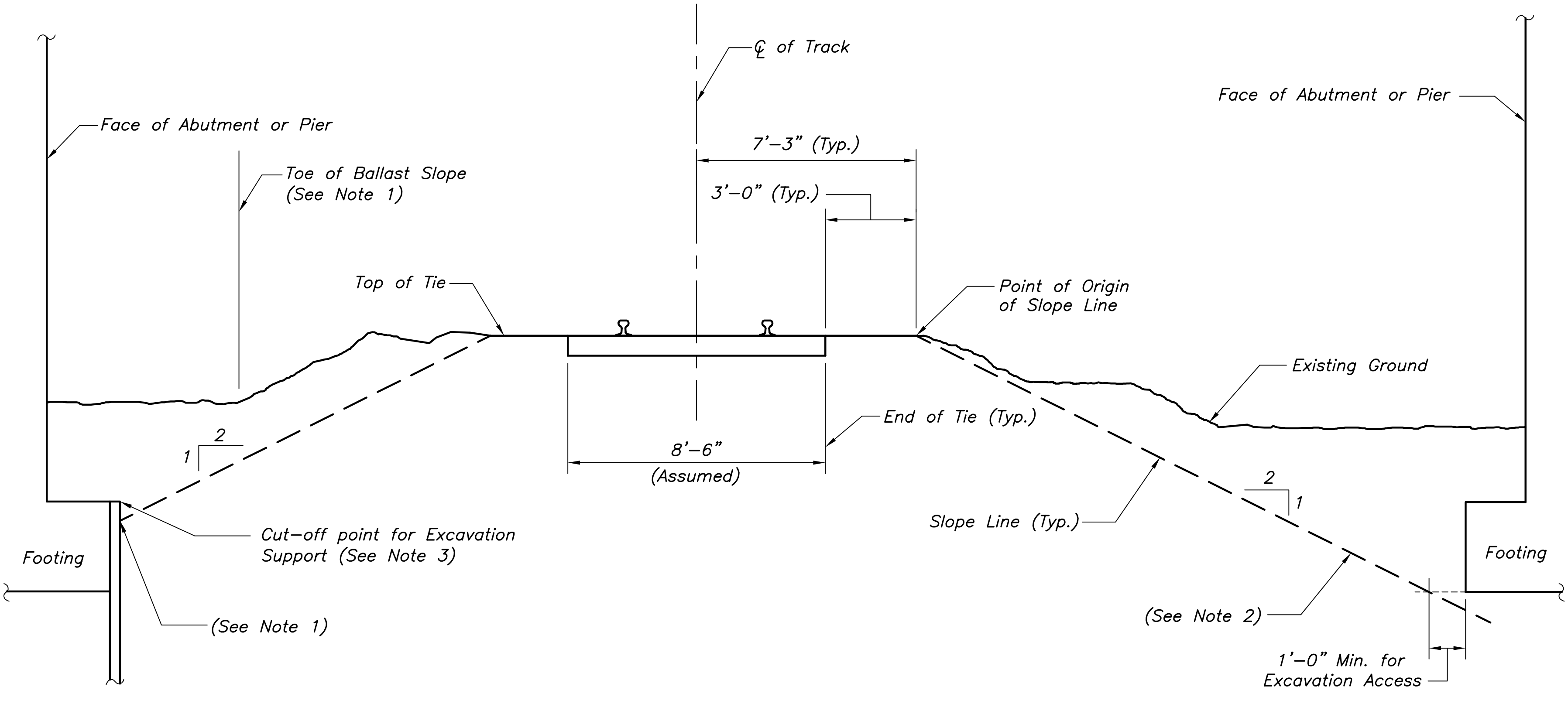


LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. Provide excavation support whenever the 2:1 slope line would be disturbed in the placement of the structure. Excavation support must not be closer to track than toe of ballast slope.
2. If elevation of Bottom of Footing falls at or above the 2:1 slope line, excavation support is not required.
3. Excavation support shall be cut off at top of tie during construction. After construction and backfilling is completed, the excavation support within 12'–0" of the track centerline shall be cut off 2'–0" below the bottom of the tie or 2'–0" below finished grade, whichever is greater. In no case shall the cut–off point be below the top of footing.
4. Excavation support for the protection of railroad shall be designed in accordance with provisions of AREMA specifications. Extent of excavation support shall be dimension on plan view of bridge.
5. Excavation support is to be designed for a lateral earth pressure from E–80 vertical loading surcharge plus 50% impact in addition to active earth pressure. The 80 kips surcharge shall be uniformly distributed over the tie length (8'–6") and axle spacing (5'–0"). Horizontal pressure on the excavation support due to the E–80 surcharge shall be determined using the strip load formula shown in the AREMA specifications. Allowable stresses for materials shall be in accordance with AREMA.



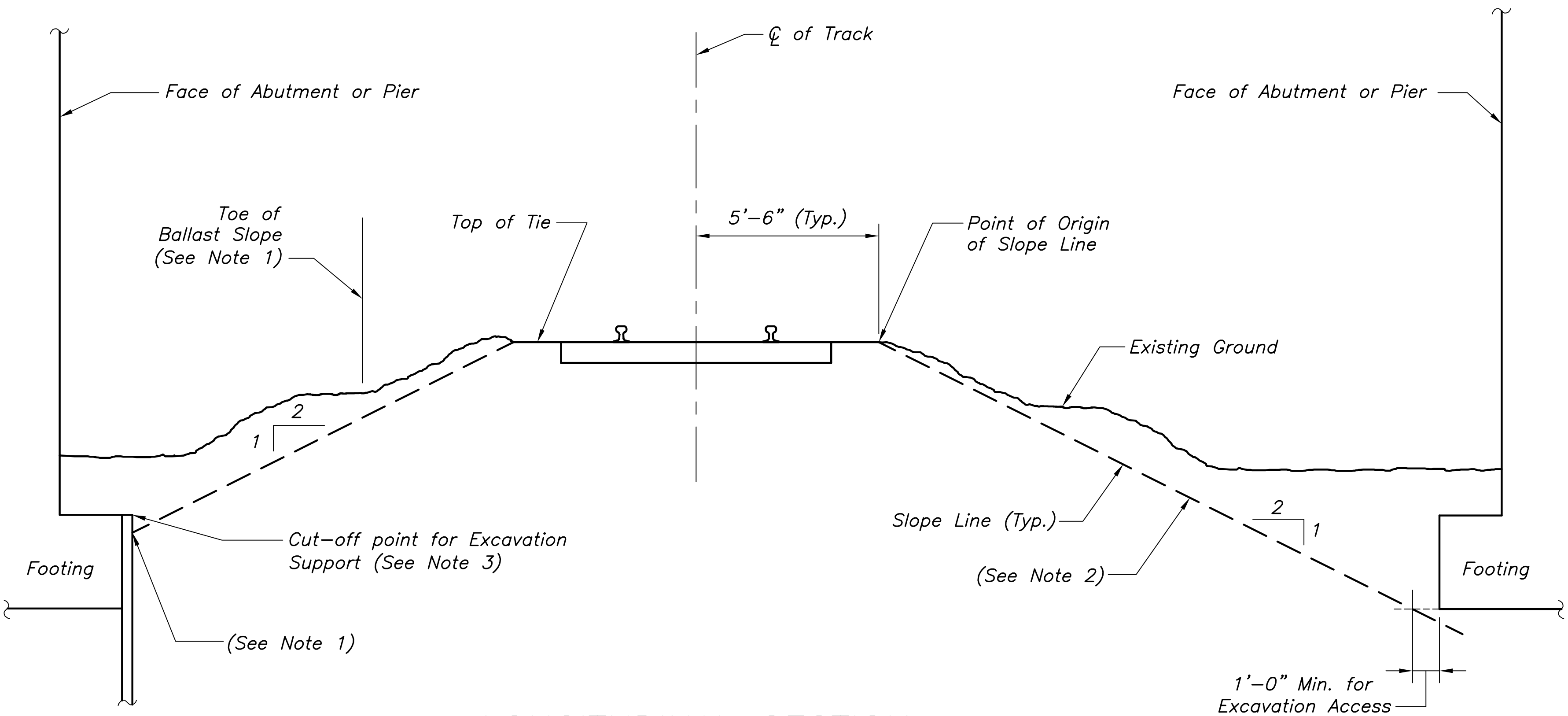
LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. Provide excavation support whenever the 2:1 slope line would be disturbed in the placement of the structure. Excavation support must not be closer to track than toe of ballast slope.
2. If elevation of Bottom of Footing falls at or above the 2:1 slope line, excavation support is not required.
3. Excavation support shall be cut off at top of footing or intersection with the influence line, whichever is higher.
4. Excavation support for the protection of railroad shall be designed in accordance with provisions of AREMA specifications. Extent of excavation support shall be dimensioned on plan view of bridge.
5. Excavation support is to be designed for a lateral earth pressure from E–80 vertical loading surcharge plus 50% impact in addition to active earth pressure. The 80 kips surcharge shall be uniformly distributed over the tie length (8'–6") and axle spacing (5'–0"). Horizontal pressure on the excavation support due to the E–80 surcharge shall be determined using the strip load formula shown in the AREMA specifications. Allowable stresses for materials shall be in accordance with AREMA.

MASS HIGHWAY BRIDGE MANUAL	EXCAVATION SUPPORT REQ'S B&M CORPORATION CLEARANCES UNDER BRIDGE	DATE OF ISSUE MAY 2005
		DRAWING NUMBER 2.1.11

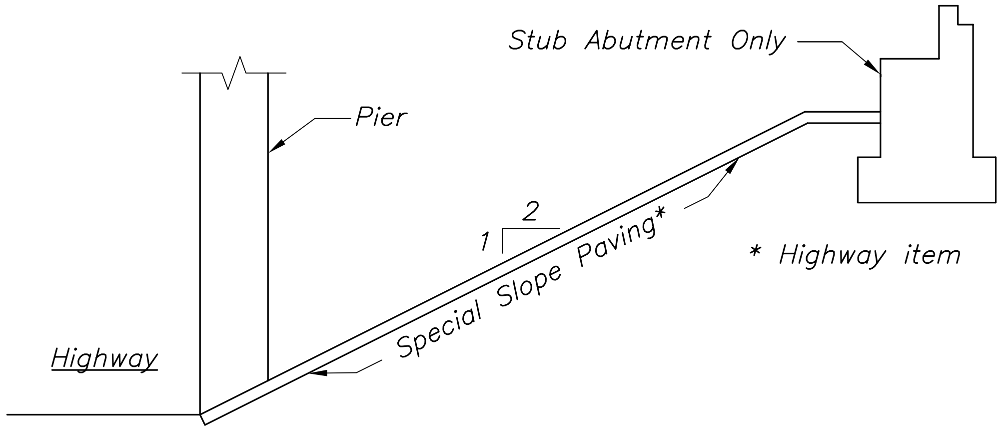


LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

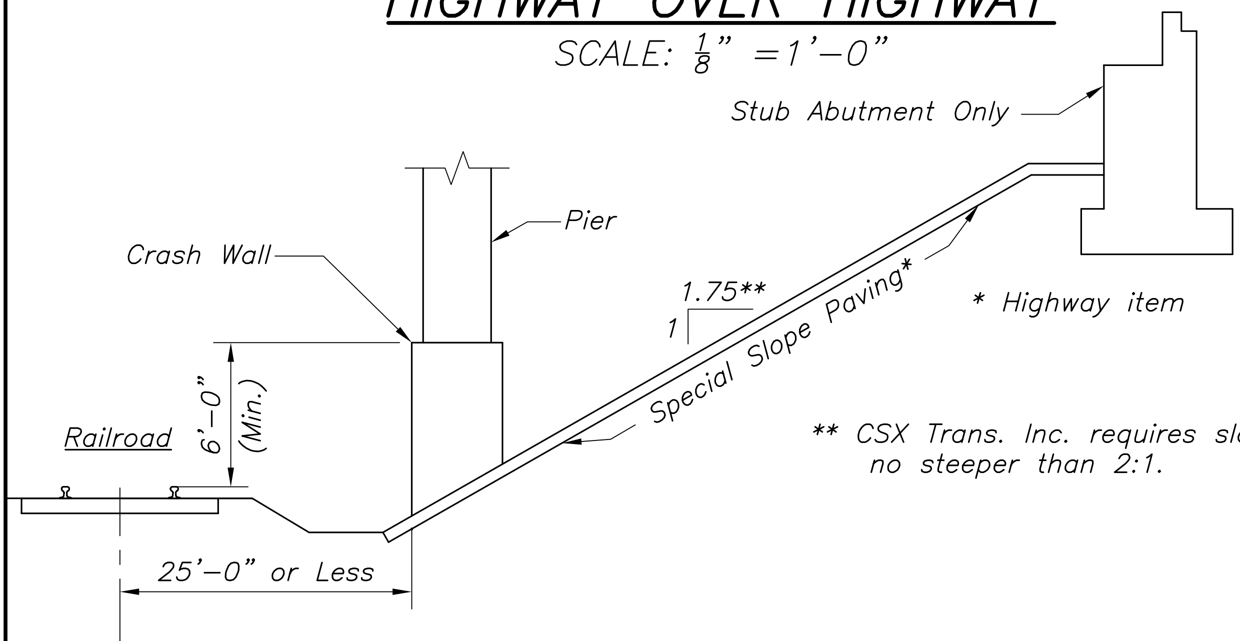
NOTES:

1. Provide excavation support whenever the 2:1 slope line would be disturbed in the placement of the structure. Excavation support must not be closer to track than toe of ballast slope.
2. If elevation of Bottom of Footing falls at or above the 2:1 slope line, excavation support is not required.
3. Excavation support shall be cut off at top of tie during construction. After construction and backfilling is completed, the excavation support within 12'–0" of the track centerline shall be cut off at the top of footing.
4. Excavation support for the protection of railroad shall be designed in accordance with provisions of AREMA specifications. Extent of excavation support shall be dimensioned on plan view of bridge.
5. Excavation support is to be designed for a lateral earth pressure from E–80 vertical loading surcharge plus 50% impact in addition to active earth pressure. The 80 kips surcharge shall be uniformly distributed over the tie length (8'–6") and axle spacing (5'–0"). Horizontal pressure on the excavation support due to the E–80 surcharge shall be determined using the strip load formula shown in the AREMA specifications. Allowable stresses for materials shall be in accordance with AREMA.



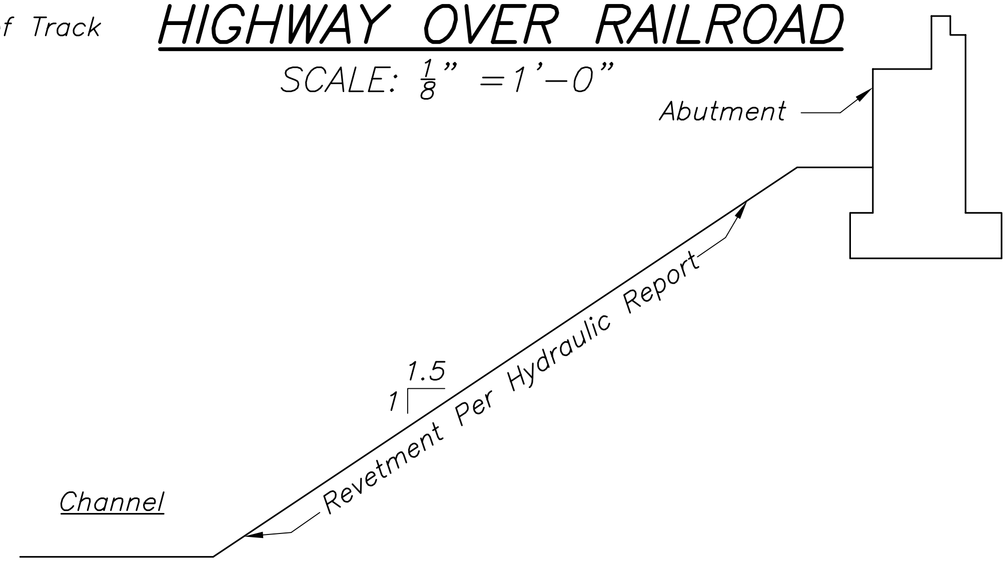
HIGHWAY OVER HIGHWAY

SCALE: $\frac{1}{8}$" =1'–0"



HIGHWAY OVER RAILROAD

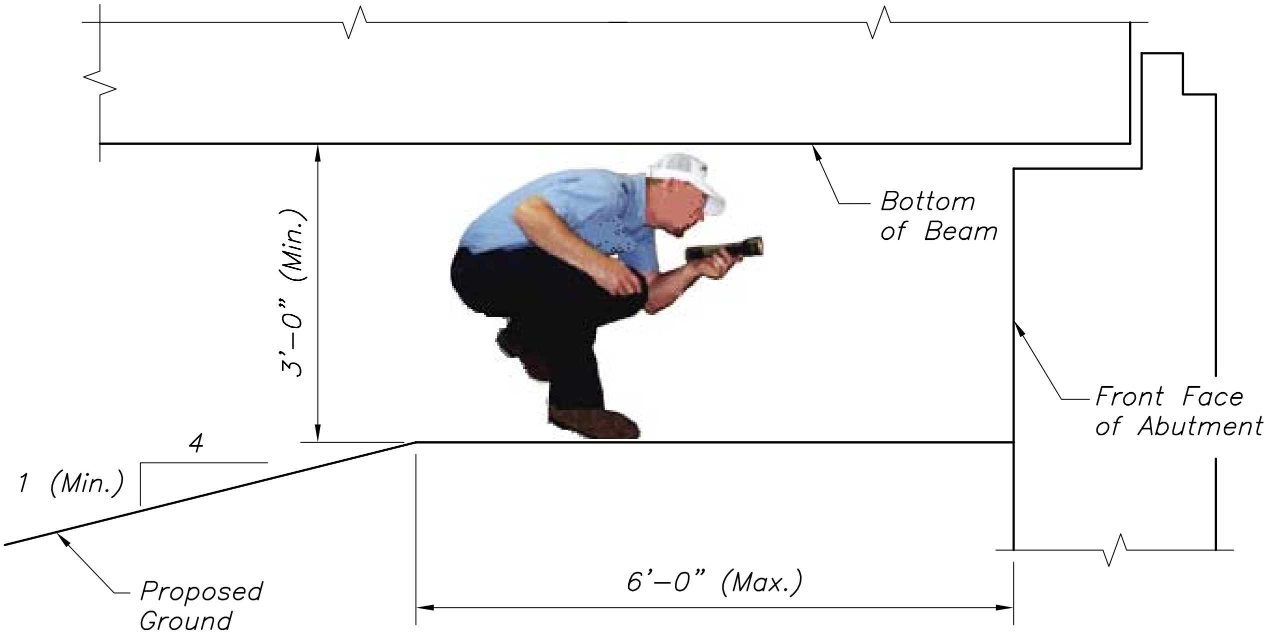
SCALE: $\frac{1}{8}$" =1'–0"



HIGHWAY OVER RIVER

SCALE: $\frac{1}{8}$" =1'–0"

MASS HIGHWAY BRIDGE MANUAL	END SPAN SLOPES	DATE OF ISSUE MAY 2005
	CLEARANCES UNDER BRIDGE	DRAWING NUMBER **2.1.13**



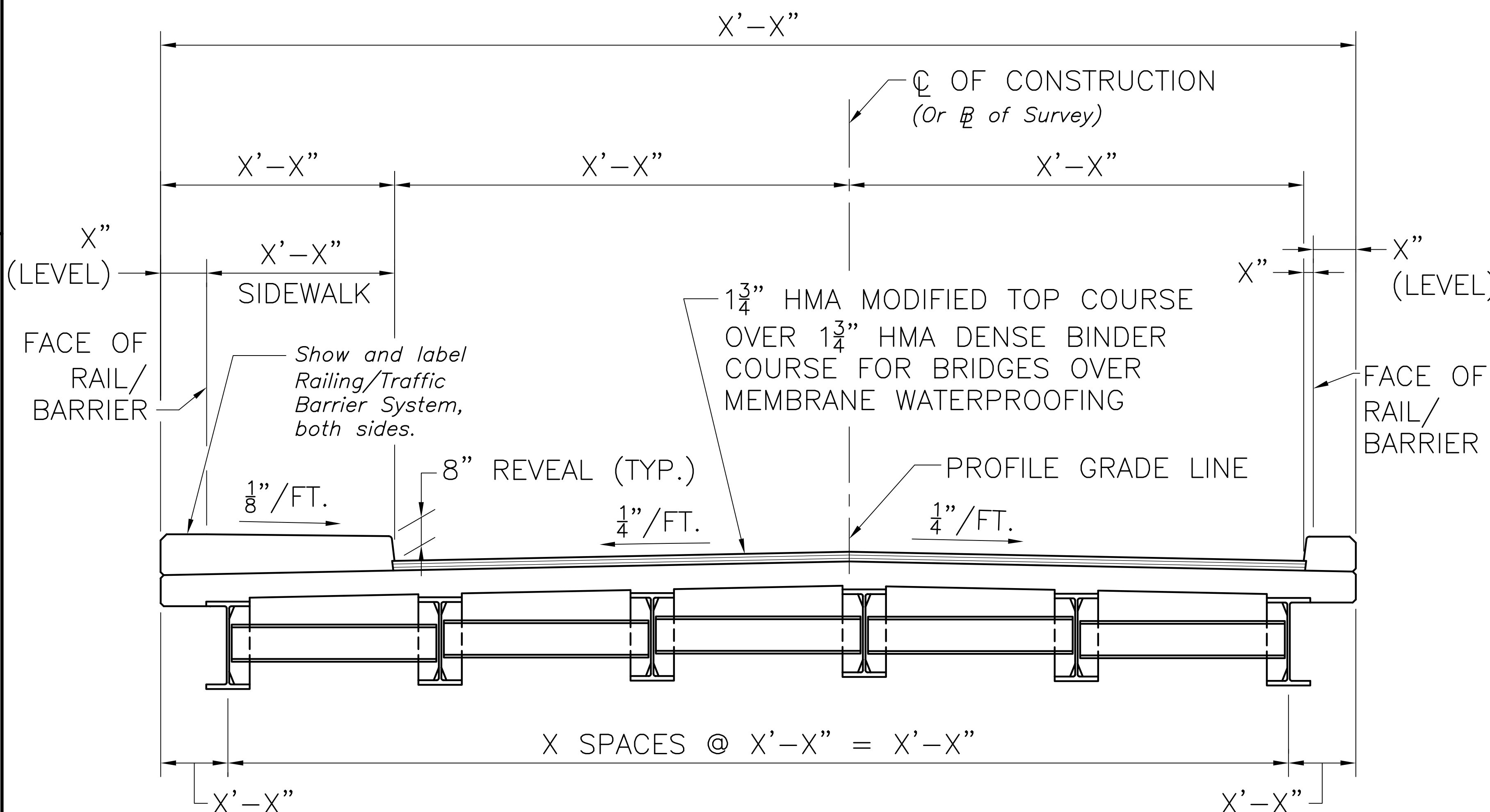
ABSOLUTE CLEARANCE REQUIREMENTS FOR INSPECTION ACCESS OF NON–STANDARD BRIDGES

NOT TO SCALE

NOTE:

The above absolute clearances shall be provided in the situations where standard bridge geometry for bridge inspection, as specified in Chapters 3 and 12, can not be satisfied. An example is a bridge spanning over existing abutments.

MASS HIGHWAY BRIDGE MANUAL	ABSOLUTE CLEARANCES FOR BRIDGE INSPECTION ACCESS CLEARANCES UNDER BRIDGE	DATE OF ISSUE MAY 2005 DRAWING NUMBER **2.1.14**



TRANSVERSE SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Transverse section shall be drawn to scale on the Construction Drawings. All dimensions and items above shall be included and altered to suit the bridge project. Show and label all utilities. Steel stringer bridge shown as an example.*
2. *When the profile slope is greater than 4% or when special conditions may warrant, the Designer shall select a wearing surface and protective system other than hot mix asphalt. The Bridge Engineer shall be consulted in this selection.*

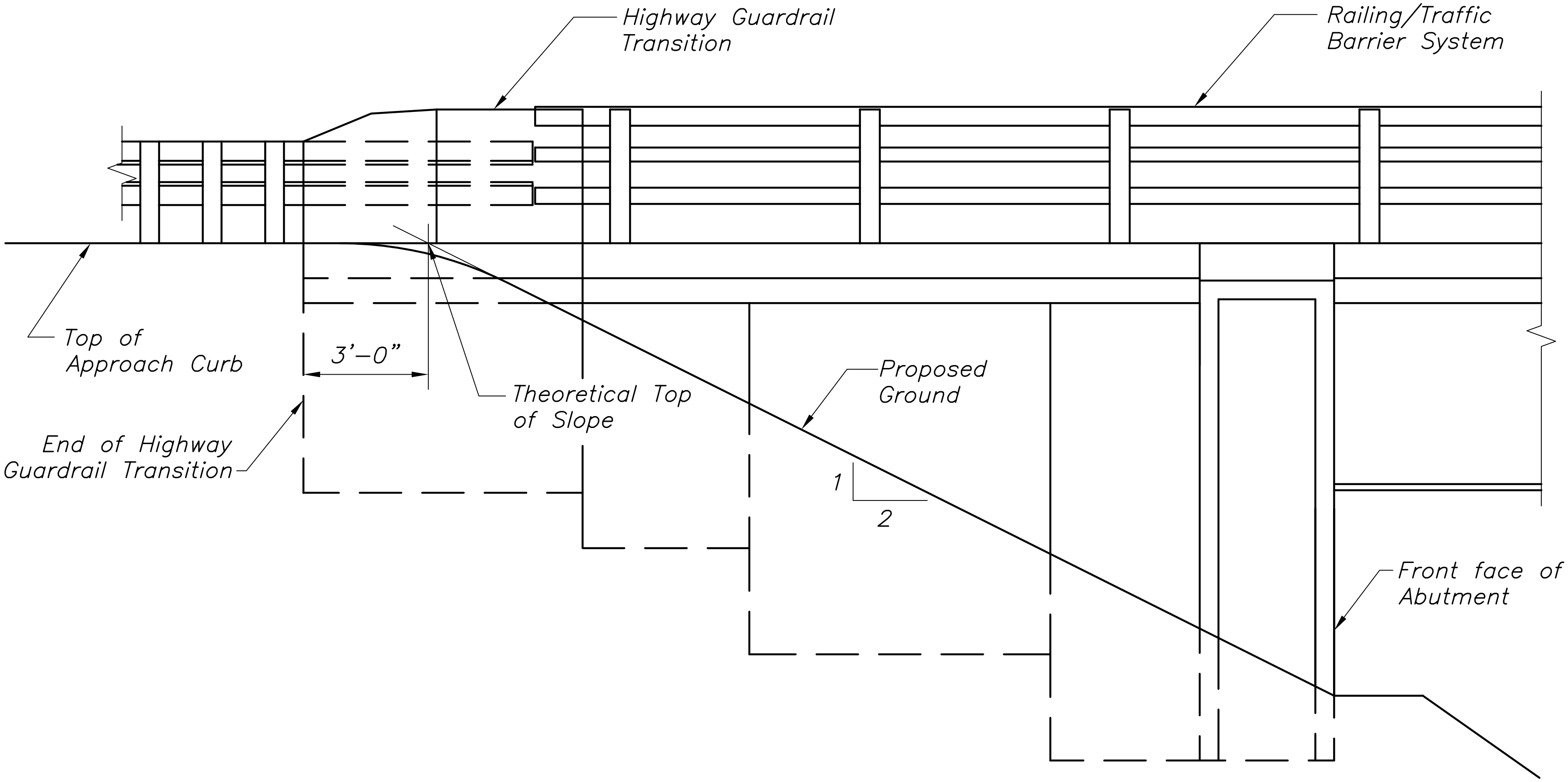
MASS HIGHWAY BRIDGE MANUAL

TYPICAL TRANSVERSE SECTION

ROADWAY CROSS SECTION OVER BRIDGE

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **2.2.1**



U–WINGWALL ELEVATION

NOT TO SCALE

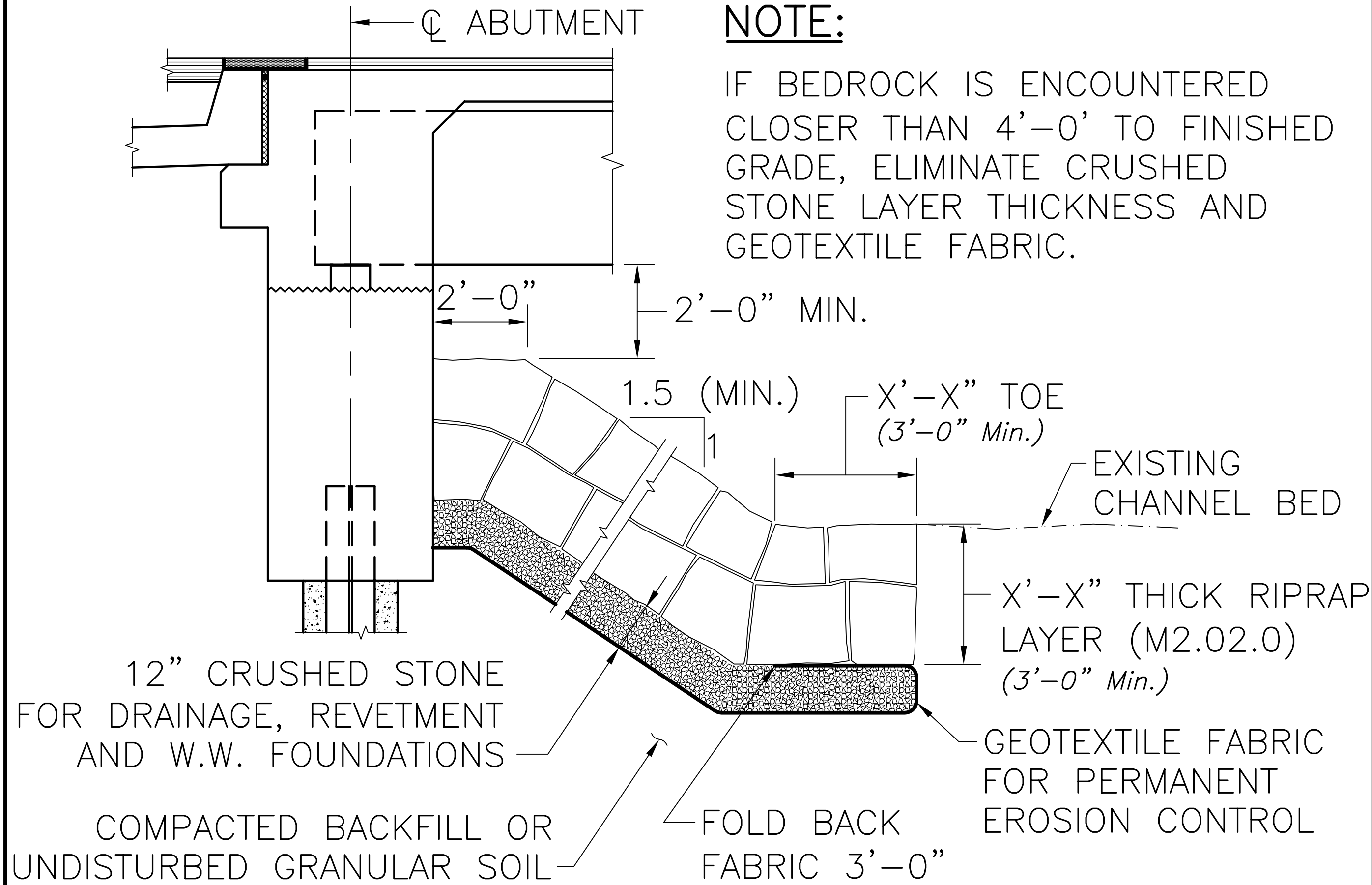
NOTES:

1. The above is to be used to calculate the theoretical length of the wingwall.
2. U–Wingwall for non–semi integral abutments is similar, except for curtain wall.

MASS HIGHWAY BRIDGE MANUAL	U–WINGWALL LENGTH WINGWALL GEOMETRY	DATE OF ISSUE MAY 2005 DRAWING NUMBER **2.3.1**

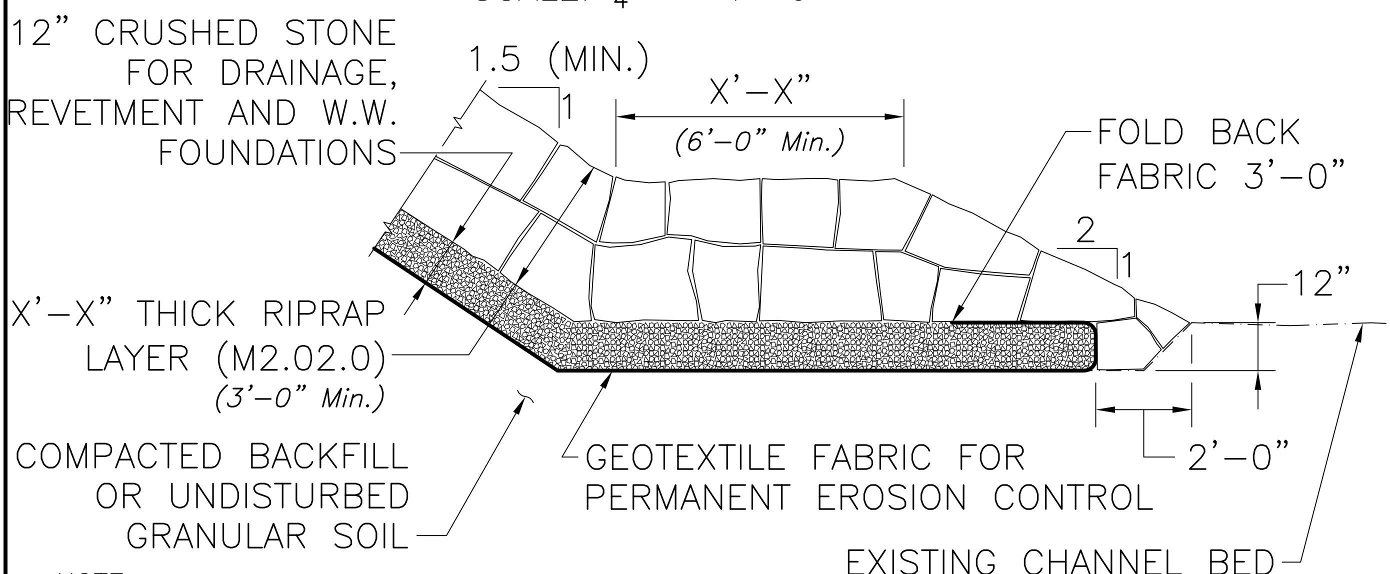
NOTE:

IF BEDROCK IS ENCOUNTERED CLOSER THAN 4'–0' TO FINISHED GRADE, ELIMINATE CRUSHED STONE LAYER THICKNESS AND GEOTEXTILE FABRIC.



RIPRAP DETAIL

SCALE: $\frac{1}{4}$" = 1'–0"

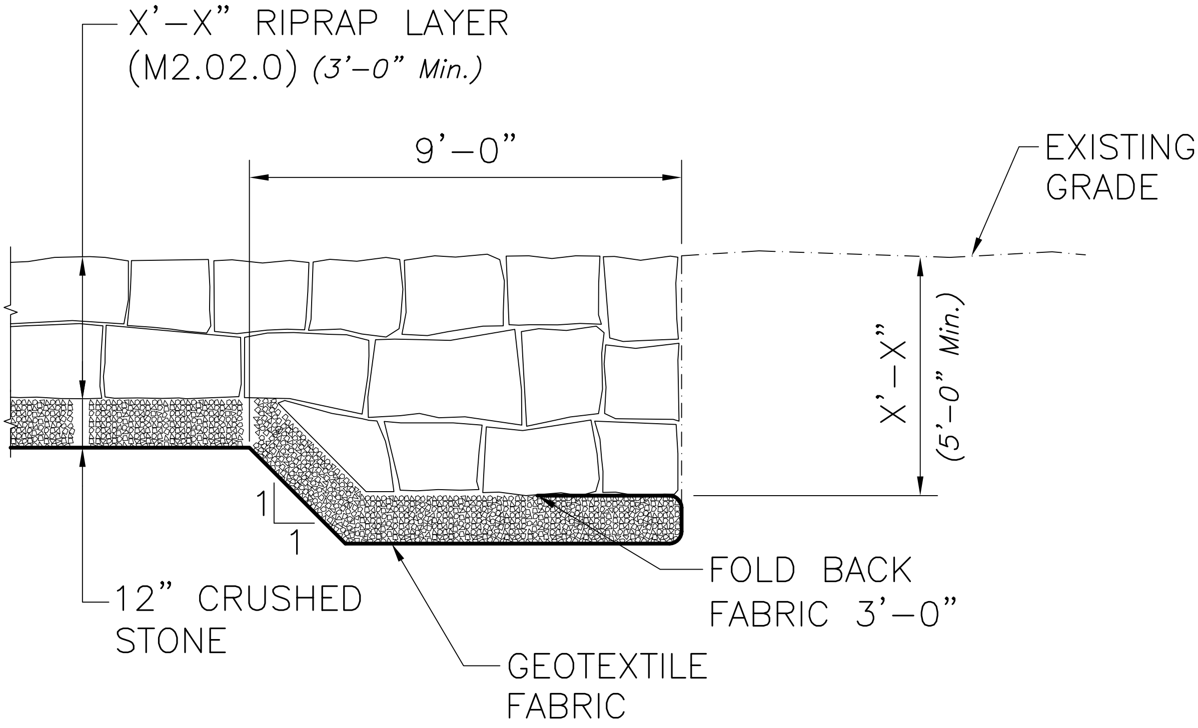


NOTE:
See Note 2 on Dwg. No. 2.4.2

RIPRAP DETAIL WITH TOE ABOVE CHANNEL BED

SCALE: $\frac{1}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	RIPRAP TOE DETAILS	DATE OF ISSUE MAY 2005
	EMBANKMENT PROTECTION	DRAWING NUMBER **2.4.1**

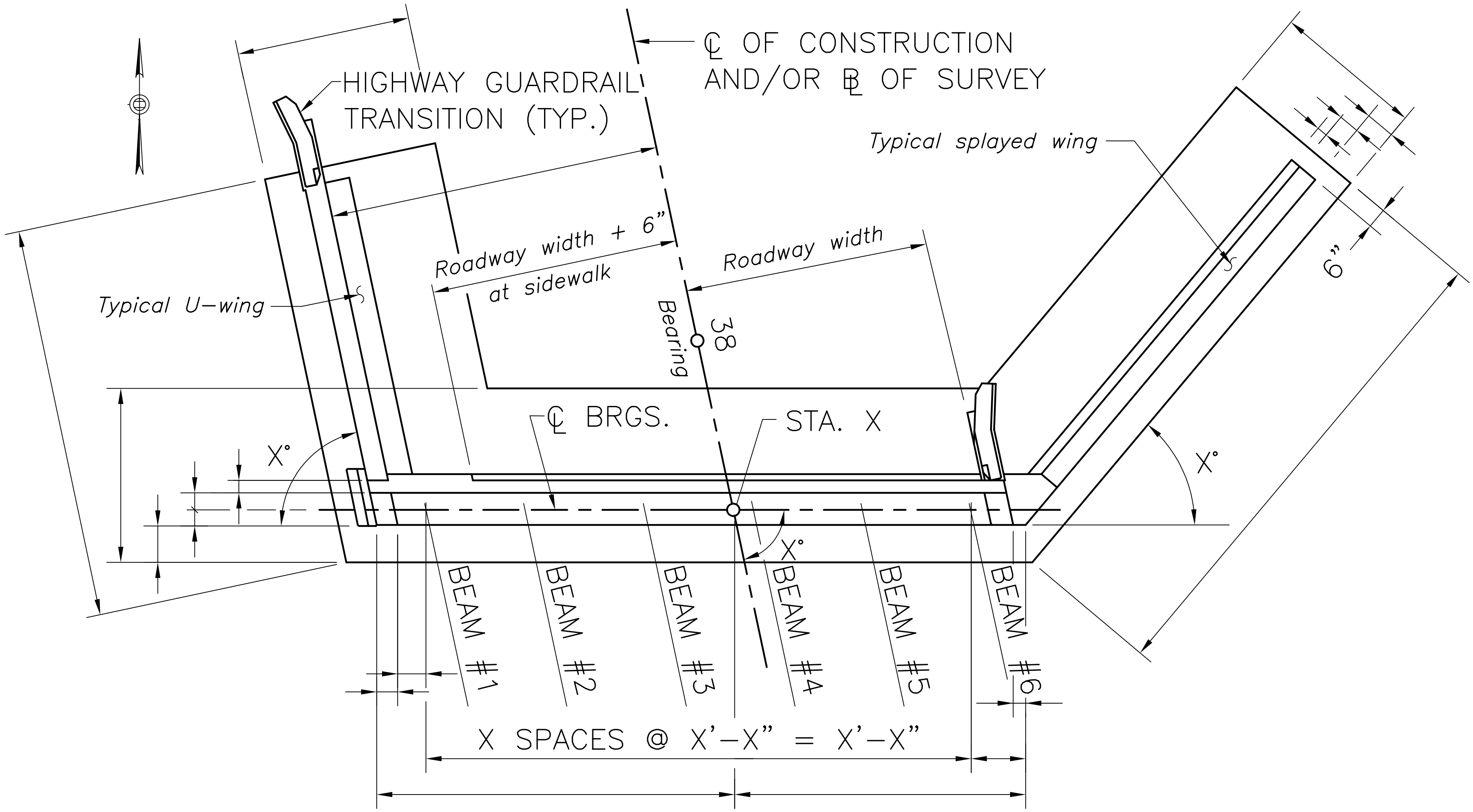


DETAIL AT UPSTREAM/DOWNSTREAM EDGE OF EMBANKMENT

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *The details presented here should be reviewed and modified to suit site specific details.*
2. *Two different toe treatments are shown on Dwg. No. 2.4.1. The Designer shall select the most appropriate for the site and show this one on the plans.*
3. *The riprap detail with toe above the channel bed reduces the quantity of required channel excavation. However, the Engineer needs to evaluate the following drawbacks of this detail:*
    a. *The embankment needs to be founded on firm granular material.*
    b. *The reduction of the channel cross section needs to be evaluated.*
    c. *Since the riprap stone is raised above the channel bed, the stone is subject to a higher water velocity than when level with the top of the channel bed.*



PLAN

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Expansion and Construction joints in the walls shall be located on the plan view on the Construction Drawings.*
2. *On the Construction Drawings, the plan view of each abutment shall be shown above and aligned with its elevation view.*
3. *The beams shall be consecutively numbered from South to North for bridges oriented generally east–west and from West to East for bridges oriented generally north–south.*
   Spans shall be consecutively numbered from West to East for bridges generally oriented east–west and from South to North for bridges oriented generally north–south.

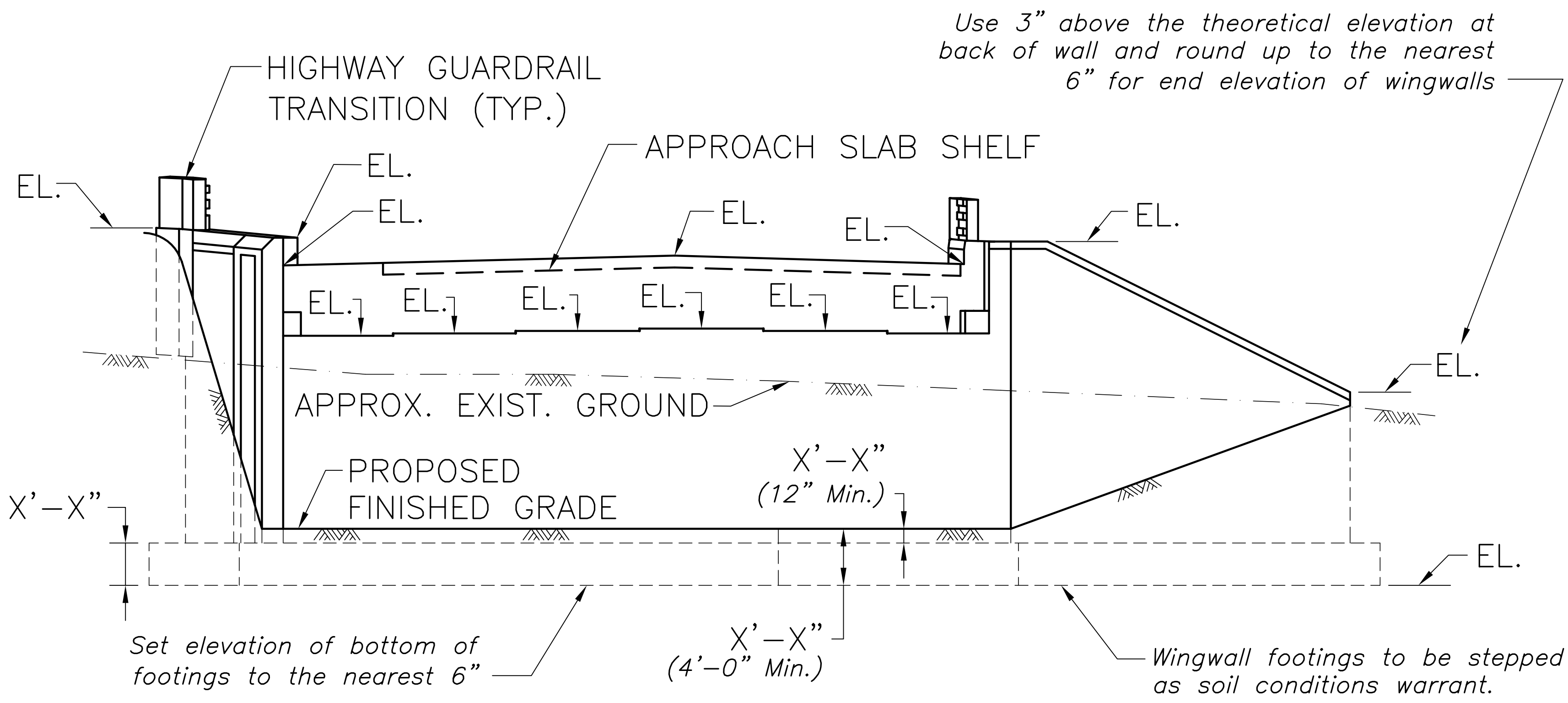
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL PLAN VIEW

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.1.1

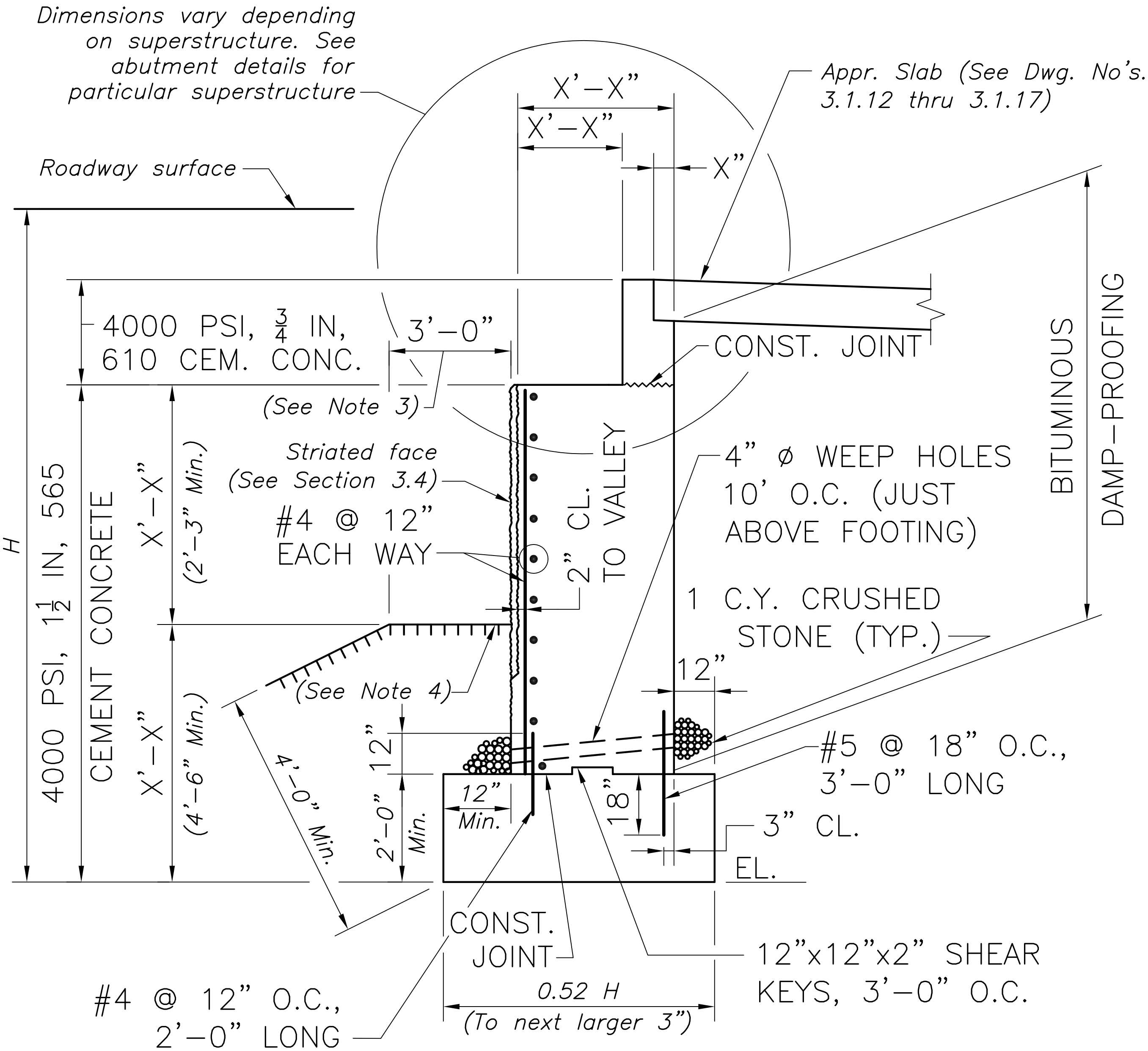


ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Show and label all expansion and construction joints.*
2. *Bridge seat elevations are to be figured to the bottom of the bearing assemblies, and so noted on the Construction Drawings.*



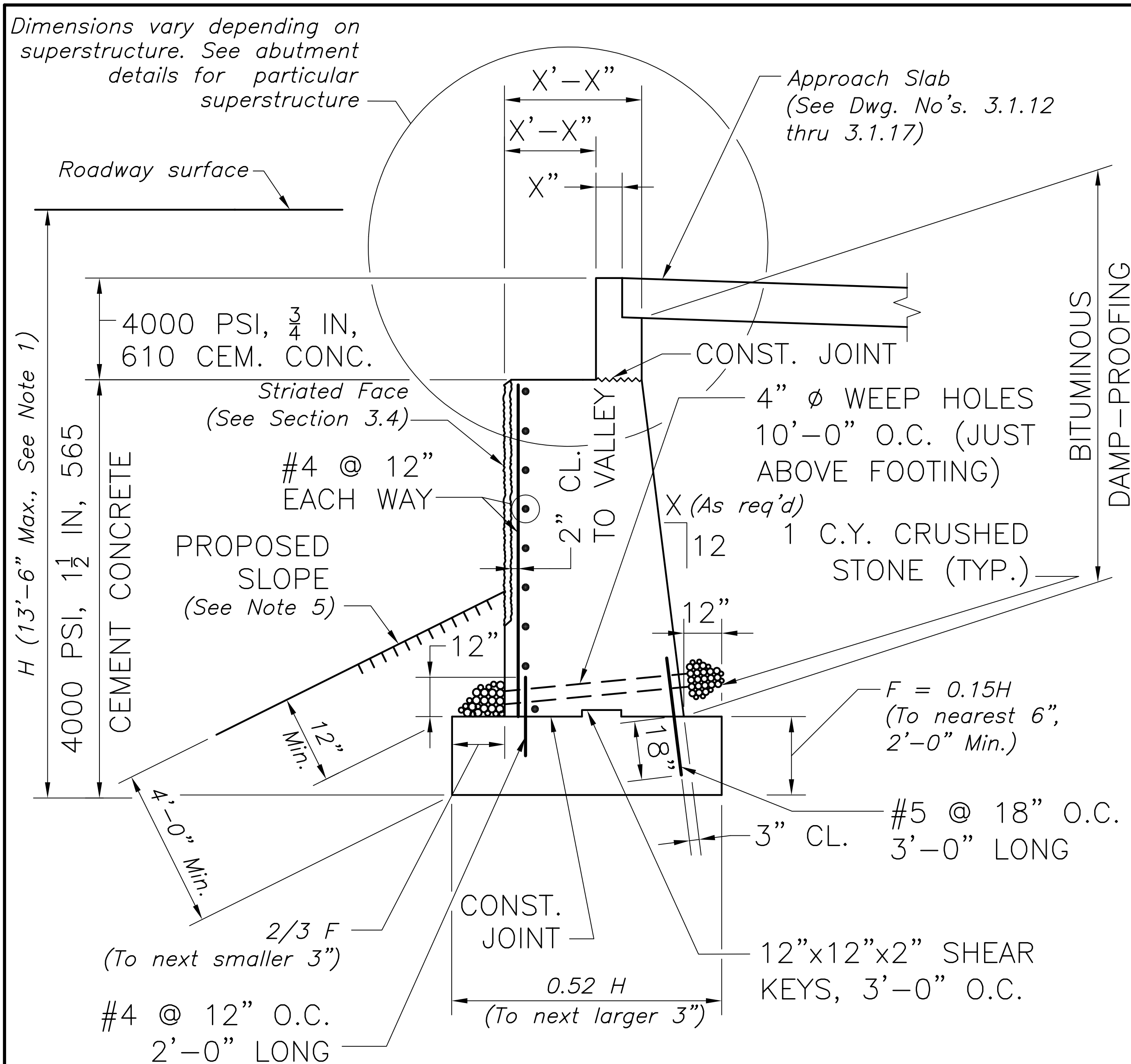
TYPICAL ABUTMENT SECTION

SCALE: 1/4" = 1'–0"

NOTES:

1. *Provide applicable pile/spread footing capacity notes from Dwg. No. 3.1.6.*
2. *If piles are required see relevant portions of Section 3.6.*
3. *All dimensions are for square sections.*
4. *Show appropriate slope treatment.*
5. *See Dwg. No. 3.1.6 for Construction Notes.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL STUB ABUTMENT SECTION ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.3**



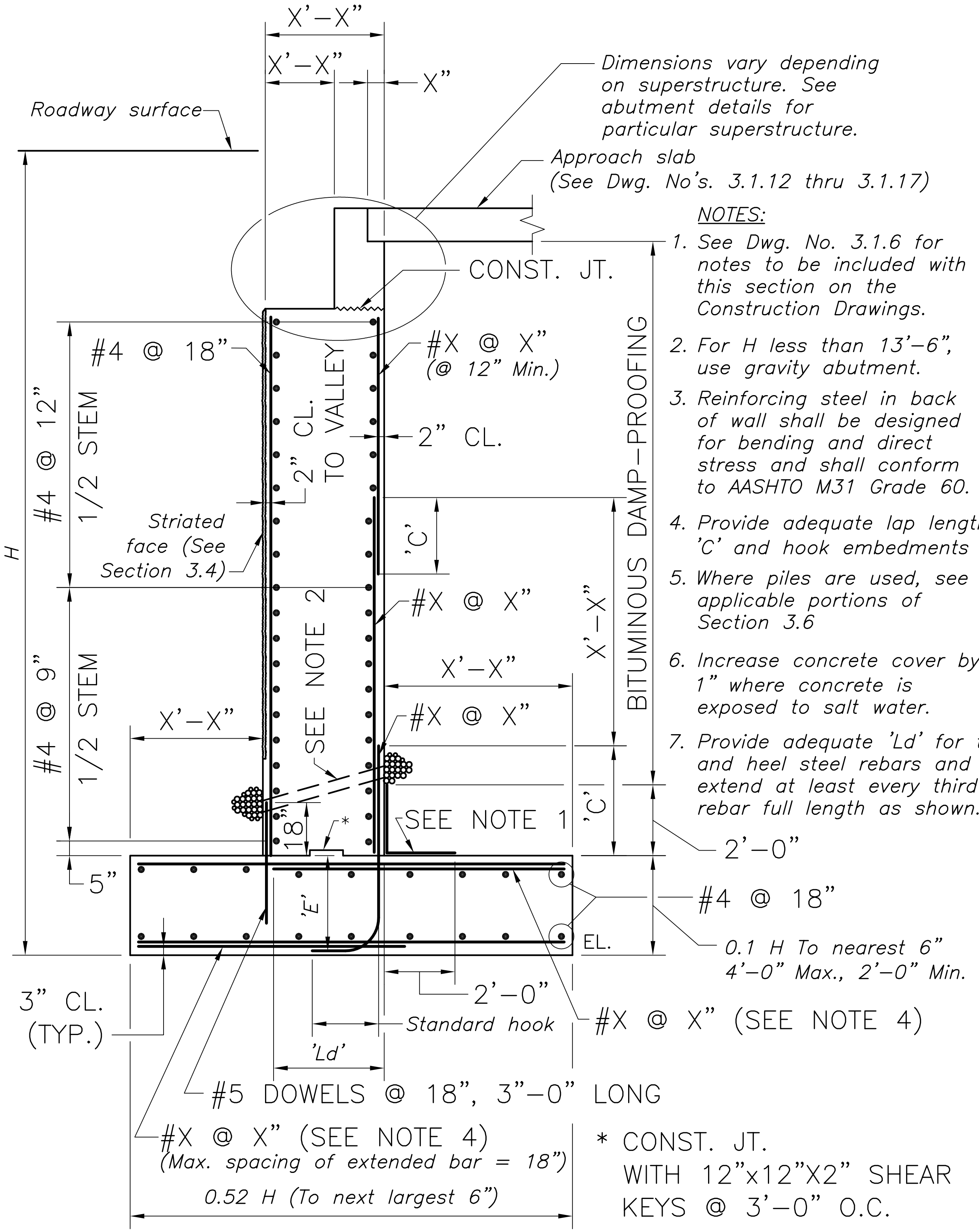
TYPICAL ABUTMENT SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Footing to be omitted when founded on ledge, for typical section see Dwg. No. 3.6.4.*
2. *Provide applicable pile/spread footing capacity notes from Dwg. No. 3.1.6.*
3. *All dimensions are for a square section.*
4. *If piles are required see relevant portions of Section 3.6.*
5. *Show appropriate slope treatment.*
6. *See Dwg. No. 3.1.6 for Construction Notes.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL GRAVITY ABUTMENT SECTION ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.4**



NOTES:

1. See Dwg. No. 3.1.6 for notes to be included with this section on the Construction Drawings.
2. For H less than 13'–6", use gravity abutment.
3. Reinforcing steel in back of wall shall be designed for bending and direct stress and shall conform to AASHTO M31 Grade 60.
4. Provide adequate lap lengths 'C' and hook embedments 'E'.
5. Where piles are used, see applicable portions of Section 3.6
6. Increase concrete cover by 1" where concrete is exposed to salt water.
7. Provide adequate 'Ld' for toe and heel steel rebars and extend at least every third rebar full length as shown.

TYPICAL ABUTMENT SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	TYPICAL CANTILEVER ABUTMENT SECTION ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.5**

NOTES: *(Include these notes with section shown on Dwg. No. 3.1.5. Include applicable capacity notes with section shown on Dwg. No's. 3.1.3 and 3.1.4.)*

1. MEMBRANE WATERPROOFING AND 8"x16"x2", 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE BLOCKS LAID IN MORTAR OR OTHER WATERPROOFING PROTECTIVE COURSE, MIN. 2" THICK AS SPECIFIED IN MHD STANDARD SPECIFICATIONS.

2. 4" ø WEEP HOLES 10'–0" O.C. (JUST ABOVE PROTECTIVE COURSE). PROVIDE 1 CUBIC YARD OF CRUSHED STONE AT EACH END OF WEEP HOLE.

3. ALL CONCRETE SHALL BE 4000 PSI, $1\frac{1}{2}$ IN, 565 CEMENT CONCRETE EXCEPT THE BACKWALL, WHICH SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE.

4. EXTEND EVERY Xth BAR FULL LENGTH AS SHOWN.
   (specify X as req'd by design)

For Spread Footings:

5. THE AVERAGE FACTORED BEARING PRESSURE = XXX KSF (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest pressure)* FACTORED BEARING RESISTANCE = XXX KSF. FACTORED BEARING RESISTANCE IS THE PRODUCT OF THE ULTIMATE BEARING RESISTANCE AND A PERFORMANCE FACTOR OF 0.XX.

For Piles:

5. THE FACTORED AXIAL LOAD PER PILE IS X KIPS (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest axial load)* THE FACTORED STRUCTURAL CAPACITY PER PILE IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE STRUCTURAL CAPACITY OF X KIPS, AN ECCENTRICITY FACTOR OF 0.XX *(omit if not applicable)* AND A STRUCTURAL PERFORMANCE FACTOR OF 0.XX.

6a. THE FACTORED GEOTECHNICAL DESIGN CAPACITY PER PILE IS X KIPS. THE ESTIMATED TIP ELEVATION IS XXX FEET.
(Use this note only when the Factored Geotechnical Capacity controls the pile axial capacity, such as from friction or friction and end bearing as specified in the Geotechnical Report.)

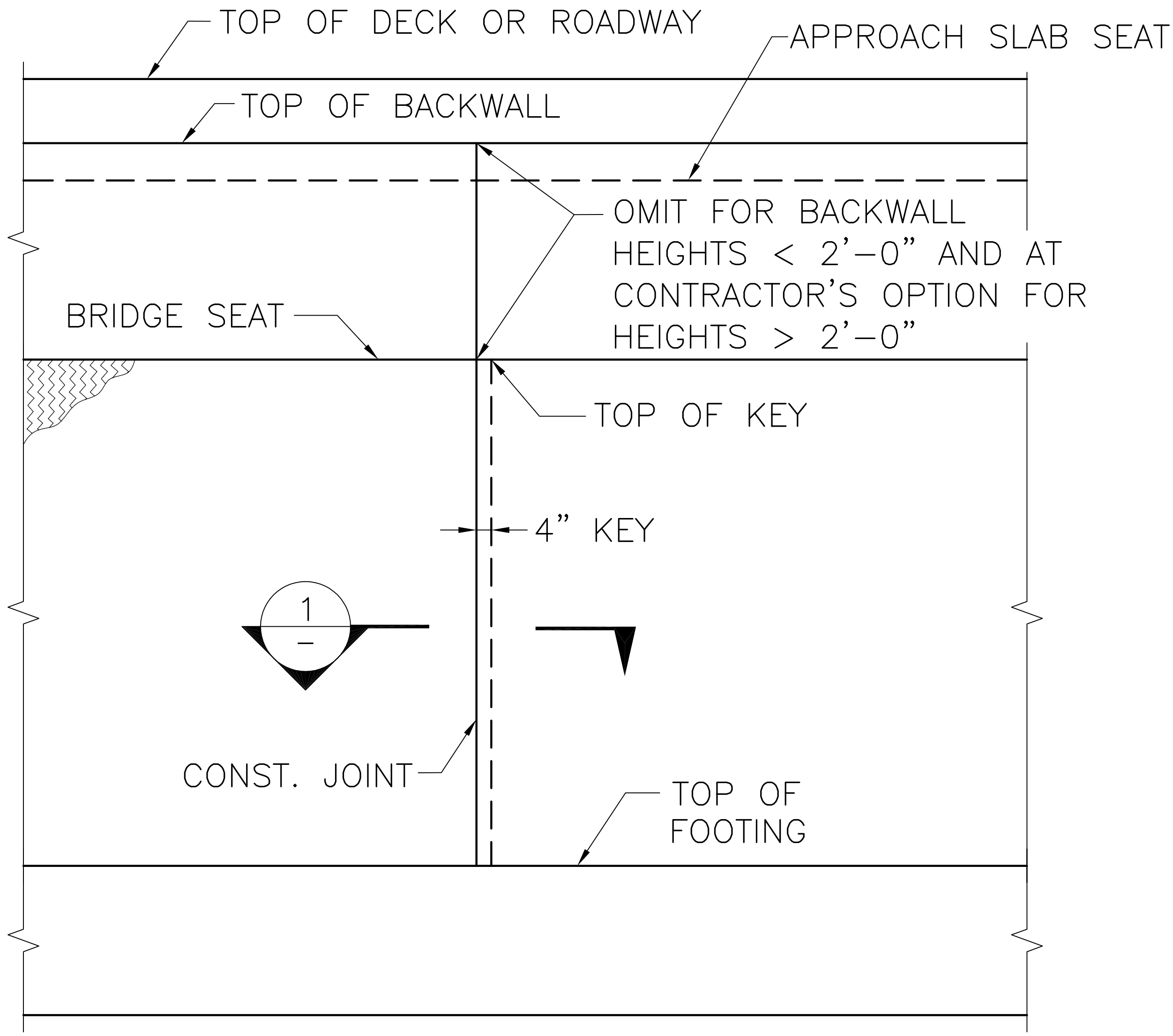
6b. THE MINIMUM TIP ELEVATION IS XXX FEET.
(Use this note only when the required pile length is not determined by the required axial capacity, i.e., lateral loading, scour resistance, or other factors, as recommended in the Geotechnical Report, determine the pile length.)

6c. PILES SHALL BE DRIVEN TO BEDROCK WITH AN ESTIMATED TIP ELEVATION OF XXX FEET. HEAVY DUTY PILE SHOES SHALL BE INSTALLED ON THE TIPS OF ALL PILES. PREFABRICATED PILE SHOES MAY BE USED IF APPROVED BY THE ENGINEER.
(Include this note only when the Factored Structural Capacity controls the pile axial capacity due to end bearing on rock as specified in the Geotechnical Report.)

7. DETERMINATION OF THE DRIVEN PILE CAPACITY, PILE DRIVING CRITERIA, AND PILE INTEGRITY SHALL BE PERFORMED USING THE XXXXXXX *(Designer to specify the Formula Method, WEAP, PDA, Static – Cyclic (Express) Load Test, Static Load Test, or other system, as recommended in the Geotechnical Report)* DRIVING/TESTING METHOD WITH A PERFORMANCE FACTOR OF 0.XX. PILES SHALL BE INSTALLED TO ACHIEVE A FACTORED DRIVEN CAPACITY EQUAL TO OR GREATER THAN THE FACTORED AXIAL DESIGN LOAD.

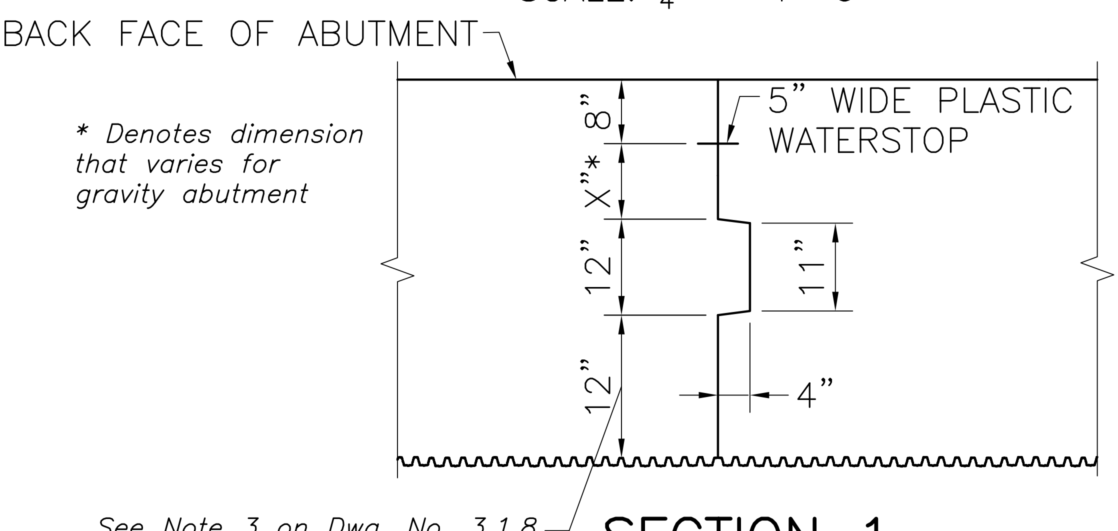
8. THE CONTRACTOR SHALL SUBMIT A PILE SCHEDULE, PILE INSTALLATION, AND PILE DRIVING/TESTING PLAN FOR REVIEW AND APPROVAL OF THE ENGINEER.

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION NOTES FOR CANTILEVER ABUTMENTS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.6**



ELEVATION OF ABUTMENT

SCALE: $\frac{1}{4}$" = 1'–0"



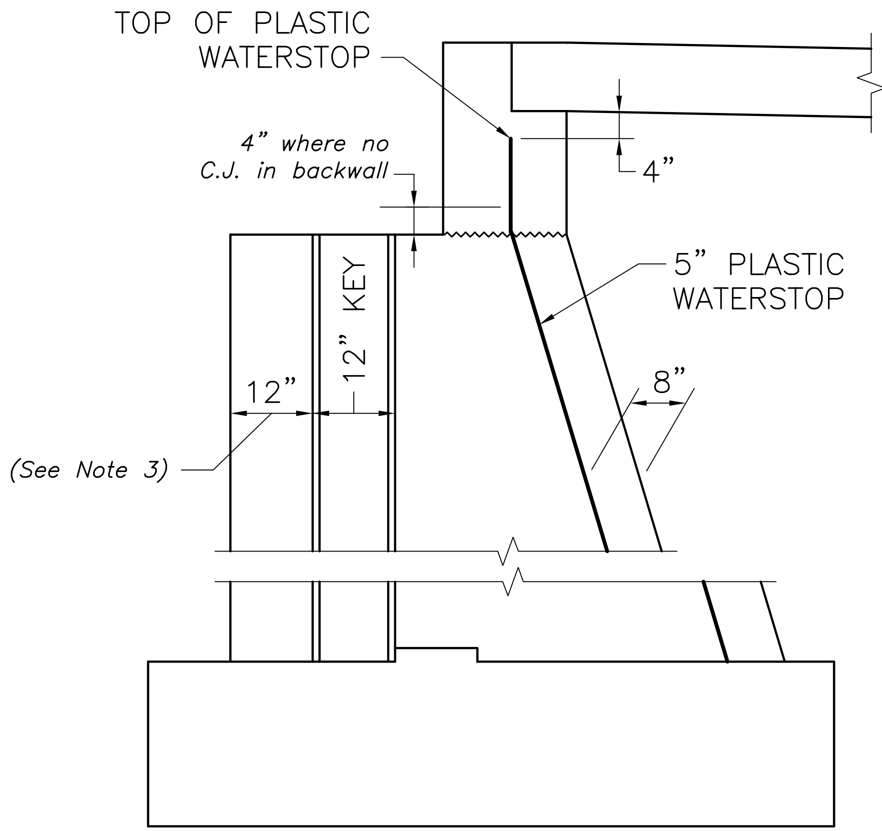
** Denotes dimension that varies for gravity abutment*

See Note 3 on Dwg. No. 3.1.8

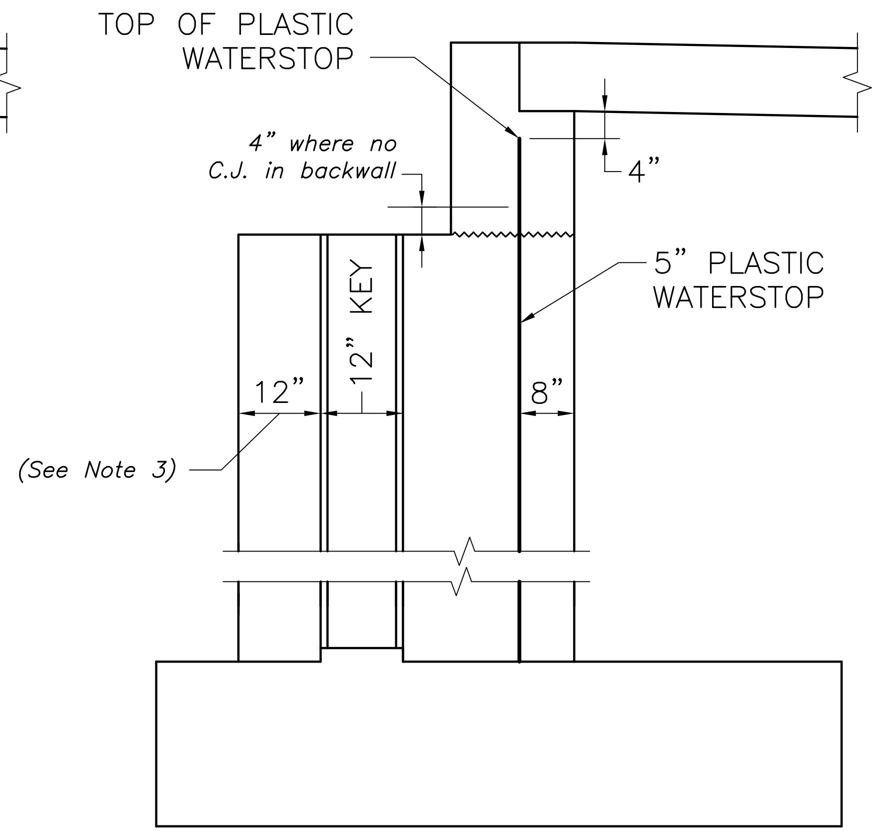
SECTION 1

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION JOINT DETAILS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.7**



GRAVITY ABUTMENT



CANTILEVER ABUTMENT

NOTE:
REINFORCEMENT SHALL BE CONTINUOUS THRU CONSTRUCTION JOINTS.

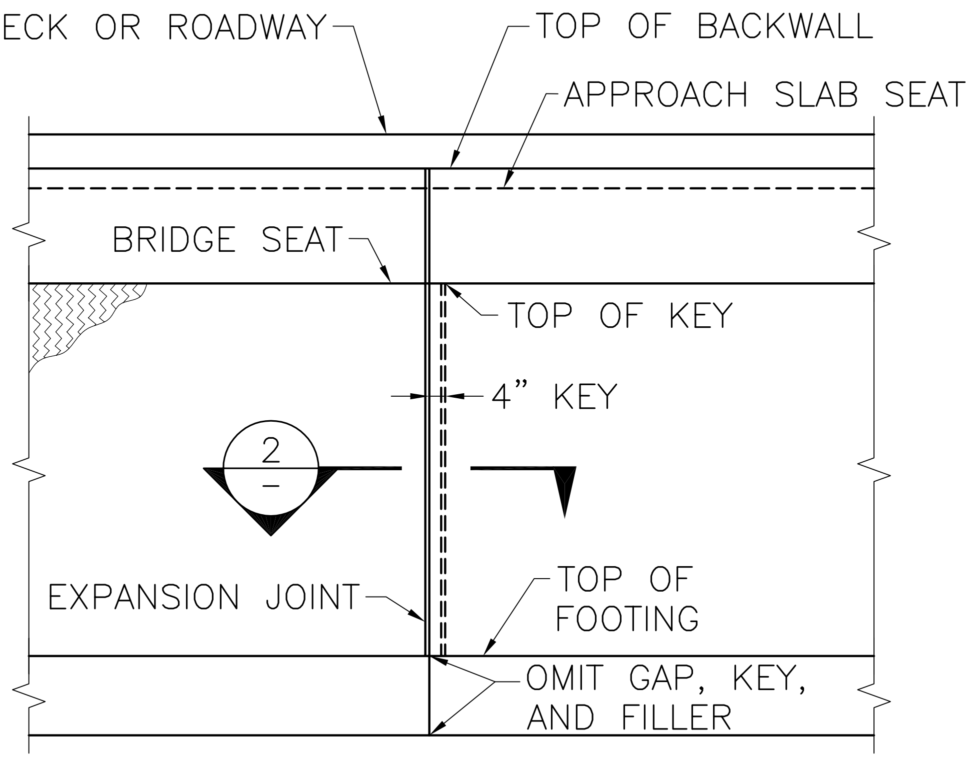
VERTICAL SECTION THRU CONSTRUCTION JOINT

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

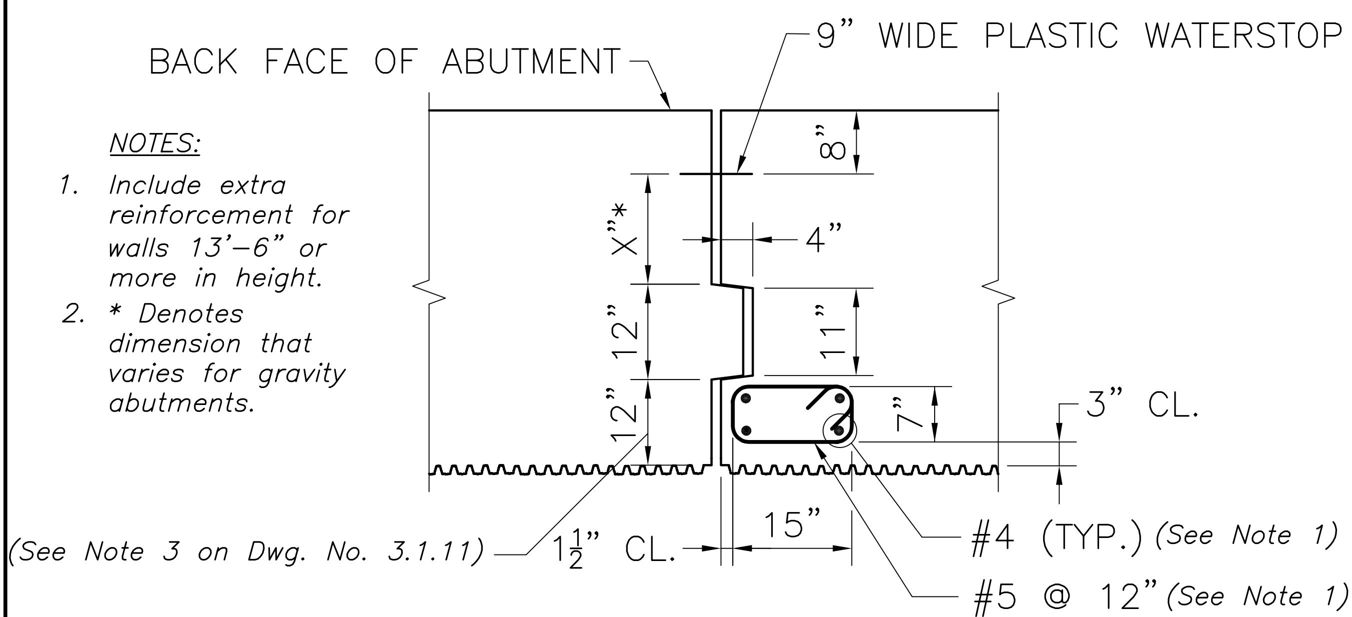
1. *Construction joints shall be located at intervals of not more than 24'.*
2. *Locate construction joints by dimensions on Construction Drawings.*
3. *If 12" clearance cannot be achieved by placing end of 12" key at face of backwall, place key farther back to achieve the 12" clearance.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION THRU CONSTRUCTION JOINT ABUTMENT DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.1.8**



ELEVATION OF ABUTMENT

SCALE: $\frac{1}{4}$" = 1'–0"



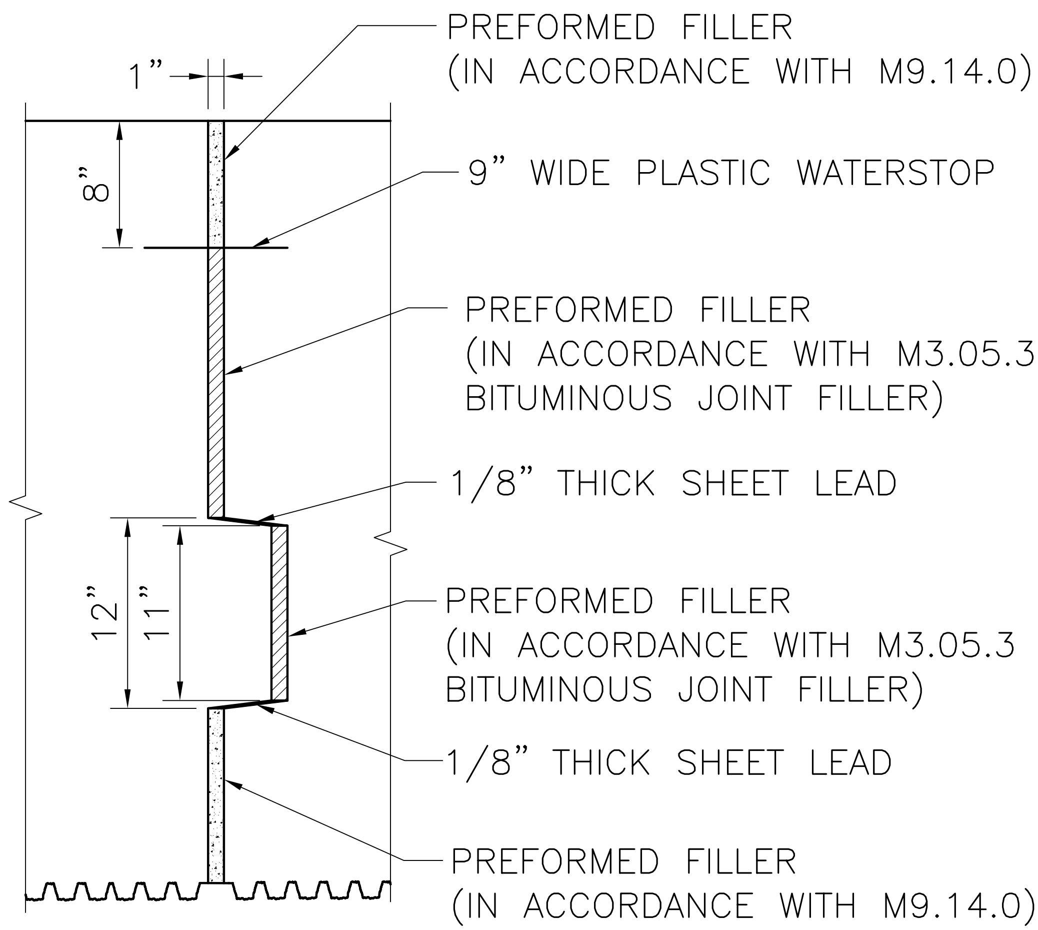
NOTES:

1. *Include extra reinforcement for walls 13'–6" or more in height.*
2. ** Denotes dimension that varies for gravity abutments.*

SECTION 2

SCALE: $\frac{1}{2}$" = 1'–0"

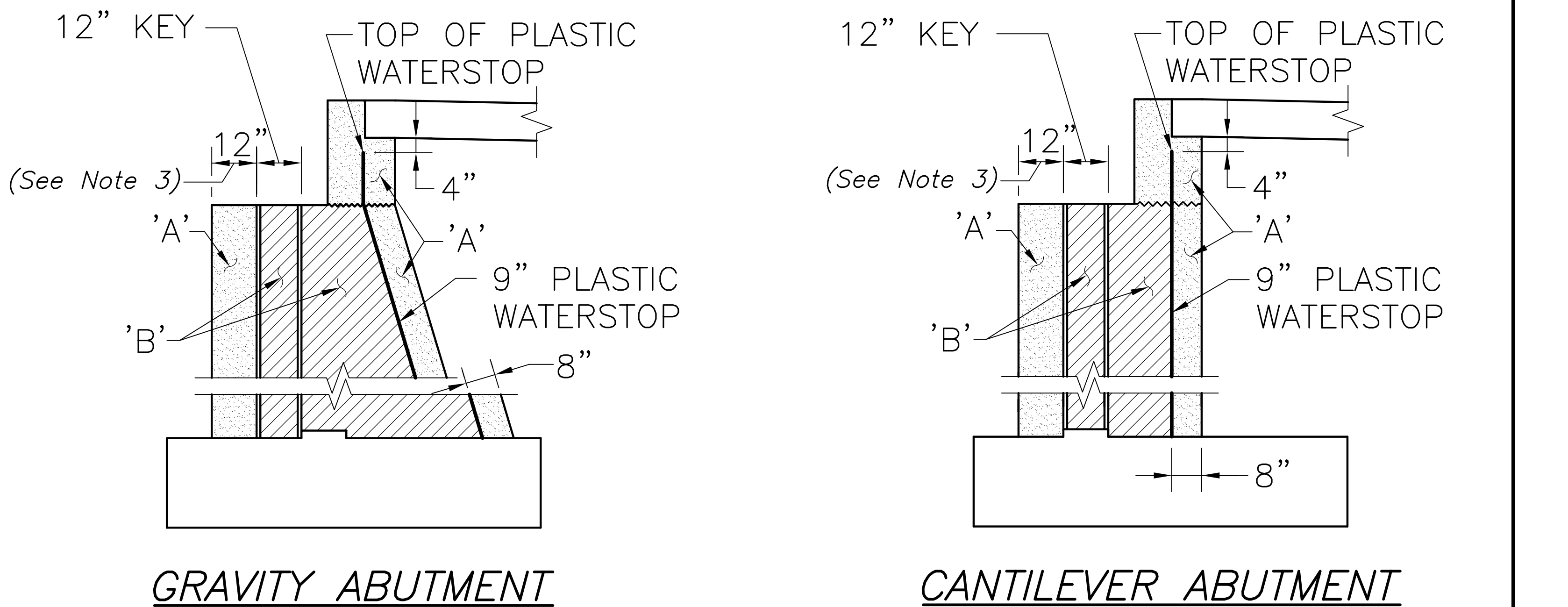
MASS HIGHWAY BRIDGE MANUAL	EXPANSION JOINT DETAILS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.9**



LIMITS OF PREFORMED FILLER

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	PREFORMED FILLER IN EXPANSION JOINT ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.10**



NOTES:

1. LONGITUDINAL REINFORCEMENT SHALL END 2" CLEAR OF EXPANSION JOINT.
2. 'A' – PREFORMED FILLER (IN ACCORDANCE WITH M9.14.0)
   'B' – PREFORMED FILLER (IN ACCORDANCE WITH M3.05.3 BITUMINOUS JOINT FILLER)
3. FILLER MATERIAL SHALL BE FASTENED SECURELY TO ONE SIDE OF JOINT.

VERTICAL SECTION THRU EXPANSION JOINT

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Expansion joints shall be located at intervals not more than 72'. In the case of long walls, the first joint in the wing from the corner of the abutment is expansion.*
2. *Locate expansion joints by dimensions on the Construction Drawings.*
3. *If 12" clearance can not be achieved by placing end of 12" key at face of backwall, place key farther back to achieve the 12" clearance.*

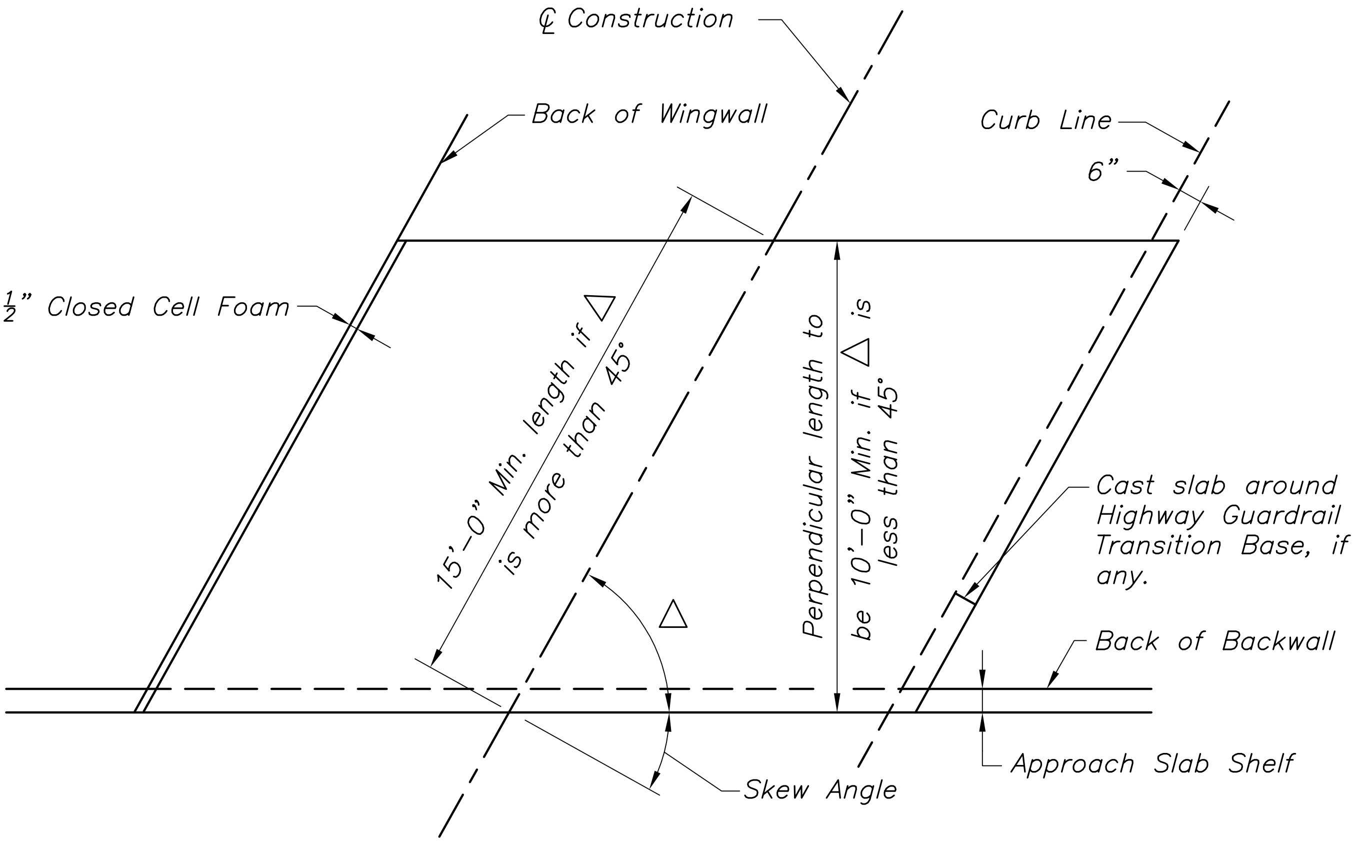
MASS HIGHWAY BRIDGE MANUAL

VERTICAL SECTION THRU EXPANSION JOINT

ABUTMENT DETAILS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: 3.1.11



U-WINGWALLS WITH SAFETY CURBS

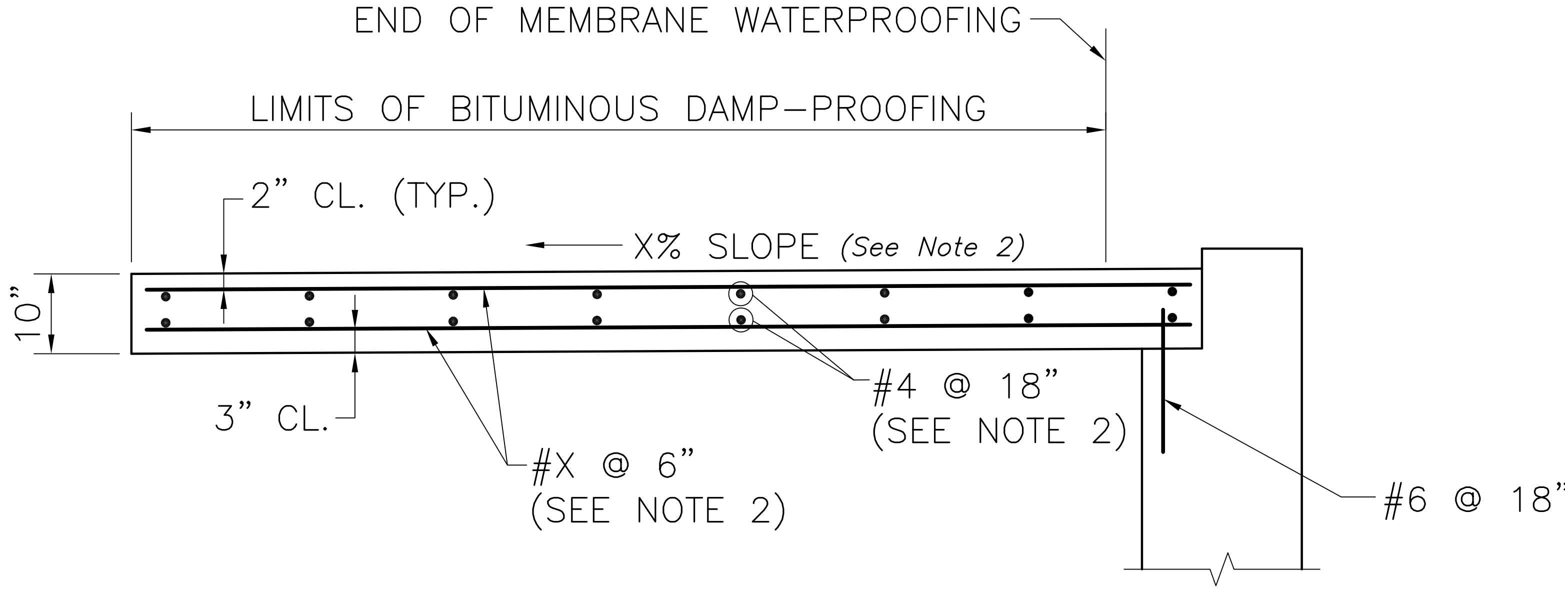
SPLAYED WINGWALLS U-WINGWALLS WITH SIDEWALKS

PLAN
NOT TO SCALE

NOTES:

1. Where angle △ is greater or equal to 45° : length of 10" thick slab along center line of construction is 15'-0" and main reinforcement is #7 @ 6" top and bottom parallel to centerline of construction.
2. Where angle △ is less than 45° : length of 10" thick slab perpendicular to abutment is 10'-0" minimum and main reinforcement is #6 @ 6" top and bottom perpendicular to abutment.
3. If removable panel is used, place steel parallel to centerline of construction and design approach slab accordingly.
4. Place #4 @ 18" top and bottom parallel to abutment and between main reinforcement.
5. Width of approach slab may have to be reduced if it interferes with utilities.

MASS HIGHWAY BRIDGE MANUAL	APPROACH SLAB DETAIL	DATE OF ISSUE MAY 2005
	ABUTMENT DETAILS	DRAWING NUMBER **3.1.12**



NOTES:

1. APPROACH SLAB TO BE 4000 PSI, $1\frac{1}{2}$ IN, 565 CEMENT CONCRETE.
2. PLACE LONGITUDINAL REINFORCEMENT *(Specify orientation per Dwg. No. 3.1.12).* PLACE TRANSVERSE REINFORCEMENT PARALLEL TO ABUTMENT.

APPROACH SLAB DETAILS

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *See Roadway Section drawings for abutment details and dimensions not shown here.*
2. *If approach roadway slopes down and away from the abutment at greater than 2%, change slope of approach slab to approach roadway grade plus 1%, rounded up to the nearest 1%. Otherwise set slope at 2%.*

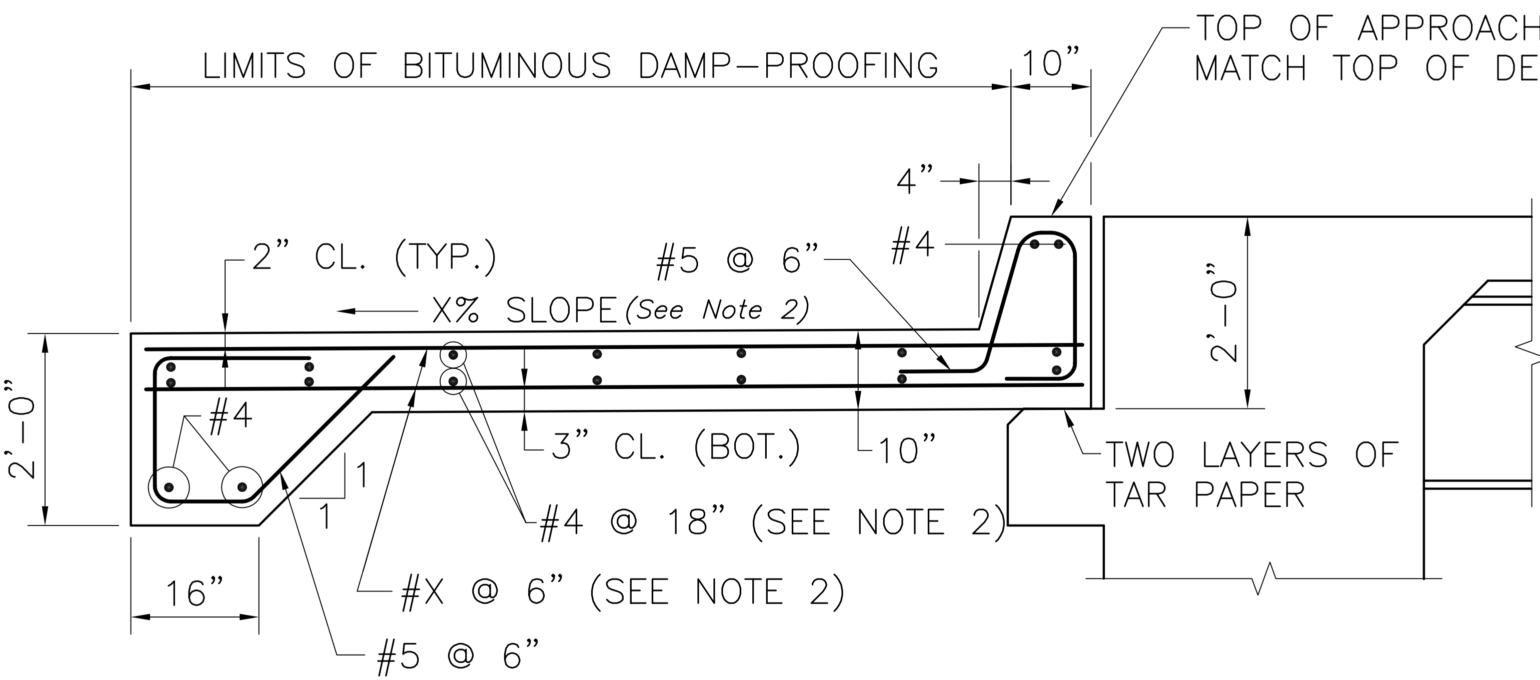
MASS HIGHWAY
BRIDGE MANUAL

APPROACH SLAB TYPE I

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.1.13



NOTES:

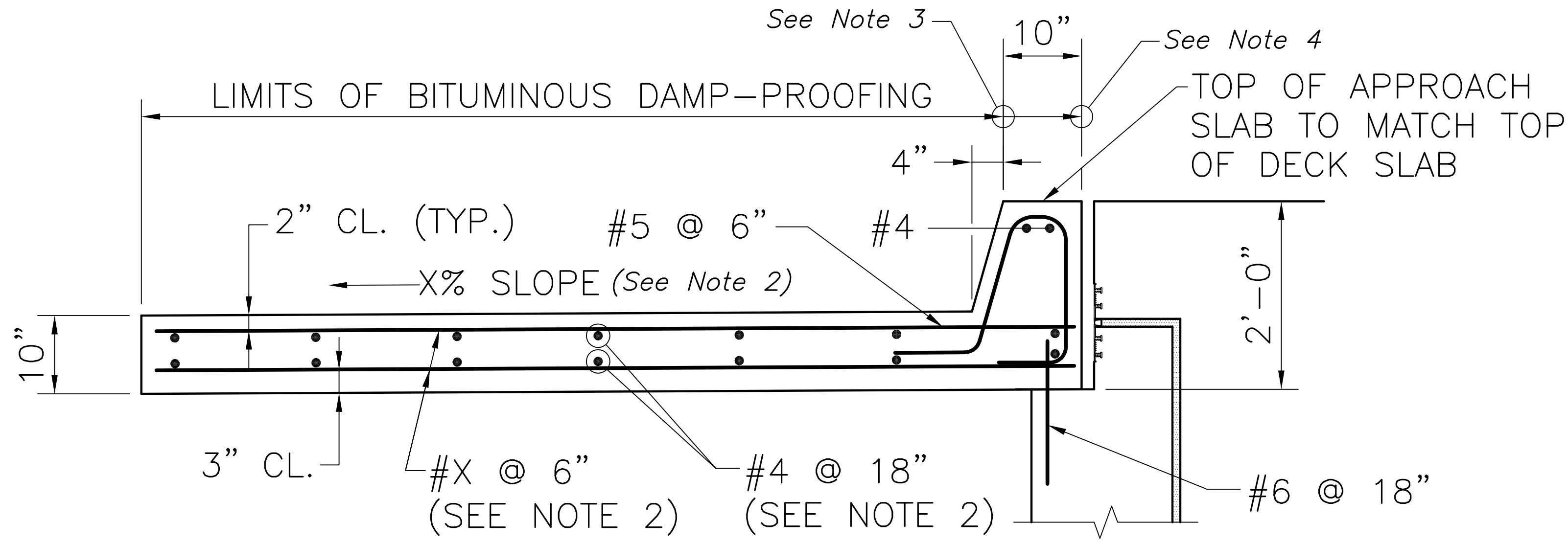
1. APPROACH SLAB TO BE 4000 PSI, $1\frac{1}{2}$ IN, 565 CEMENT CONCRETE.
2. PLACE LONGITUDINAL REINFORCEMENT *(Specify orientation per Dwg. No. 3.1.12).* PLACE TRANSVERSE REINFORCEMENT PARALLEL TO ABUTMENT.

APPROACH SLAB DETAILS

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *See Roadway Section drawings for abutment details and dimensions not shown here.*
2. *If approach roadway slopes down and away from the abutment at greater than 2%, change slope of approach slab to approach roadway grade plus 1%, rounded up to the nearest 1%. Otherwise set slope at 2%.*



NOTES:

1. APPROACH SLAB TO BE 4000 PSI, $1\frac{1}{2}$ IN, 565 CEMENT CONCRETE.

2. PLACE LONGITUDINAL REINFORCEMENT *(Specify orientation per Dwg. No. 3.1.12).* PLACE TRANSVERSE REINFORCEMENT PARALLEL TO ABUTMENT.

APPROACH SLAB DETAILS

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *See Roadway Section drawings for abutment details and dimensions not shown here.*
2. *If approach roadway slopes down and away from the abutment at greater than 2%, change the slope of approach slab to approach roadway grade plus 1%, rounded up to the nearest 1%. Otherwise set slope at 2%.*
3. *End Bituminous damp-proofing here when using Asphaltic Bridge Joints.*
4. *End Bituminous damp-proofing here when using armored joints.*

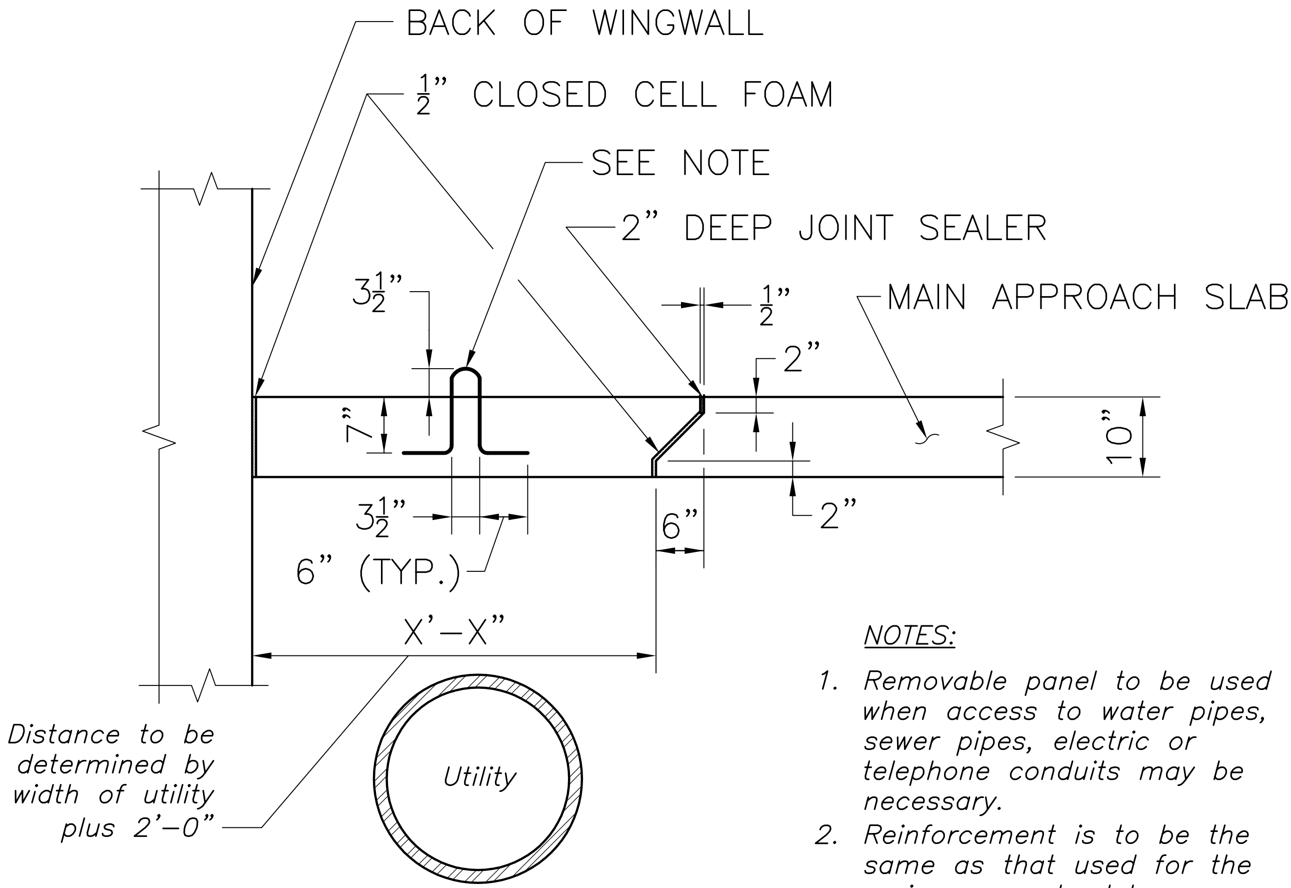
MASS HIGHWAY BRIDGE MANUAL

APPROACH SLAB TYPE III

ABUTMENT DETAILS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **3.1.15**



NOTES:

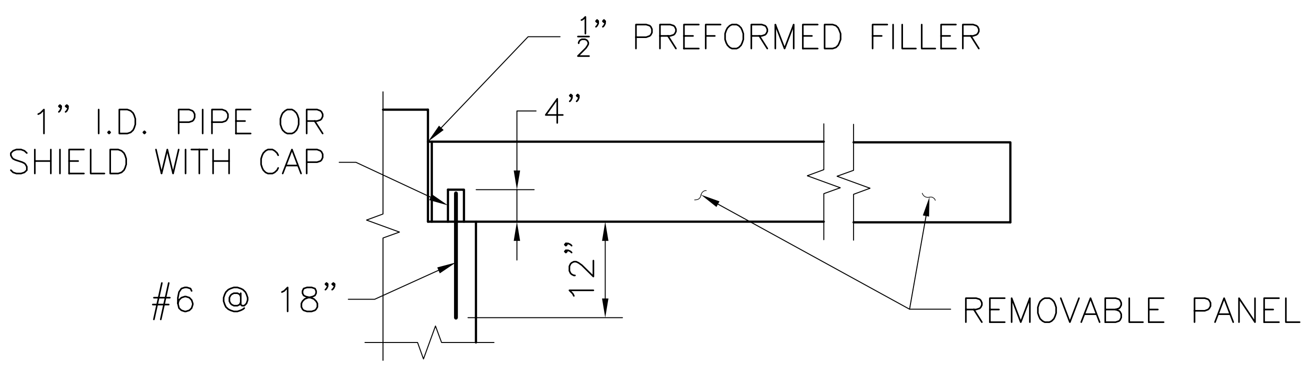
1. *Removable panel to be used when access to water pipes, sewer pipes, electric or telephone conduits may be necessary.*
2. *Reinforcement is to be the same as that used for the main approach slab.*

NOTE:

2 LIFT HOOKS REQUIRED. USE #5 COATED REBAR AT QUARTER POINTS.

SECTION 1

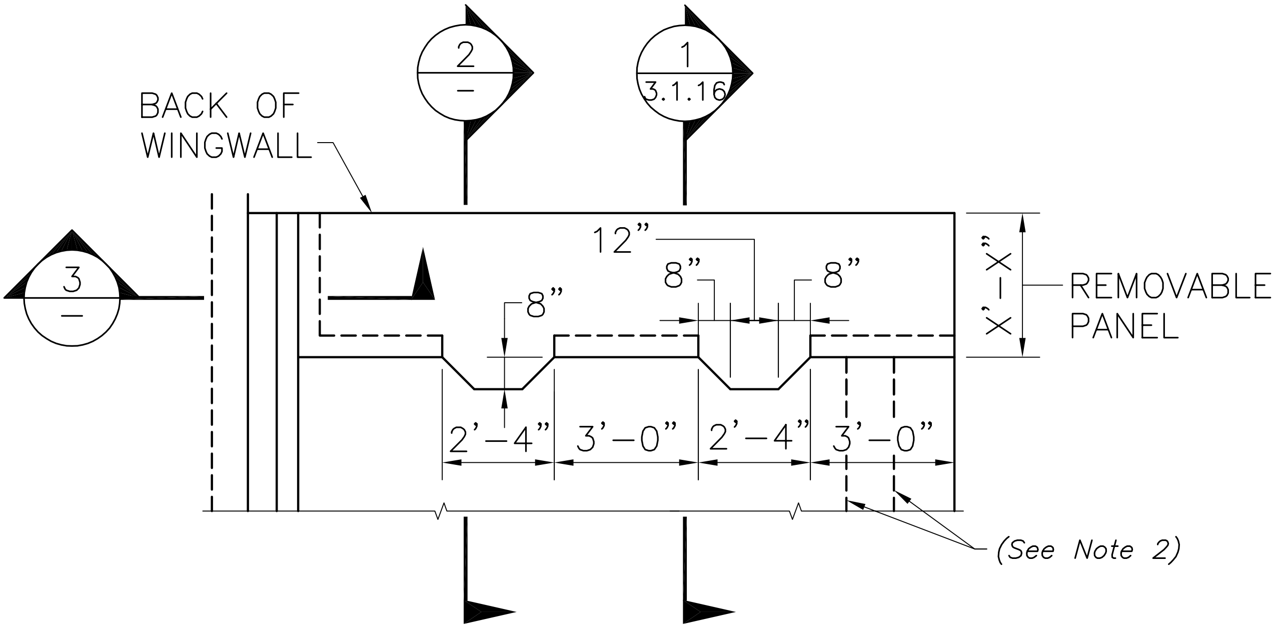
SCALE: ½" = 1'–0"



PANEL DETAIL AT ABUTMENT

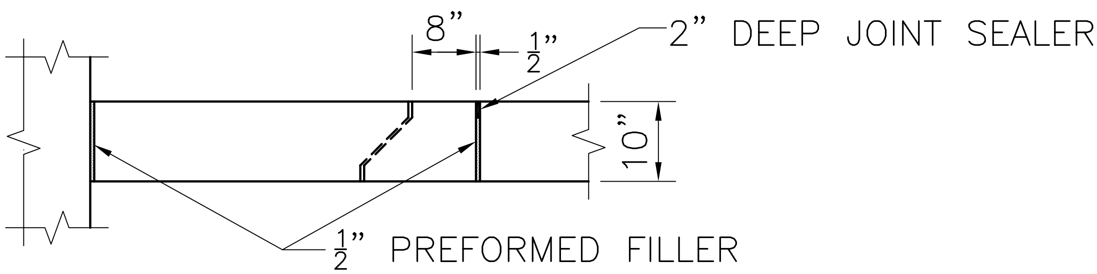
SCALE: ½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	REMOVABLE PANEL FOR APPROACH SLAB TYPE I ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.16**



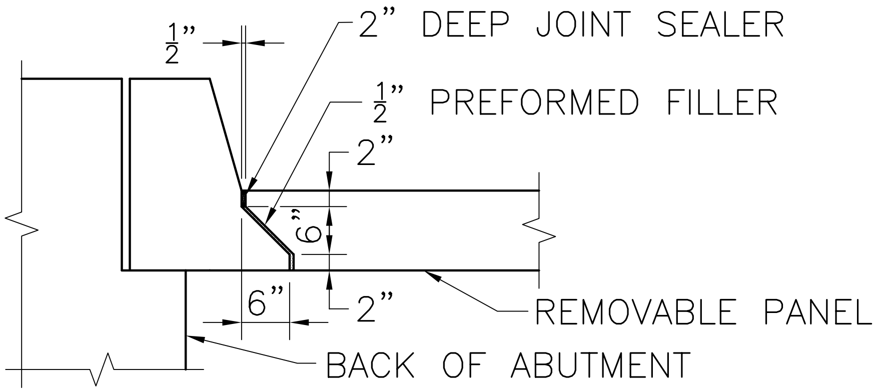
PLAN OF REMOVABLE PANEL

SCALE: $\frac{1}{4}$" = 1'–0"



SECTION 2

SCALE: $\frac{1}{2}$" = 1'–0"



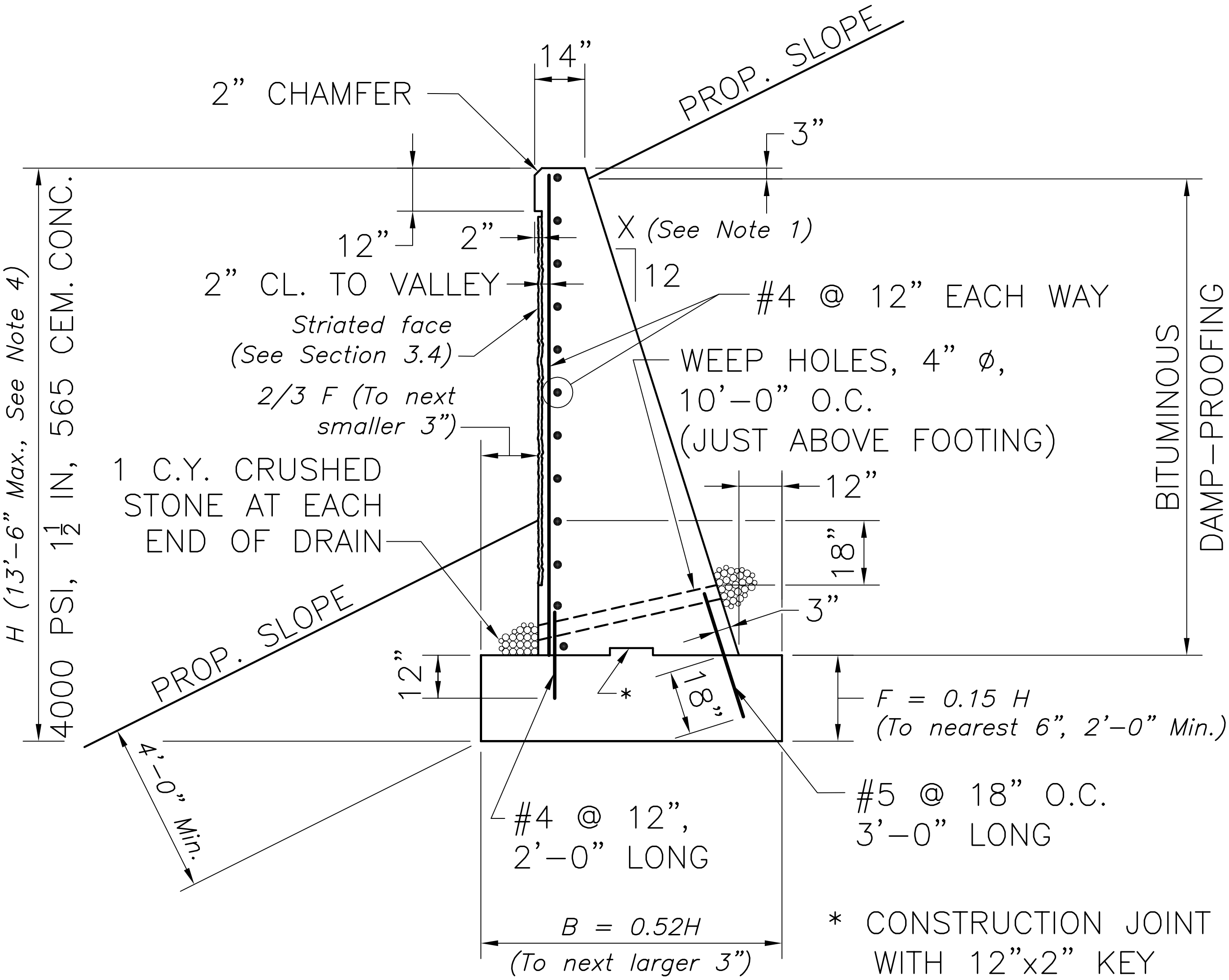
SECTION 3

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Use Section thru Removable Panel on Dwg. No. 3.1.16 for Section 1 and for additional guidelines not shown here.*
2. *Show key for Approach Slab Type II. Omit key on removable panel.*

MASS HIGHWAY BRIDGE MANUAL	REMOVABLE PANEL FOR APPR. SLAB TYPES II & III ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.1.17**



FOR RETAINING WALLS OR SPLAYED WINGWALLS

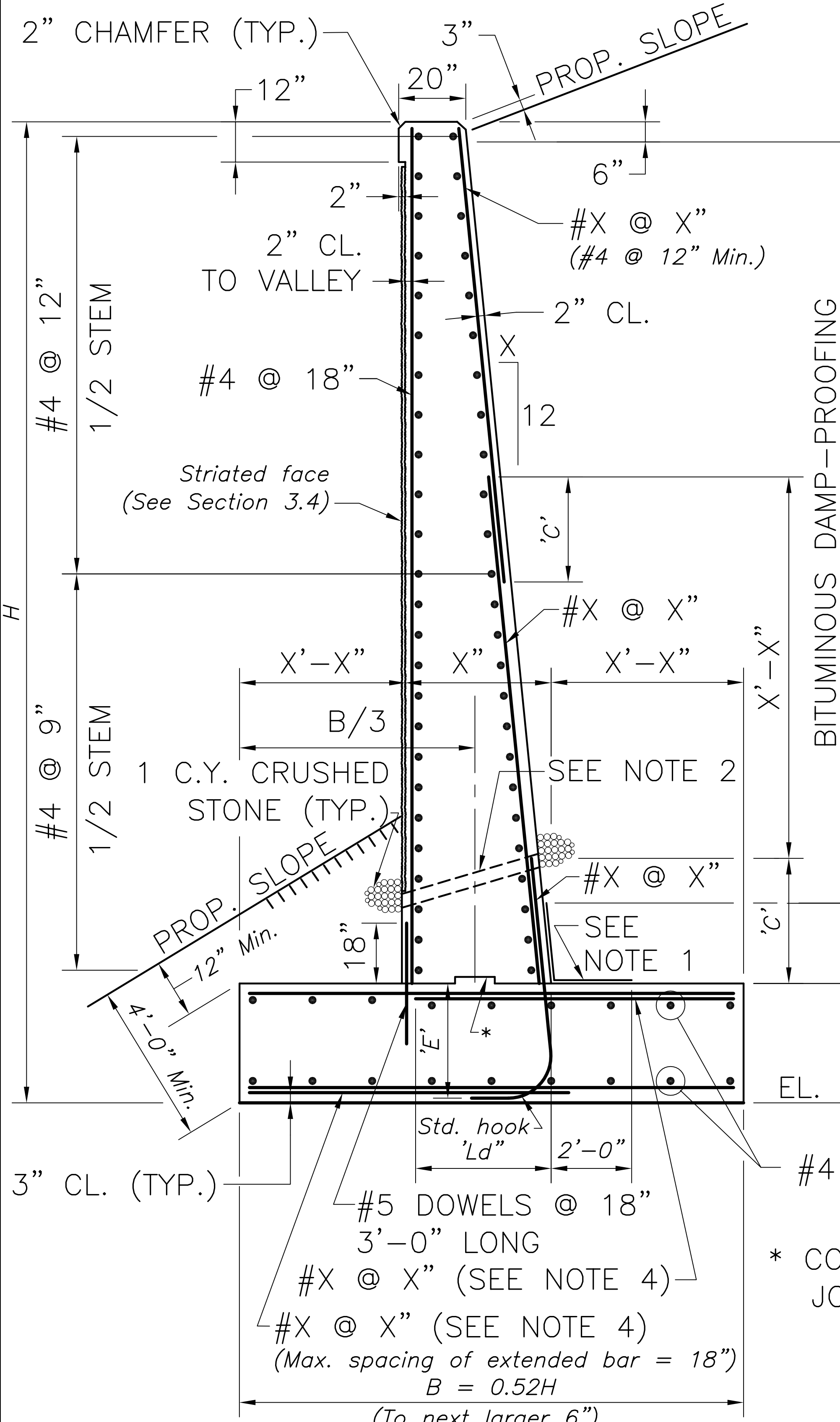
TYPICAL SECTION

SCALE: ¼" = 1'–0"

NOTES:

1. *The back batter shall be constant and shall be determined by the highest section contained between expansion joints.*
2. *Show maximum factored toe pressure or pile load, if on piles.*
3. *If piles are required, see Section 3.6.*
4. *Footing to be omitted when founded on ledge. For typical section see Dwg. No. 3.6.4.*
5. *Design base width including any live load surcharge and include the effects of sloping backfills where applicable.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL GRAVITY RETAINING WALL SECTION WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.2.1**



NOTES:

1. *See Dwg. No. 3.2.3 for notes to be included with this section on the Construction Drawings.*
2. *For H less than 13'-6", use gravity retaining wall.*
3. *Provide adequate lap lengths 'C' and hook embedments 'E'.*
4. *See Dwg. No. 3.2.3 for the continuation of these Designer Notes.*

TYPICAL SECTION

SCALE: $\frac{1}{4}$" = 1'-0"

FOR RETAINING WALLS OR SPLAYED WINGWALLS

MASS HIGHWAY
BRIDGE MANUAL

TYPICAL CANTILEVER RETAINING WALL SECTION

WINGWALL DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.2.2

NOTES: *(Include these notes with section shown on Dwg. No. 3.2.2)*

1. MEMBRANE WATERPROOFING AND 8"x16"x2", 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE BLOCKS LAID IN MORTAR OR OTHER WATERPROOFING PROTECTIVE COURSE, MIN. 2" THICK AS SPECIFIED IN THE STANDARD SPECIFICATIONS. *(Cantilever Walls only)*

2. 4" ø WEEP HOLES 10'–0" O.C. (JUST ABOVE PROTECTIVE COURSE).

3. ALL CONCRETE SHALL BE 4000 PSI, $1\frac{1}{2}$ IN, 565 CEMENT CONCRETE.

4. EXTEND EVERY THIRD BAR FULL LENGTH AS SHOWN. *(modify this note if closer spacing is required by design)*

For Spread Footings:

5. THE AVERAGE FACTORED BEARING PRESSURE = XXX KSF (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest pressure)* FACTORED BEARING RESISTANCE = XXX KSF. FACTORED BEARING RESISTANCE IS THE PRODUCT OF THE ULTIMATE BEARING RESISTANCE AND A PERFORMANCE FACTOR OF 0.XX.

For Piles:

5. THE FACTORED AXIAL LOAD PER PILE IS X KIPS (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest axial load)* THE FACTORED STRUCTURAL CAPACITY PER PILE IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE STRUCTURAL CAPACITY OF X KIPS, AN ECCENTRICITY FACTOR OF 0.XX *(omit if not applicable)* AND A STRUCTURAL PERFORMANCE FACTOR OF 0.XX.

6a. THE FACTORED GEOTECHNICAL DESIGN CAPACITY PER PILE IS X KIPS. THE ESTIMATED TIP ELEVATION IS XXX FEET. *(Use this note only when the Factored Geotechnical Capacity controls the pile axial capacity, such as from friction or friction and end bearing as specified in the Geotechnical Report.)*

6b. THE MINIMUM TIP ELEVATION IS XXX FEET. *(Use this note only when the required pile length is not determined by the required axial capacity, i.e., lateral loading, scour resistance, or other factors, as recommended in the Geotechnical Report, determine the pile length.)*

6c. PILES SHALL BE DRIVEN TO BEDROCK WITH AN ESTIMATED TIP ELEVATION OF XXX FEET. HEAVY DUTY PILE SHOES SHALL BE INSTALLED ON THE TIPS OF ALL PILES. PREFABRICATED PILE SHOES MAY BE USED IF APPROVED BY THE ENGINEER. *(Include this note only when the Factored Structural Capacity controls the pile axial capacity due to end bearing on rock as specified in the Geotechnical Report.)*

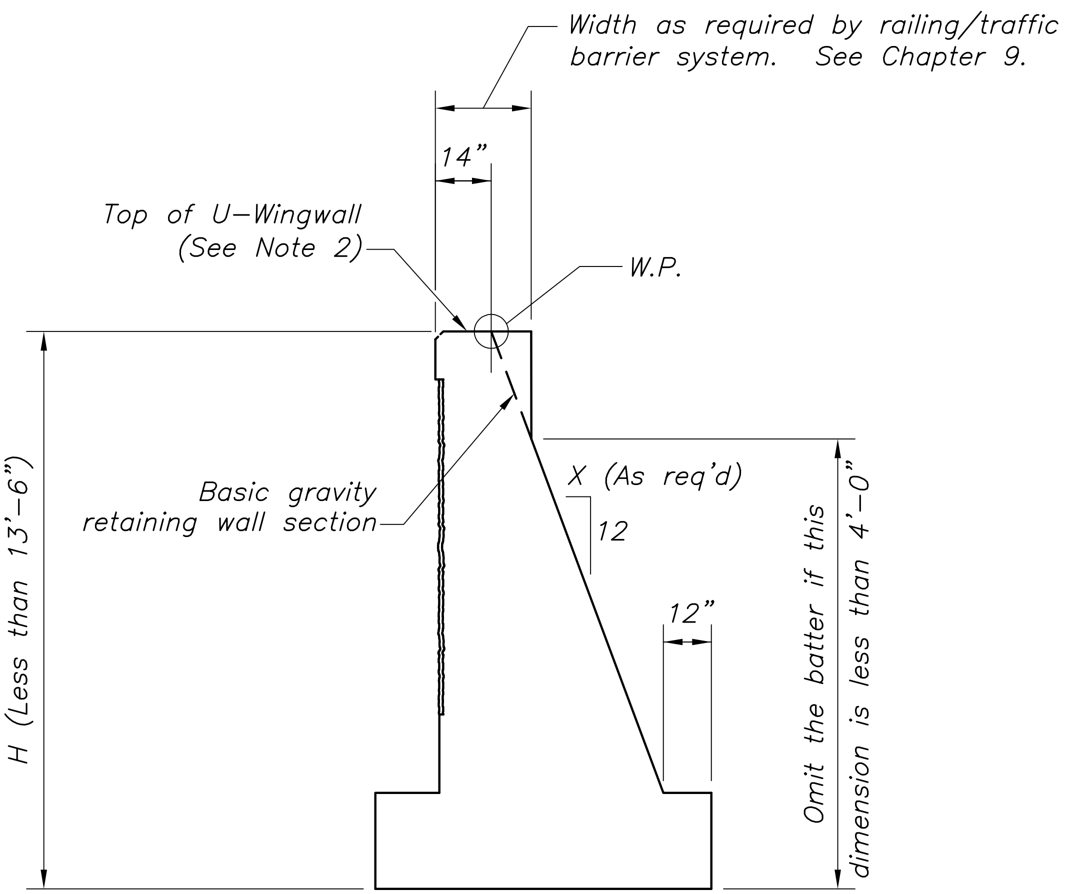
7. DETERMINATION OF THE DRIVEN PILE CAPACITY, PILE DRIVING CRITERIA, AND PILE INTEGRITY SHALL BE PERFORMED USING THE XXXXXXX *(Designer to specify the Formula Method, WEAP, PDA, Static – Cyclic (Express) Load Test, Static Load Test, or other system, as recommended in the Geotechnical Report)* DRIVING/TESTING METHOD WITH A PERFORMANCE FACTOR OF 0.XX. PILES SHALL BE INSTALLED TO ACHIEVE A FACTORED DRIVEN CAPACITY EQUAL TO OR GREATER THAN THE FACTORED AXIAL DESIGN LOAD.

8. THE CONTRACTOR SHALL SUBMIT A PILE SCHEDULE, PILE INSTALLATION, AND PILE DRIVING/TESTING PLAN FOR REVIEW AND APPROVAL OF THE ENGINEER.

NOTES: (Continued from Dwg. No. 3.2.2)

5. *Reinforcing steel in back of wall shall be designed for bending and direct stress and shall conform to AASHTO M 31 Grade 60.*
6. *Provide adequate lap lengths 'C', embedment lengths 'L_d', and hook embedment lengths 'E'.*
7. *Where piles are used, see Section 3.6.*
8. *Consult the Bridge Engineer for concrete protection strategies in marine environments.*
9. *Design base width including any live load surcharge and the effects of sloping backfill.*
10. *Where design height H is greater than 30'–0", consider a counterfort design.*
11. *Where height of walls varies between expansion joints, the design of that segment of retaining wall may be based on the geometry of a section taken through the 1/4 point of the segment adjacent to the highest end of the wall.*
12. *Provide adequate 'L_d' for toe and heel steel rebars and extend at least every third rebar full length.*

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION NOTES FOR CANTILEVER RETAINING WALL WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.2.3**



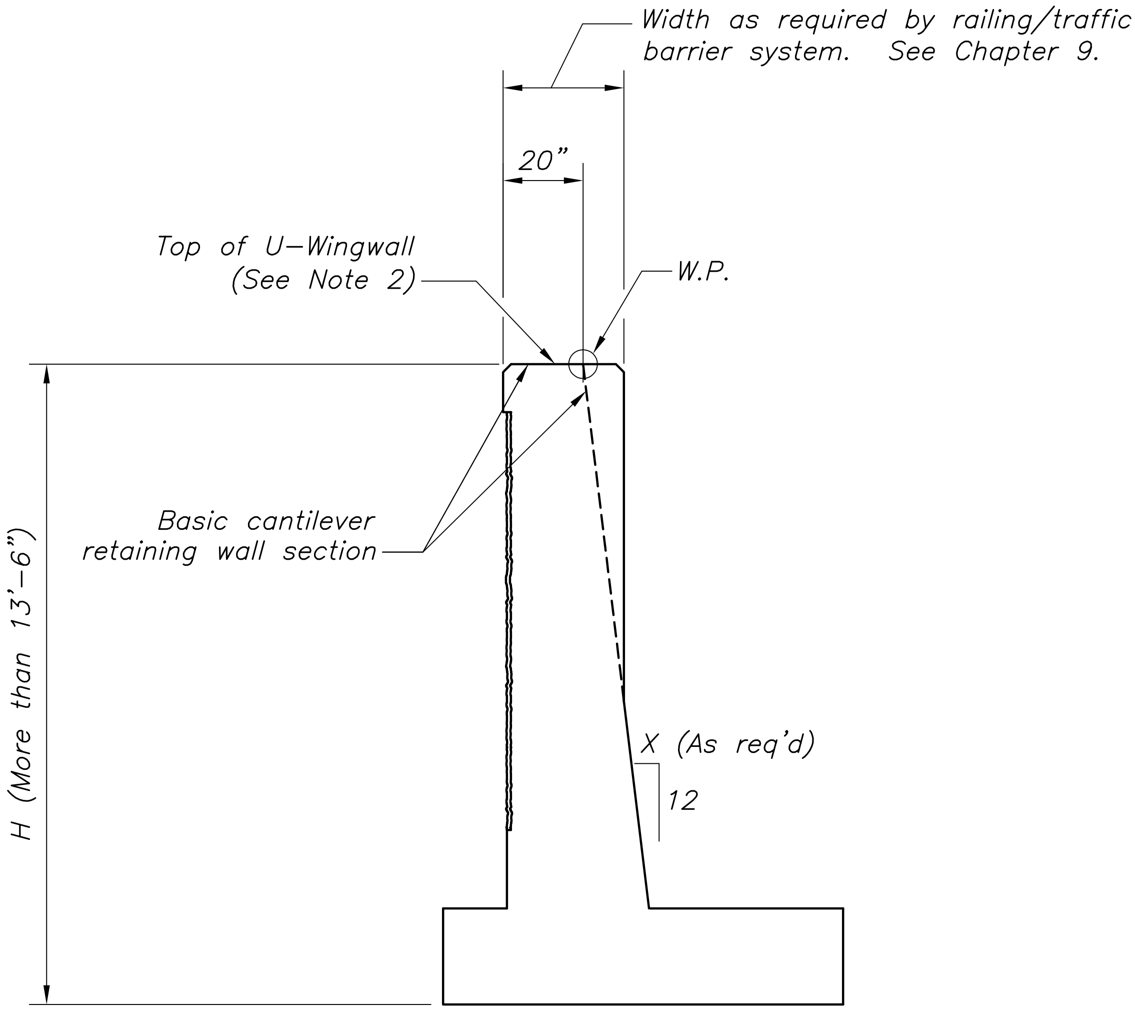
TYPICAL GEOMETRY

NOT TO SCALE

NOTES:

1. For the Typical Section through a gravity U-wingwall, see Dwg. No. 3.2.1 and modify the geometry as shown above and as specified in Note 2.
2. The top of U-Wingwall may fall above or below the top of roadway depending on the type of railing/traffic barrier system. See Top of U-Wingwall Details shown in Chapter 9 under the appropriate railing. Match any construction joints and additional reinforcement shown in the detail.

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR GRAVITY U-WINGWALL WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 3.2.4



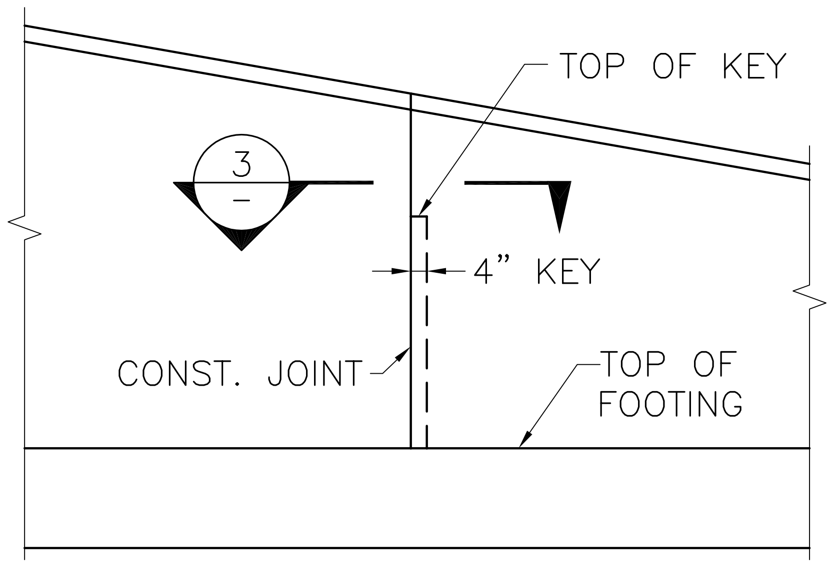
TYPICAL GEOMETRY

NOT TO SCALE

NOTES:

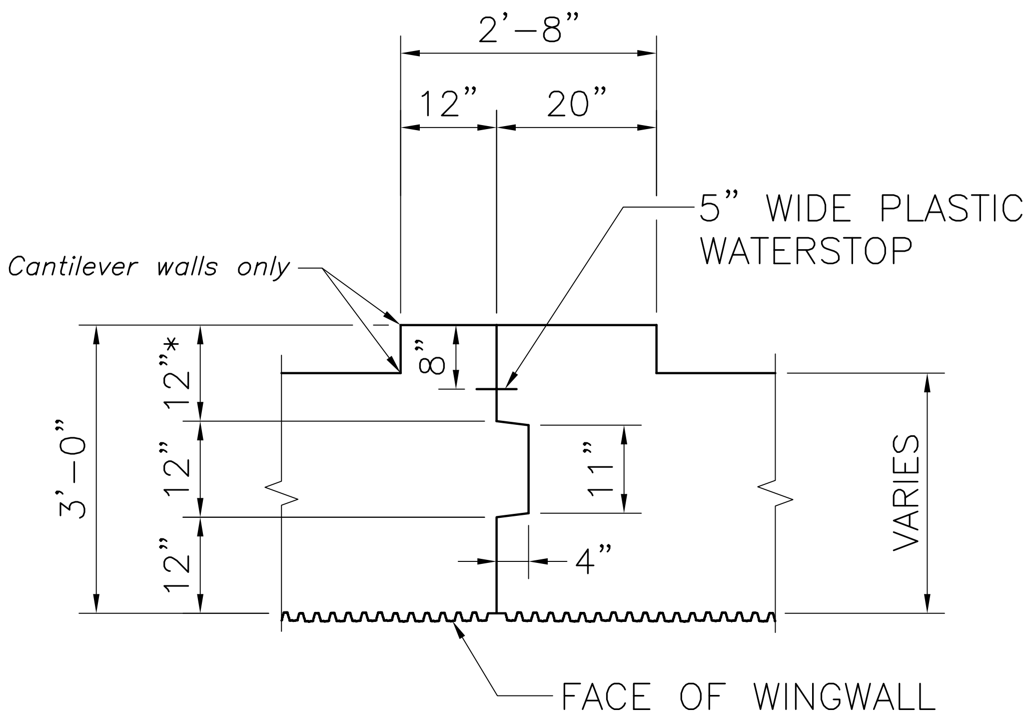
1. For the Typical Section through a cantilever U-wingwall, see Dwg. No. 3.2.2 and modify the geometry as shown above and as specified in Note 2.
2. The top of U-Wingwall may fall above or below the top of roadway depending on the type of railing/traffic barrier system. See Top of U-Wingwall Details shown in Chapter 9 under the appropriate railing. Match any construction joints and additional reinforcement shown in the detail.

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR CANTILEVER U-WINGWALL WINGWALL DETAILS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **3.2.5**



WINGWALL ELEVATION

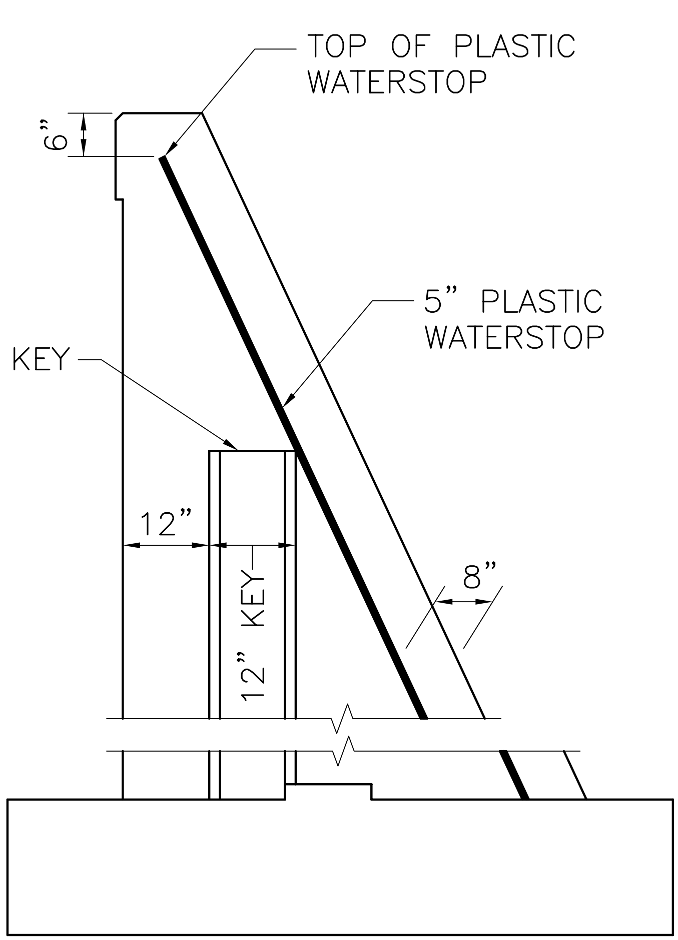
SCALE: $\frac{1}{4}$" = 1'–0"

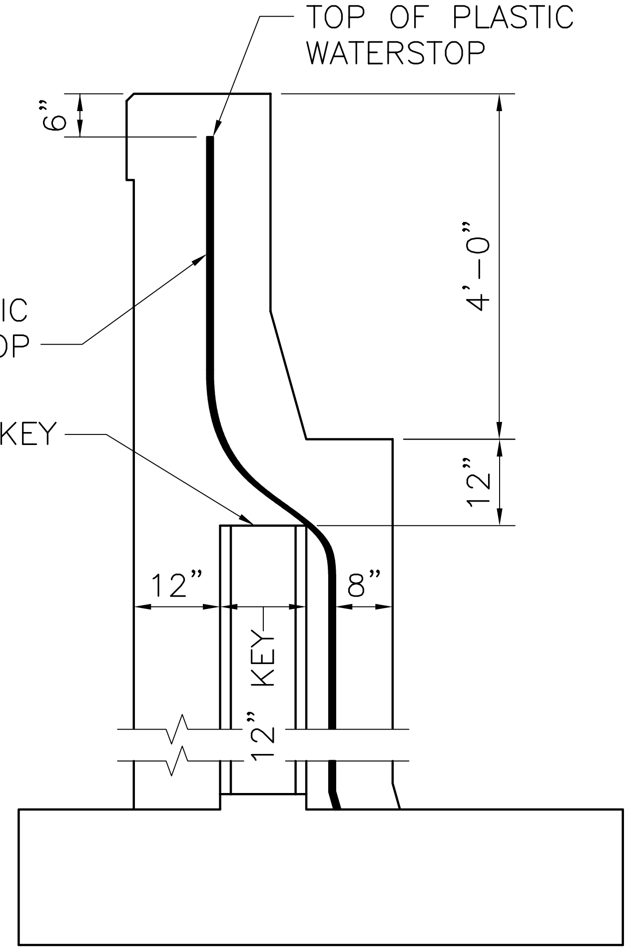


** Denotes dimensions that vary for gravity wall.*

SECTION 3

SCALE: $\frac{1}{2}$" = 1'–0"





NOTE:

REINFORCEMENT SHALL BE CONTINUOUS THROUGH CONSTRUCTION JOINTS.

GRAVITY WINGWALL

CANTILEVER WINGWALL

VERTICAL SECTION THROUGH CONSTRUCTION JOINT

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Construction joints shall be located at intervals of not more than 24'.*
2. *Locate construction joints by dimensions on Construction Drawings.*

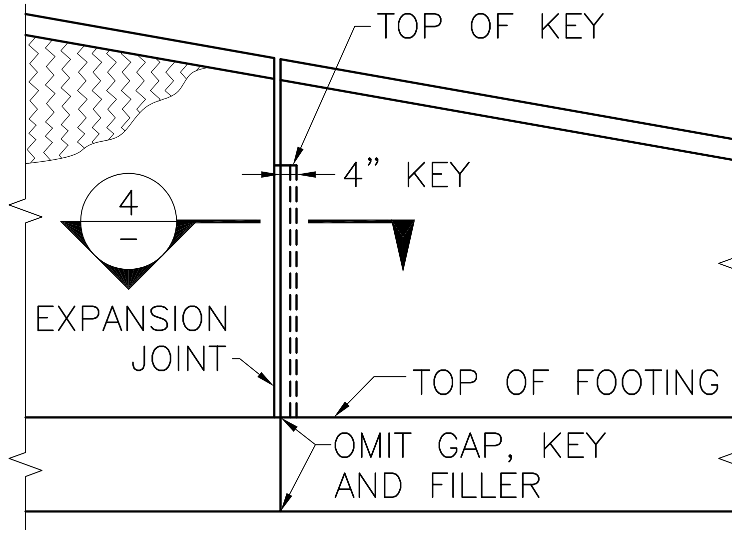
MASS HIGHWAY BRIDGE MANUAL

VERTICAL SECTION THROUGH CONSTRUCTION JOINT

WINGWALL DETAILS

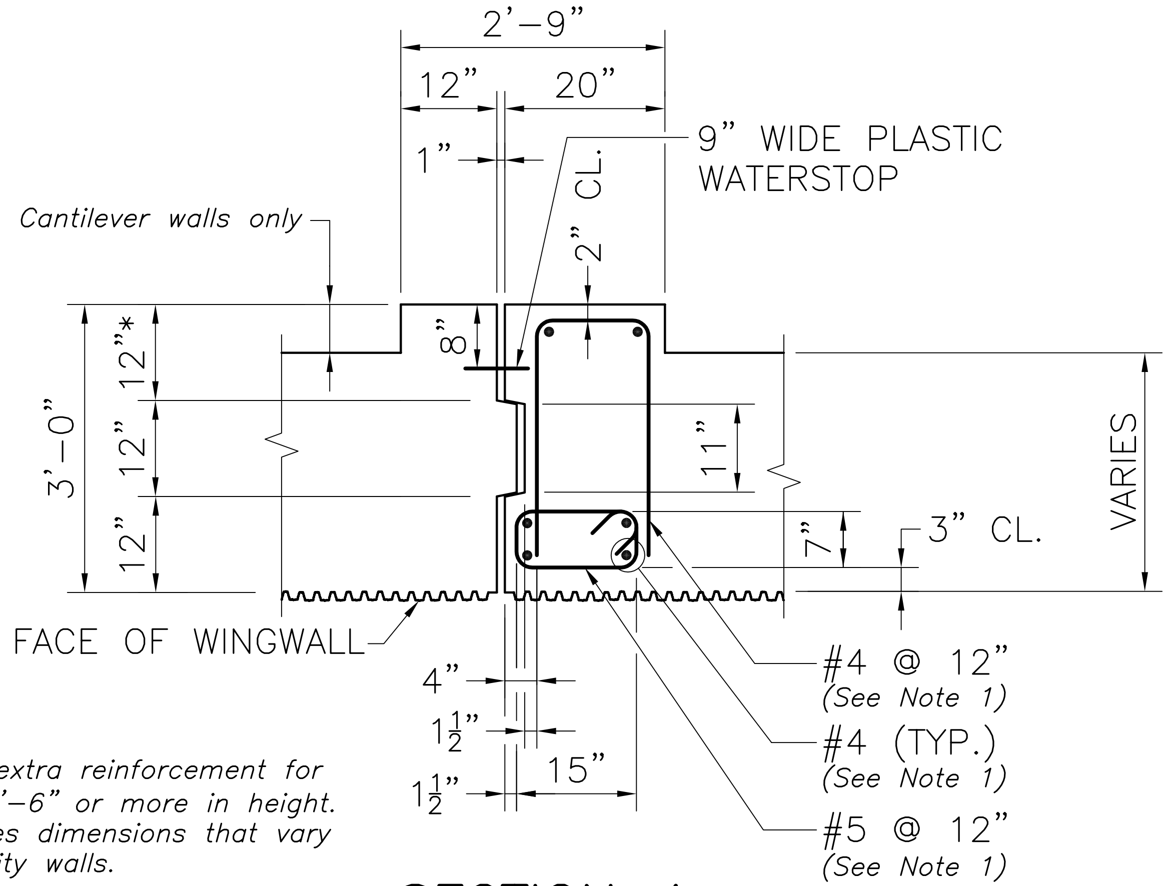
DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **3.2.7**



WINGWALL ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"



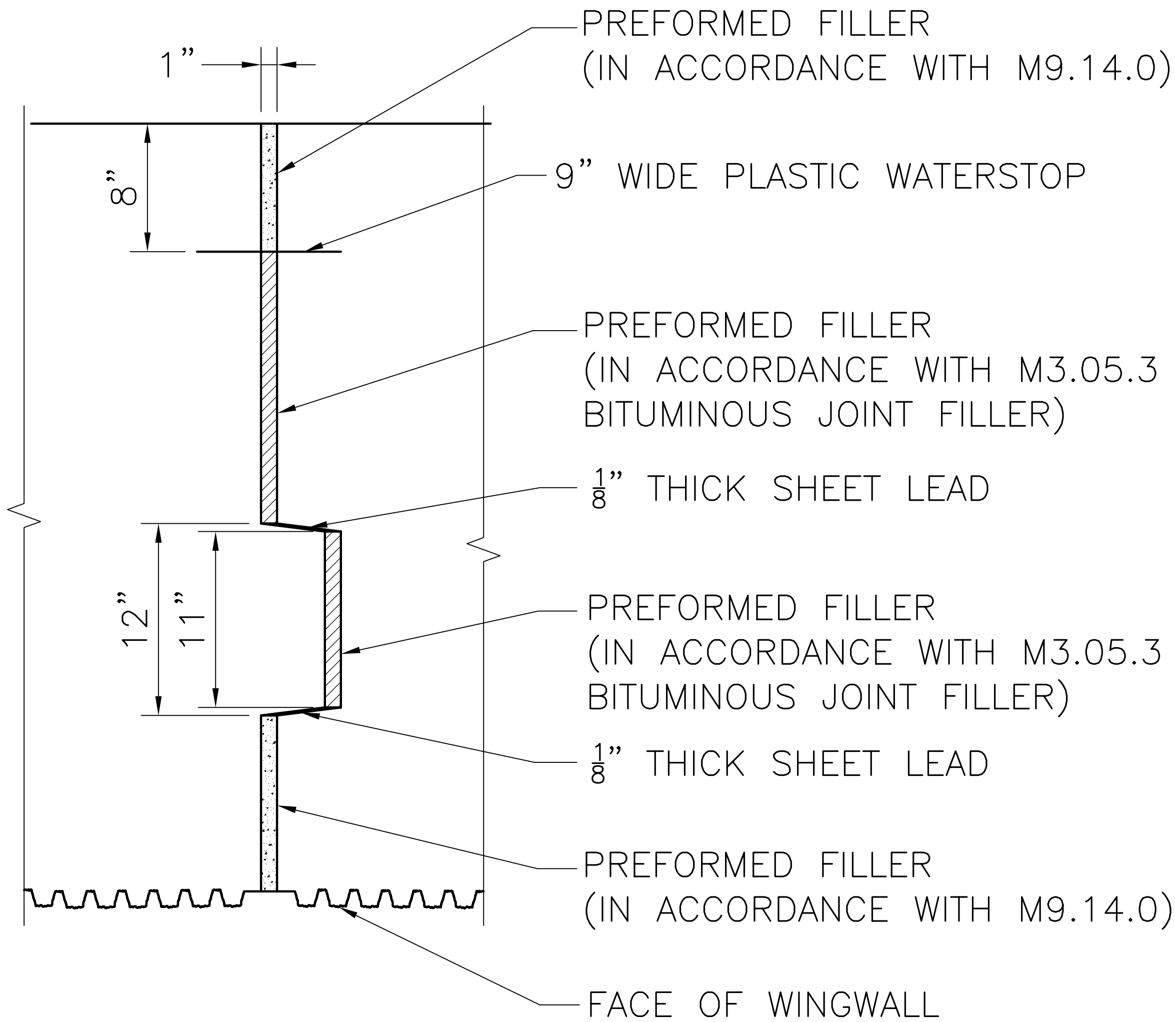
NOTES:

1. *Include extra reinforcement for walls 13'–6" or more in height.*
2. ** Denotes dimensions that vary for gravity walls.*

SECTION 4

SCALE: $\frac{1}{2}$" = 1'–0"

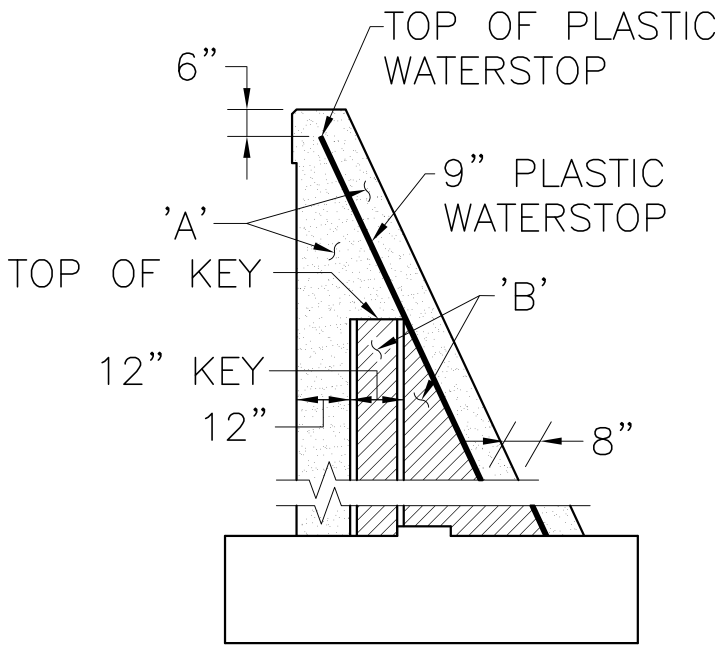
MASS HIGHWAY BRIDGE MANUAL	EXPANSION JOINT DETAILS	DATE OF ISSUE MAY 2005
	WINGWALL DETAILS	DRAWING NUMBER **3.2.8**



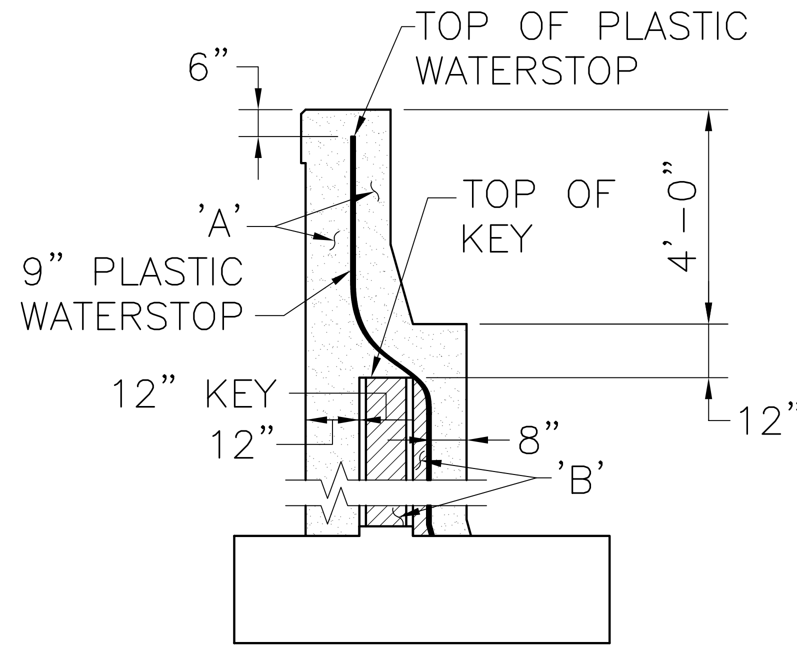
LIMITS OF PREFORMED FILLER

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	PREFORMED FILLER IN EXPANSION JOINTS WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.2.9**



GRAVITY WINGWALL



CANTILEVER WINGWALL

NOTES:

1. LONGITUDINAL REINFORCMENT SHALL END 2” CLEAR OF EXPANSION JOINT.
2. ’A’ – PREFORMED FILLER (IN ACCORDANCE WITH M9.14.0).
   ’B’ – PREFORMED FILLER (IN ACCORDANCE WITH M3.05.3 BITUMINOUS JOINT FILLER).
3. FILLER MATERIAL SHALL BE FASTENED SECURELY TO ONE SIDE OF JOINT.

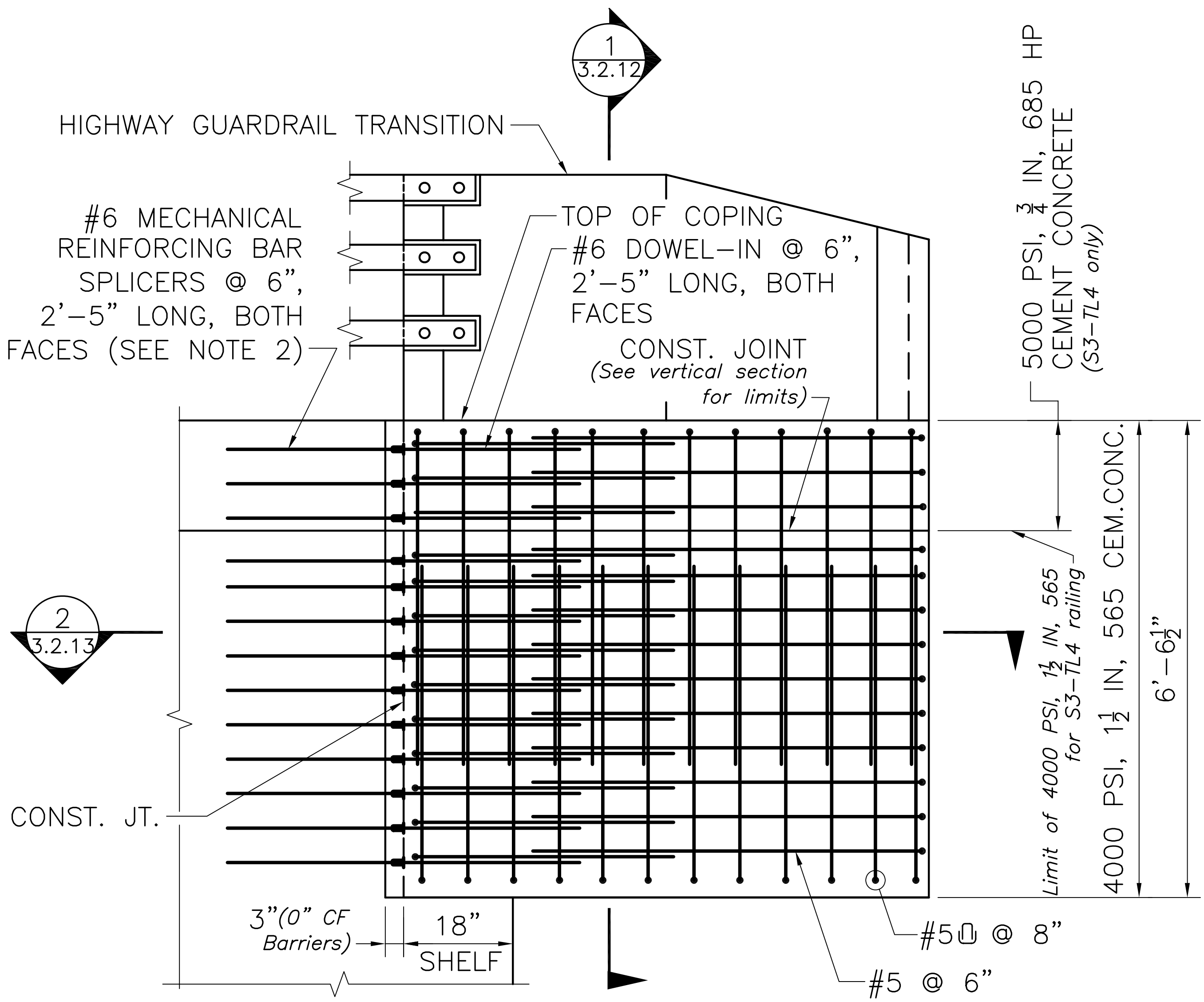
VERTICAL SECTION THRU EXPANSION JOINT

NOT TO SCALE

NOTES:

1. *Expansion joints shall be located at intervals not more than 72’. In the case of long wingwalls, the first joint in the wing from the corner of the abutment is expansion.*
2. *Locate expansion joints by dimensions on Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION THROUGH EXPANSION JOINT WINGWALL DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.2.10**



NOTES:

1. GRAVEL BORROW SHALL BE PLACED AND THOROUGHLY COMPACTED TO THE GRADE OF THE BOTTOM OF THE GUARDRAIL TRANSITION BASE. WHERE NO GRAVEL BORROW IS REQUIRED BELOW THE GUARDRAIL TRANSITION BASE, THE CONCRETE SHALL BE PLACED ON UNDISTURBED SOIL.

2. THE CONTRACTOR MAY SUBSTITUTE #6 DOWELS, 4'-10" LONG FOR THE MECHANICAL REINFORCING BAR SPLICERS AND THREADED REBAR.

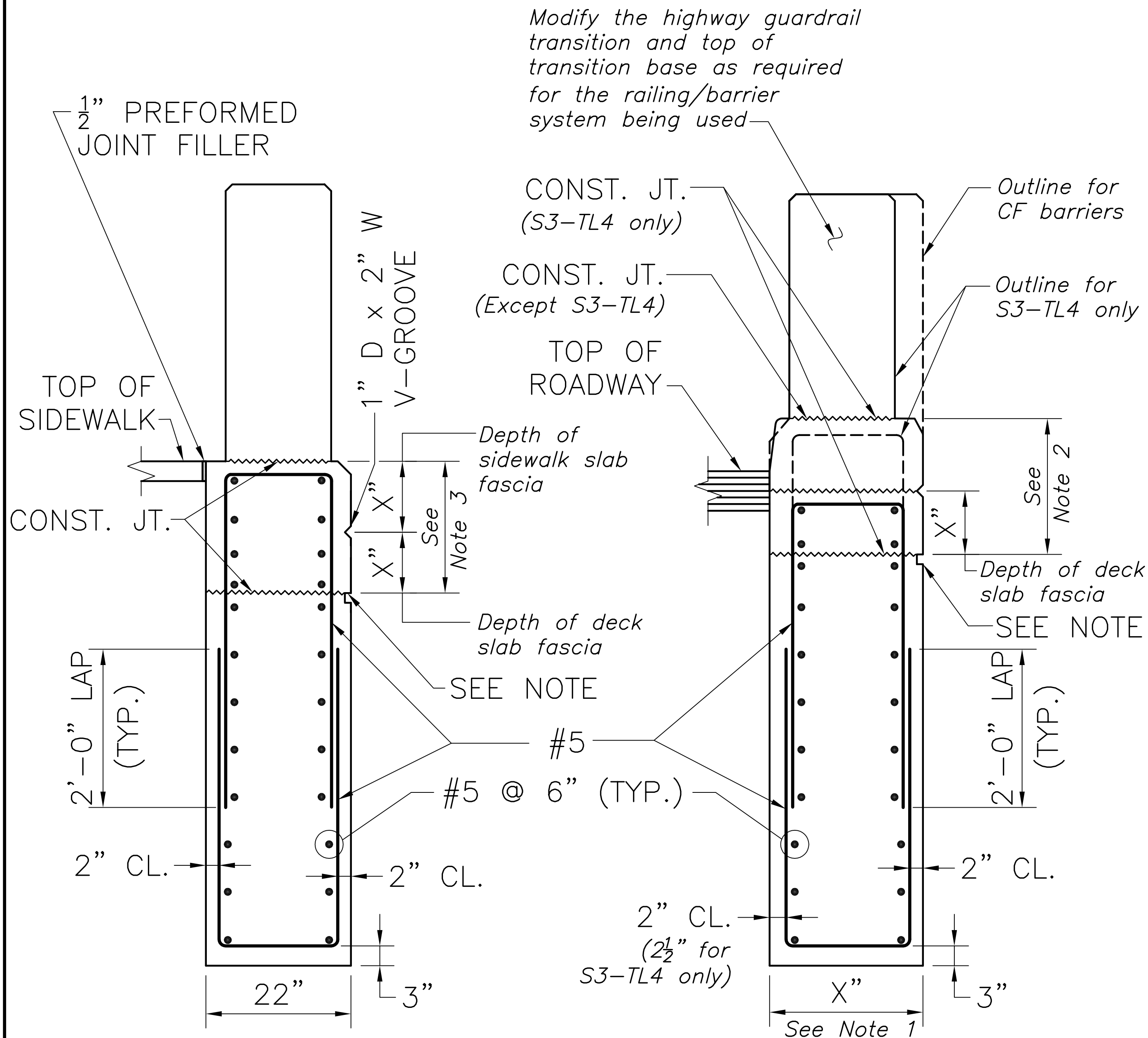
GUARDRAIL TRANSITION BASE ELEVATION

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *Guardrail transition base support is provided to prevent vertical misaligment between highway guardrail transition and approach guardrail due to settlement.*
2. *Elevation at sidewalk for S3-TL4 shown. Elevation for other railings/barriers and at safety curb is similar.*

MASS HIGHWAY BRIDGE MANUAL	GUARDRAIL TRANSITION BASE ELEVATION AT U-WINGWALLS WINGWALL DETAILS	DATE OF ISSUE AUGUST 2007 DRAWING NUMBER **3.2.11**



NOTE:

$1\frac{1}{2}$" H x 1" D GROOVE. ALIGN WITH GROOVE AT TOP OF STRIATIONS.

SIDEWALK SECTION 1

SCALE: $\frac{1}{2}$" = 1'-0"

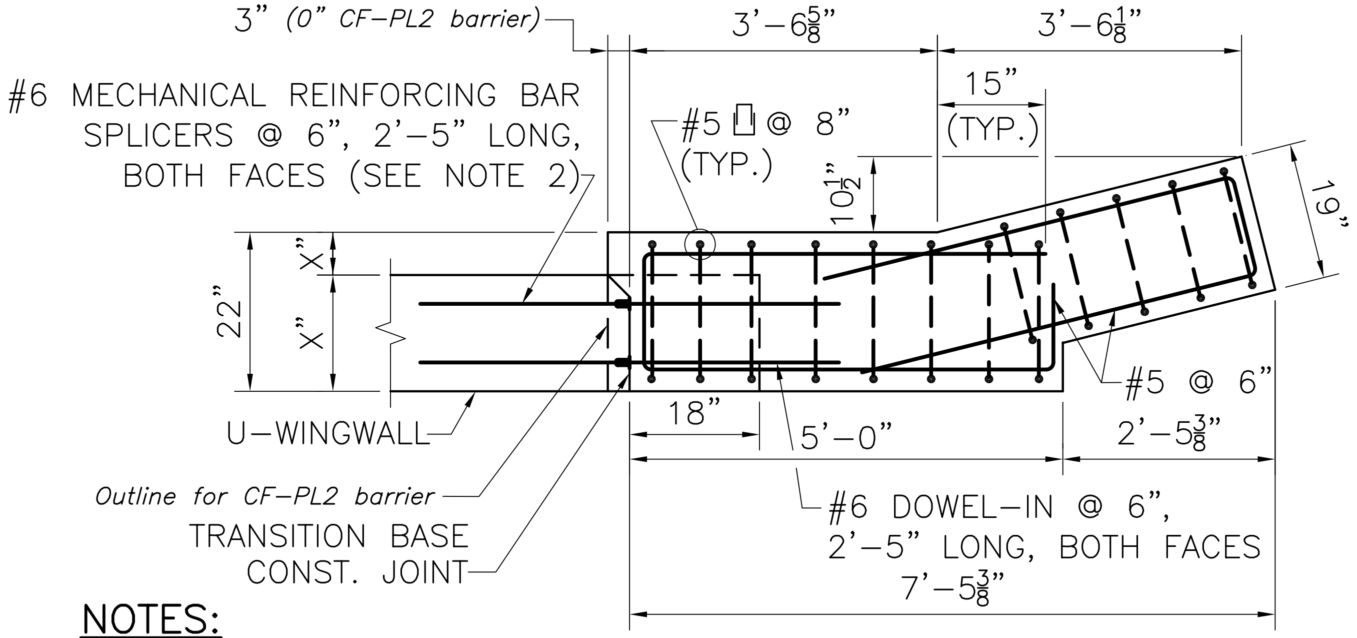
SAFETY CURB AND CF BARRIER SECTION 1

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *X = 2'-0" for CF-PL3 barrier and X = 22" for all other railing/barrier systems.*
2. *The Designer shall verify that this dimension is at least $16\frac{1}{2}$" for S3-TL4 railing. If not, set it to $16\frac{1}{2}$" along the entire U-Wingwall.*
3. *For S3-TL4 railing set this dimension to $16\frac{1}{2}$".*

MASS HIGHWAY BRIDGE MANUAL	GUARDRAIL TRANSITION BASE SECTIONS AT U-WINGWALLS WINGWALL DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.2.12**



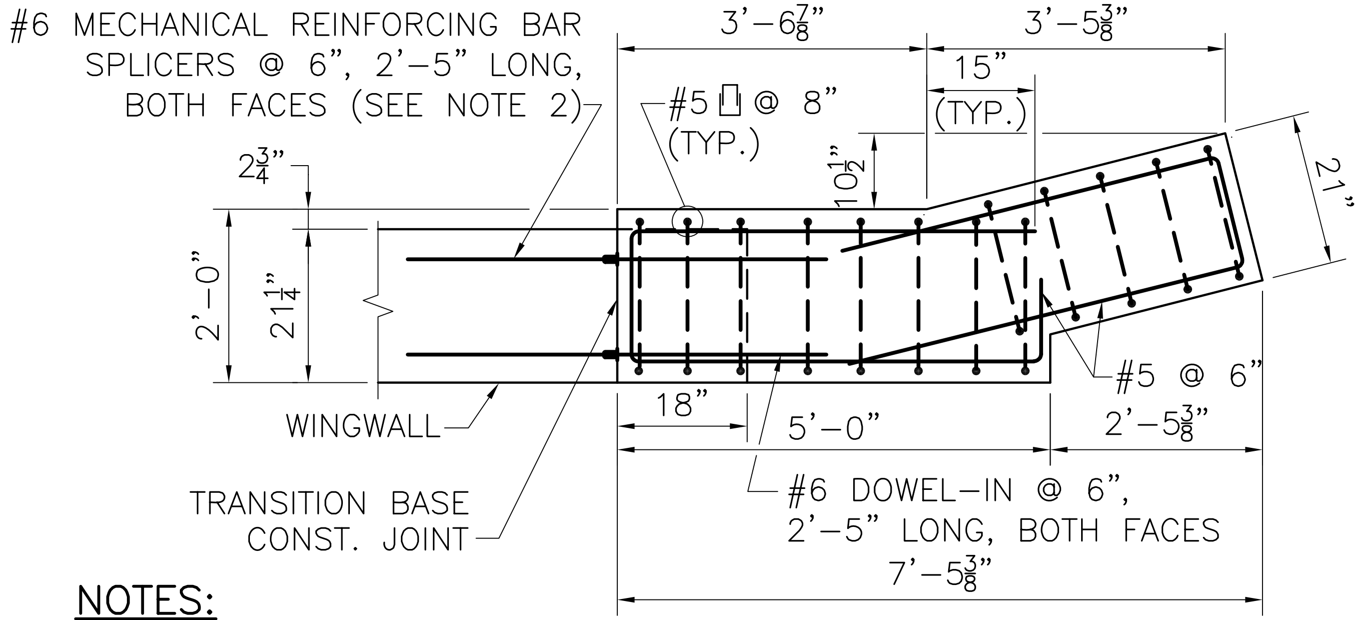
NOTES:

1. WINGWALL REINFORCEMENT AND STRIATIONS NOT SHOWN FOR CLARITY.

2. THE CONTRACTOR MAY SUBSTITUTE #6 DOWELS, 4'–10" LONG FOR MECHANICAL REINFORCING BAR SPLICERS AND THREADED REBAR.

SECTION 2 *(All Barriers except CF–PL3)*

SCALE: $\frac{1}{2}$" = 1'–0"



NOTES:

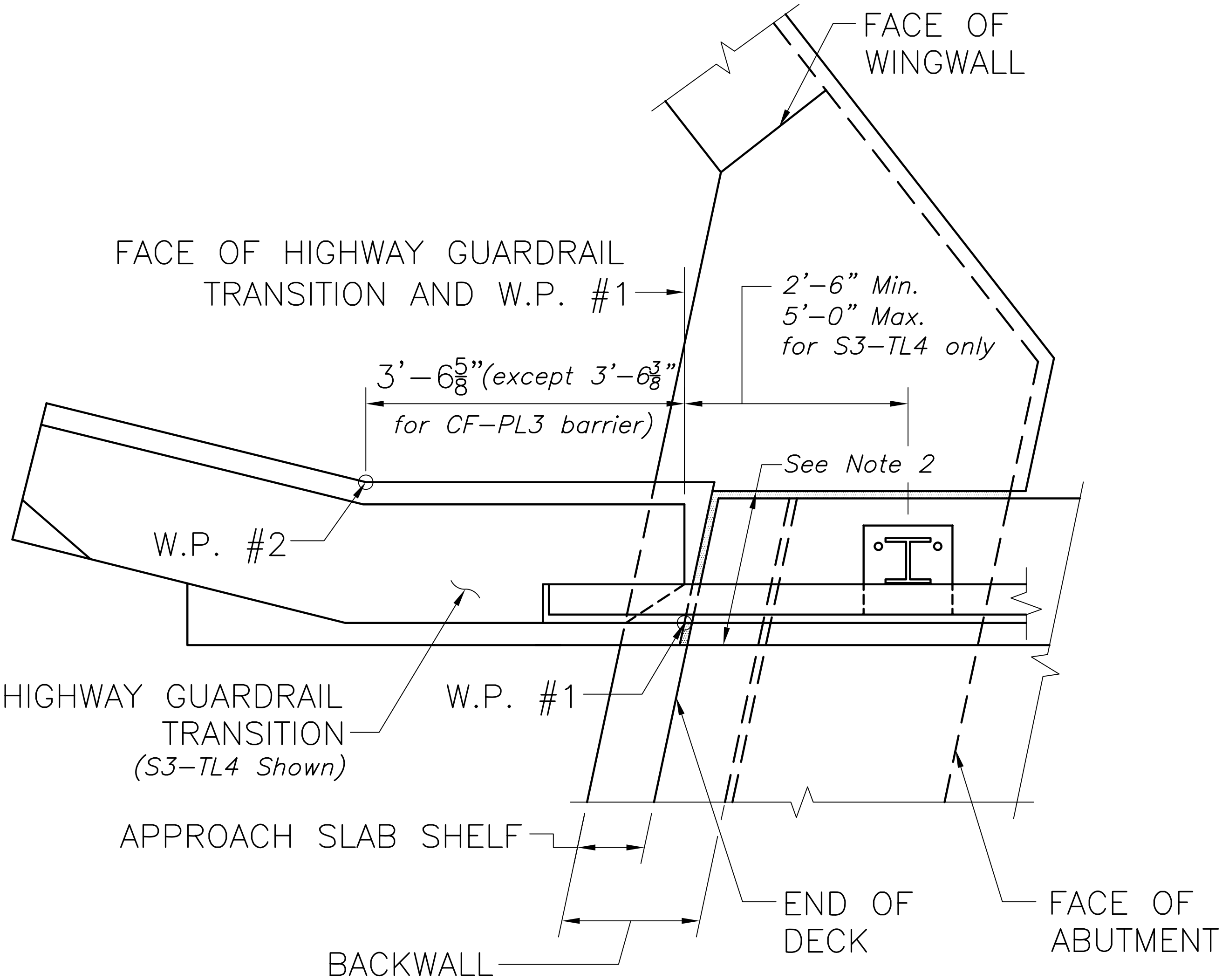
1. WINGWALL REINFORCEMENT AND STRIATIONS NOT SHOWN FOR CLARITY.

2. THE CONTRACTOR MAY SUBSTITUTE #6 DOWELS, 4'–10" LONG FOR MECHANICAL REINFORCING BAR SPLICERS AND THREADED REBAR.

SECTION 2 *(CF–PL3 Barrier)*

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	GUARDRAIL TRANSITION BASE HORIZONTAL SECTIONS WINGWALL DETAILS	DATE OF ISSUE AUGUST 2007 DRAWING NUMBER **3.2.13**

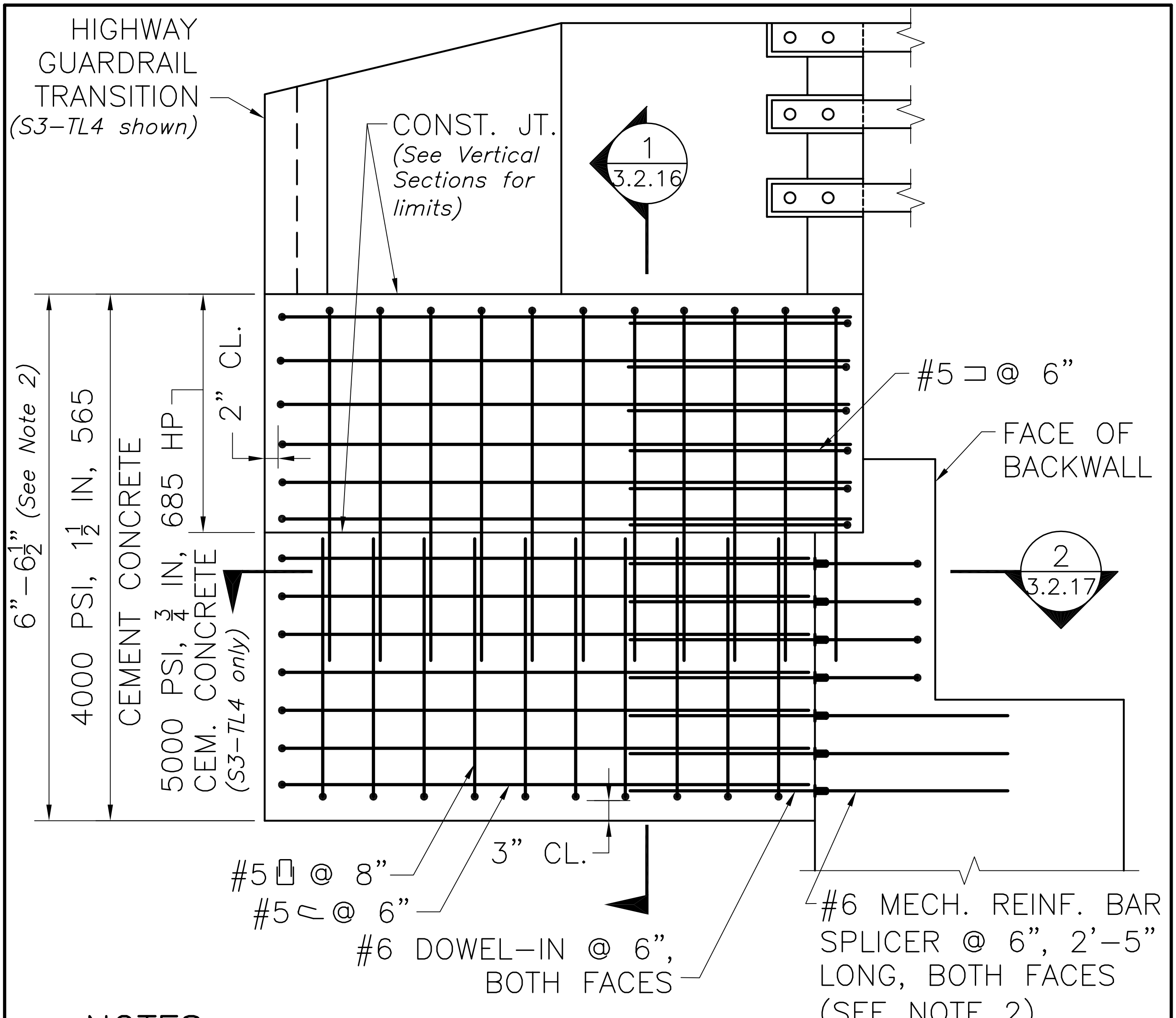


GUARDRAIL TRANSITION PLAN AT SPLAYED WINGWALL

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Striations not shown for clarity.*
2. *For skews up to 30°, the transition base end may be angled to follow the skew. For skews greater than 30°, the transition base end, the backwall, and the bridge end shall be set square to the curb line to eliminate acute corners.*



NOTES:

1. GRAVEL BORROW SHALL BE PLACED AND THOROUGHLY COMPACTED TO THE GRADE OF THE BOTTOM OF THE GUARDRAIL TRANSITION BASE BEFORE PLACING THE GUARDRAIL TRANSITION BASE CONCRETE. *(See Note 2)*
2. THE CONTRACTOR MAY SUBSTITUTE #6, 4'–10" LONG FOR THE MECHANICAL REINFORCING BAR SPLICERS FOR THE DOWEL BAR SLICER AND THREADED REBAR.

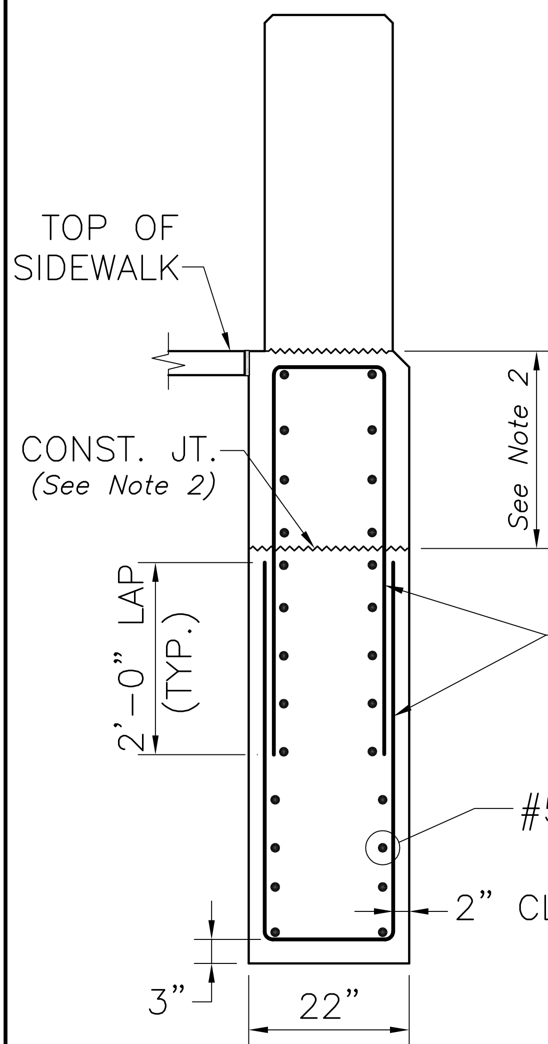
GUARDRAIL TRANSITION BASE ELEVATION

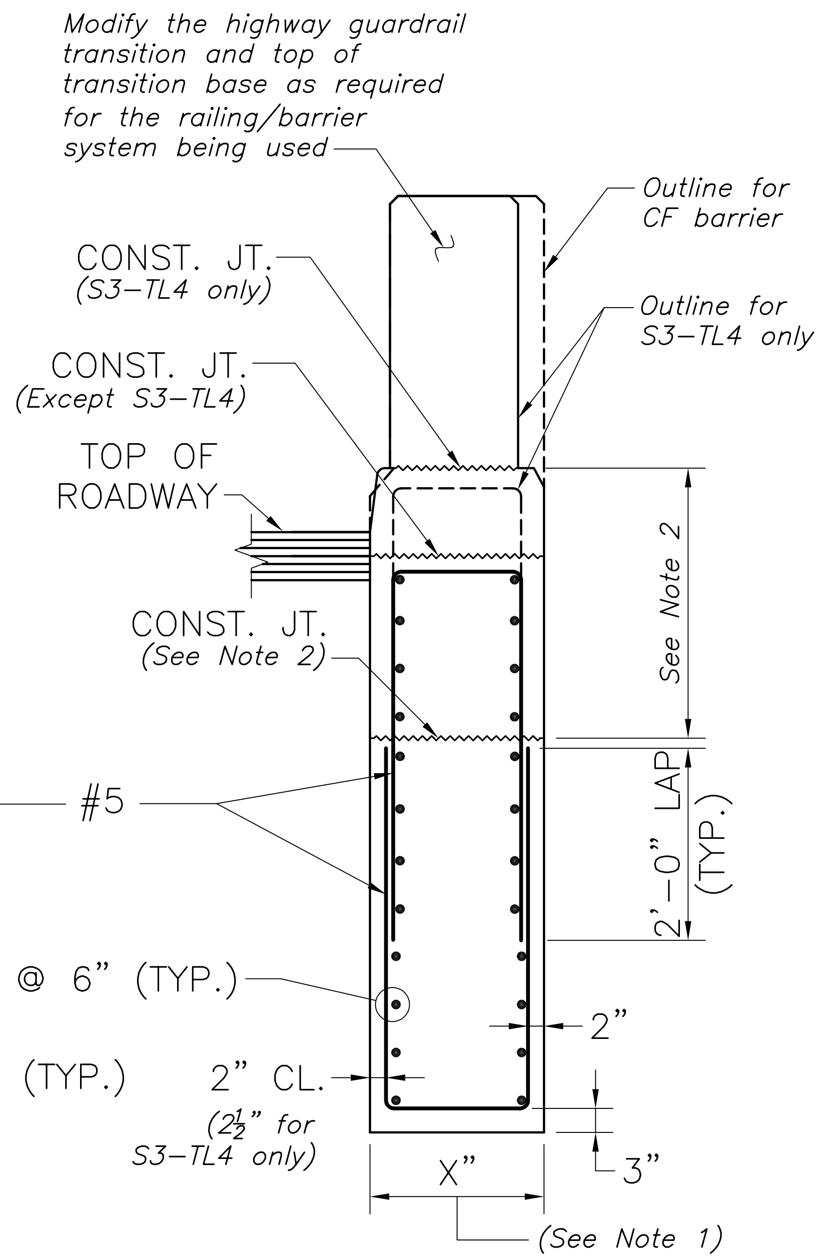
SCALE: ½" = 1'–0"

NOTES:

1. *Elevation at sidewalk for S3–TL4 shown. Elevation for other railings/barriers and at safety curb similar.*
2. *When abutment height is less than 12'–0", extend transition base to top of footing, provide hooked #5 dowels into abutment and eliminate Construction Note No. 1.*

MASS HIGHWAY BRIDGE MANUAL	TRANSITION BASE ELEVATION AT SPLAYED WINGWALL WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.2.15**





SIDEWALK SECTION 1

SCALE: $\frac{1}{2}$" = 1'–0"

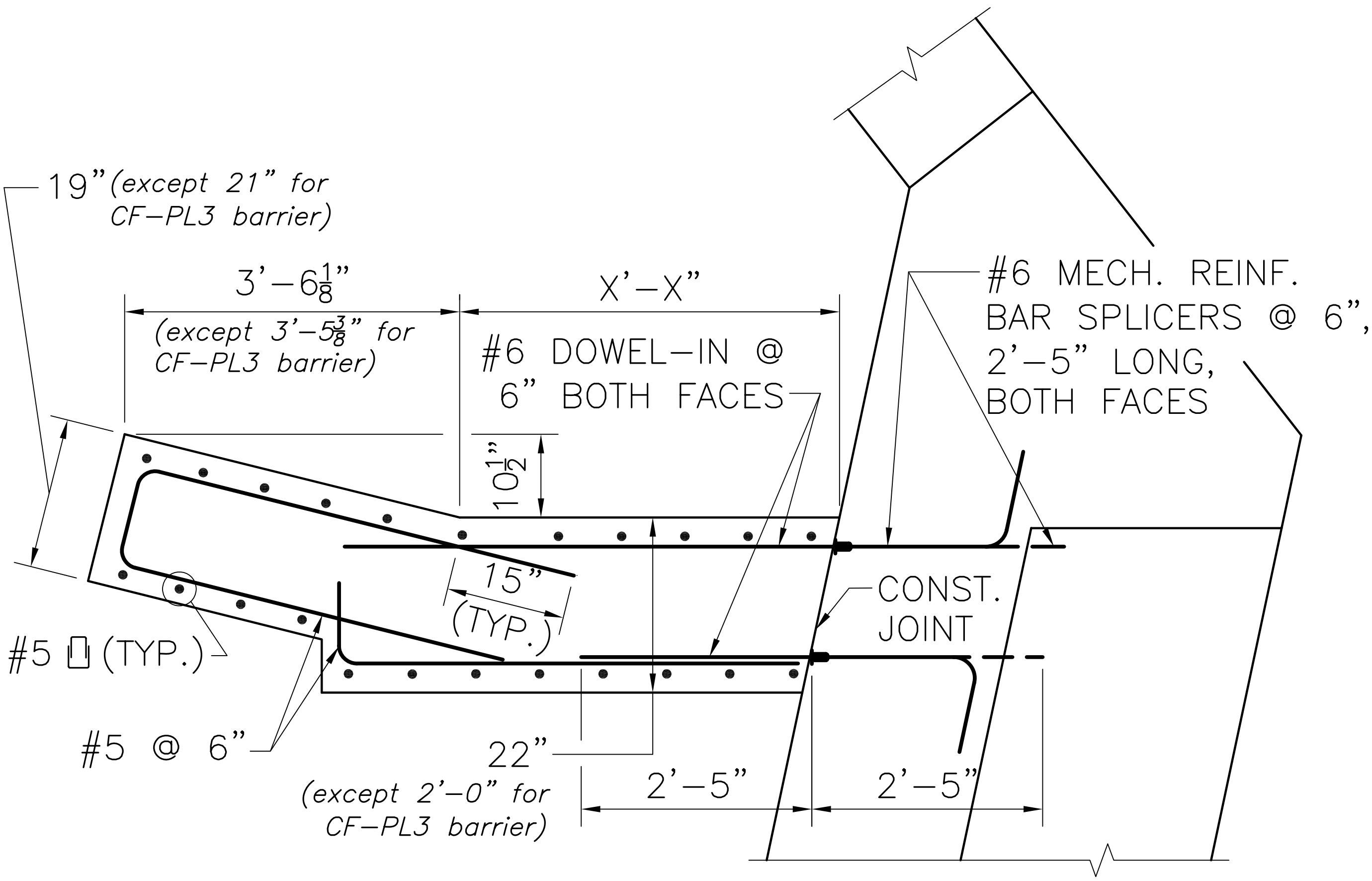
SAFETY CURB AND CF BARRIER SECTION 1

SCALE: $\frac{1}{2}$" = 1'–0"

Notes:

1. *X = 2'–0" for CF–PL3 barrier and X = 22" for all other railing/barrier systems.*
2. *The need for and location of this construction joint depends on the particular End of Deck Details being used. The S3–TL4 railing transition always requires this construction joint and the top of pour to be a minimum $16\frac{1}{2}$" deep.*

MASS HIGHWAY BRIDGE MANUAL	GUARDRAIL TRANSITION BASE VERTICAL SECTIONS WINGWALL DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.2.16**



NOTES:

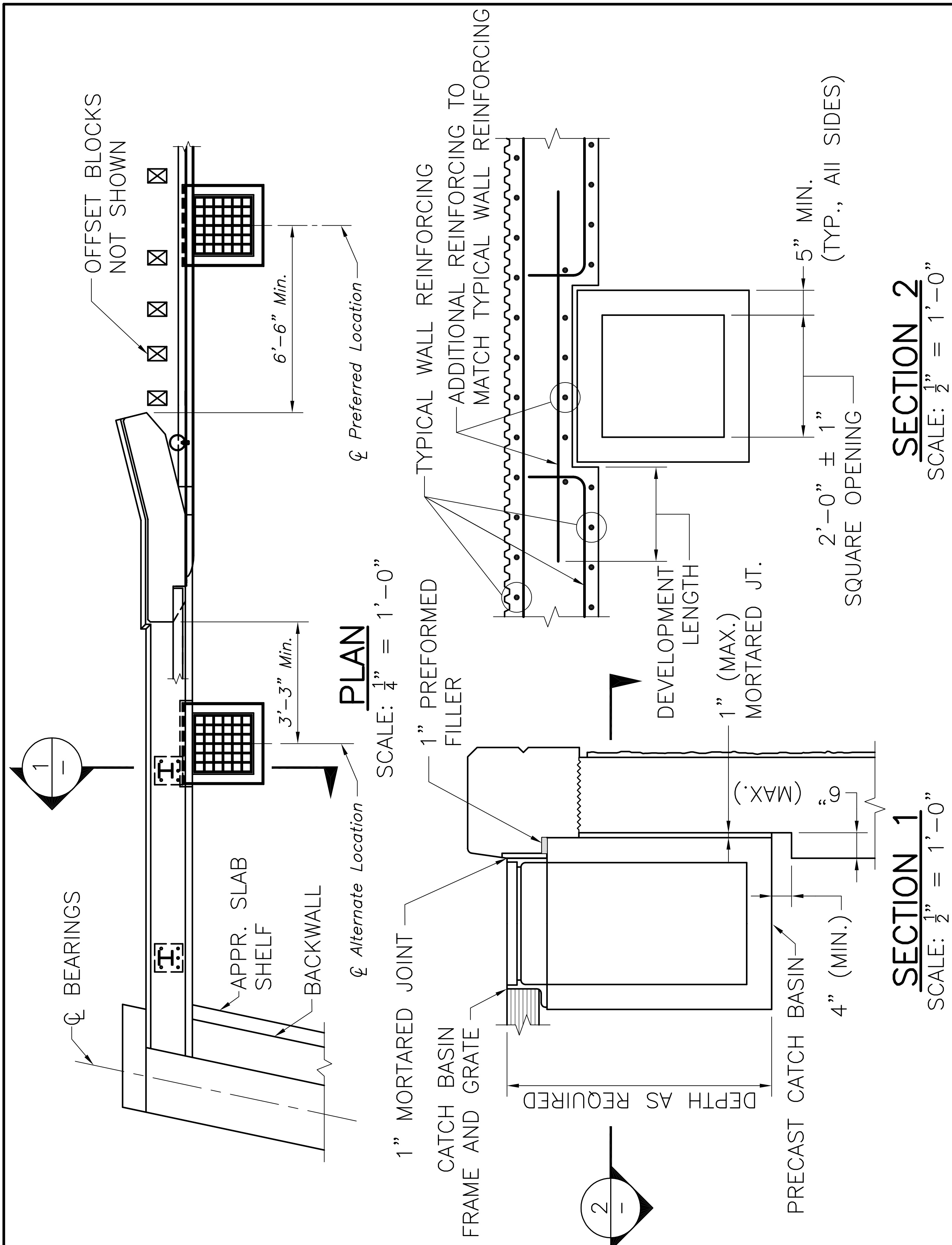
1. BACKWALL REINFORCEMENT AND STRIATIONS NOT SHOWN FOR CLARITY.

2. THE CONTRACTOR MAY SUBSTITUTE #6 DOWELS FOR THE MECHANICAL REINFORCING BAR SPLICER AND THE DOWEL–IN. EMBED STRAIGHT BARS AS SHOWN IN ABUTMENT AND USE HOOKED BARS AS SHOWN IN THE BACKWALL.

SECTION 2

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	GUARDRAIL TRANSITION BASE HORIZONTAL SECTION WINGWALL DETAILS	DATE OF ISSUE: AUGUST 2007 DRAWING NUMBER: **3.2.17**



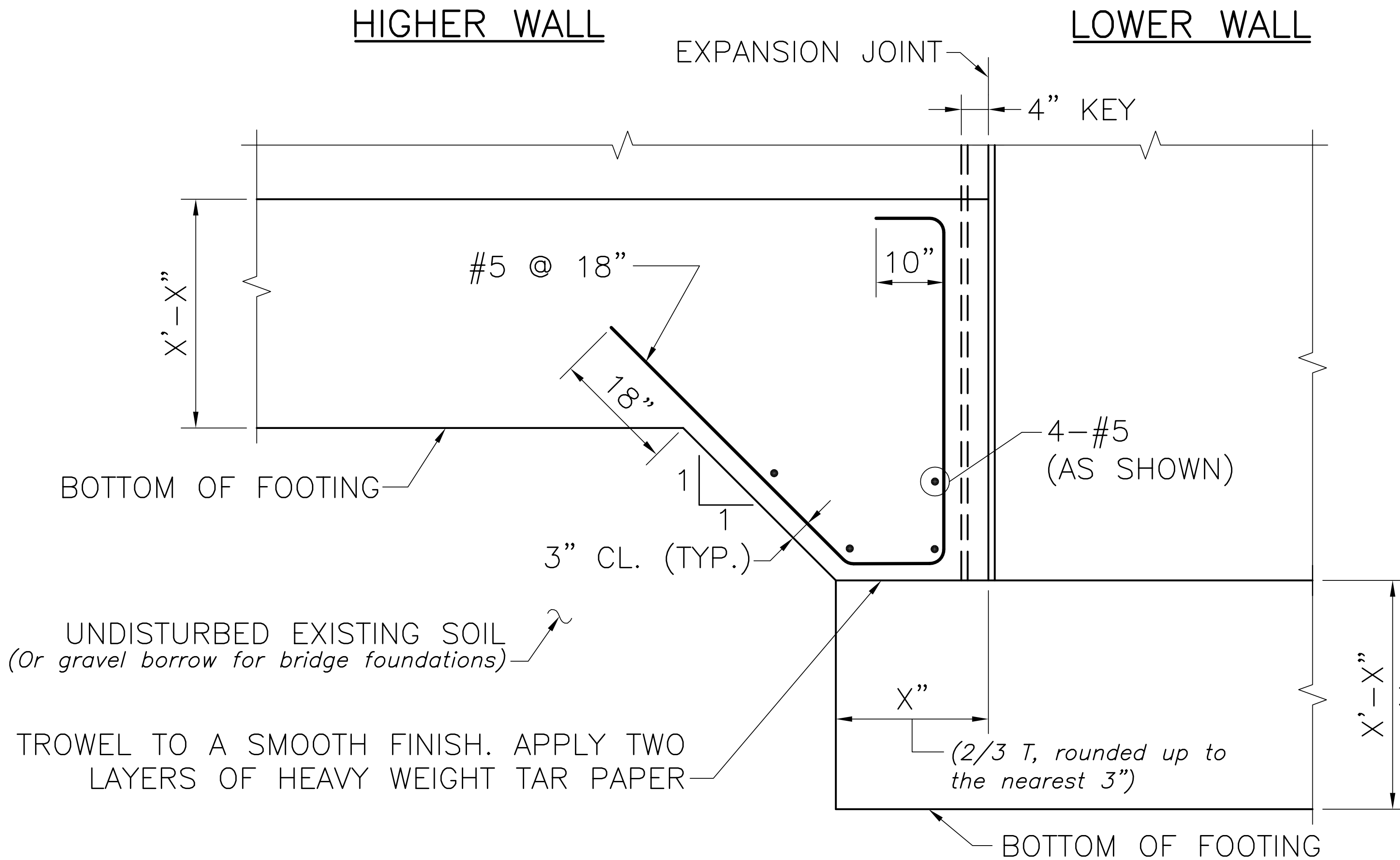
MASS HIGHWAY
BRIDGE MANUAL

CATCH BASIN AT U-BACK WINGWALL

WINGWALL DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.2.18

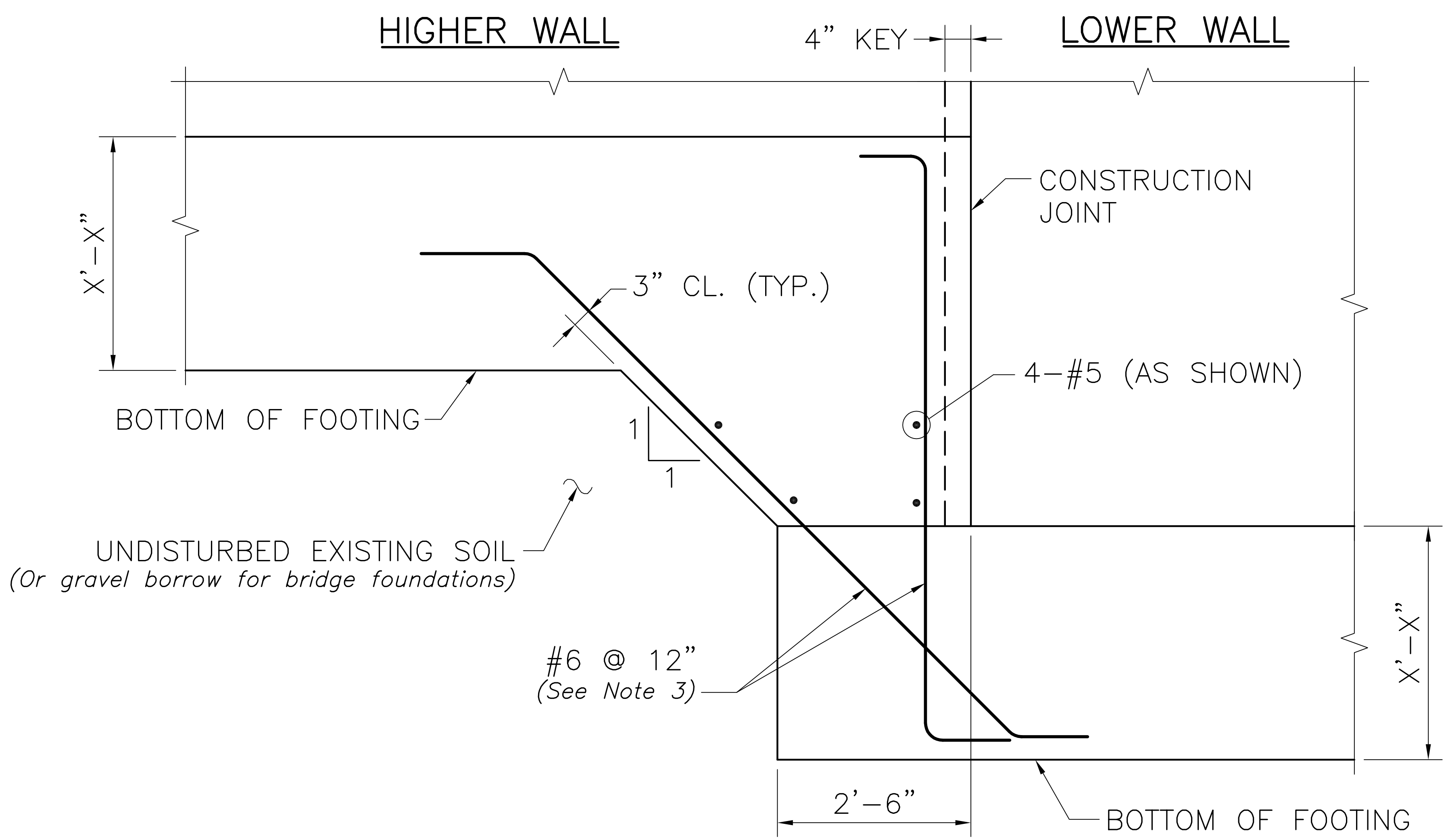


STEPPED–UP FOOTING DETAIL

SCALE: $\frac{1}{2}$” = 1’–0”

NOTES:

1. *This detail may be used for cantilever or gravity walls or a combination of cantilever and gravity walls.*
2. *Height of step from bottom of higher footing to bottom of lower footing shall not be excessive. A step height of about 5’–0” is reasonable.*



STEPPED–UP FOOTING DETAIL

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *This detail may be used for cantilever or gravity walls or a combination of cantilever and gravity walls.*
2. *Height of step from bottom of higher footing to bottom of lower footing shall not be excessive. A step height of about 5'–0" is reasonable.*
3. *Provide proper embedment lengths and clearances for #6 @ 12" on the Construction Drawings.*

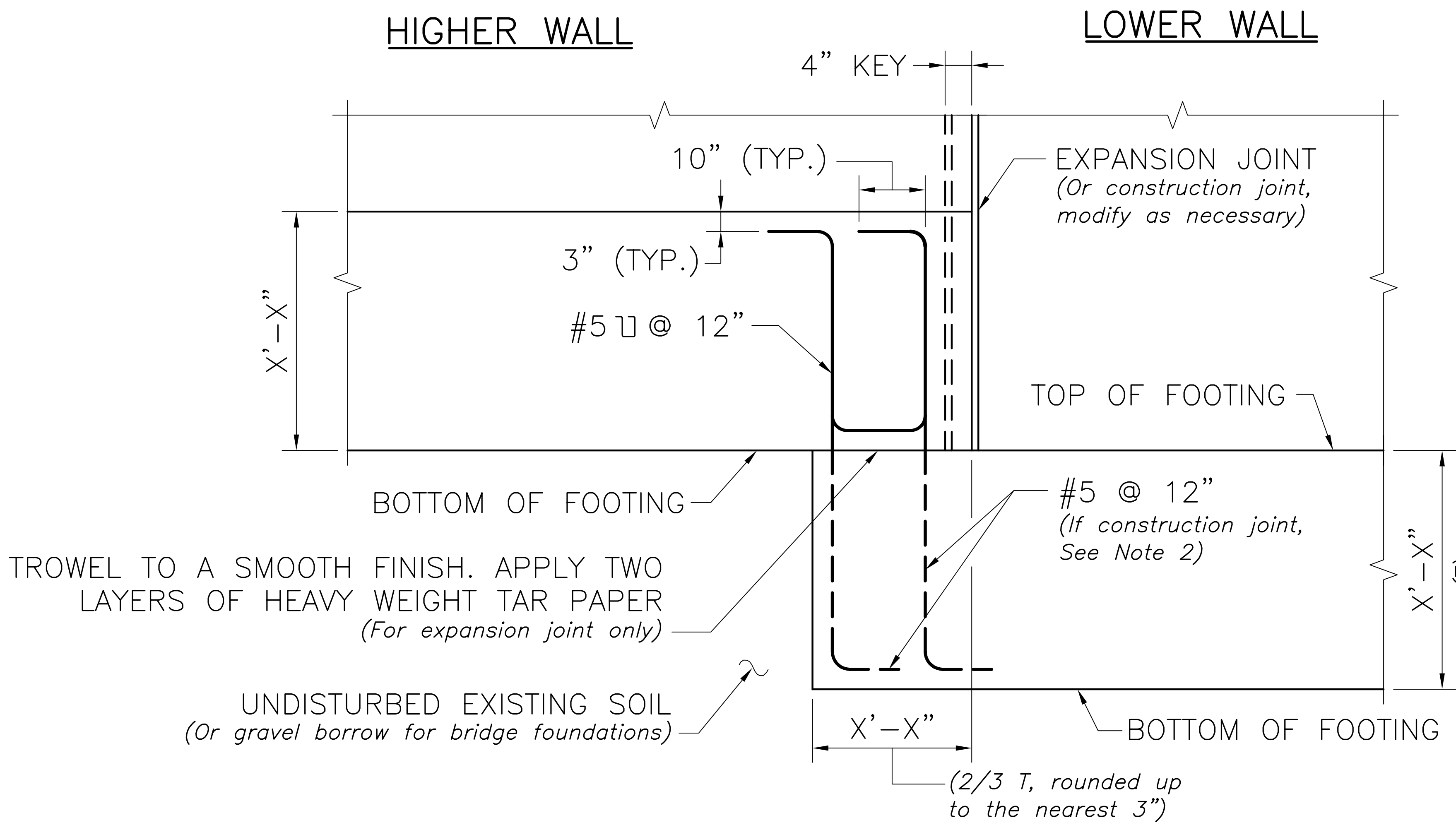
MASS HIGHWAY
BRIDGE MANUAL

CONSTRUCTION JOINT AT STEP

STEPPED–UP FOOTING

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.3.2



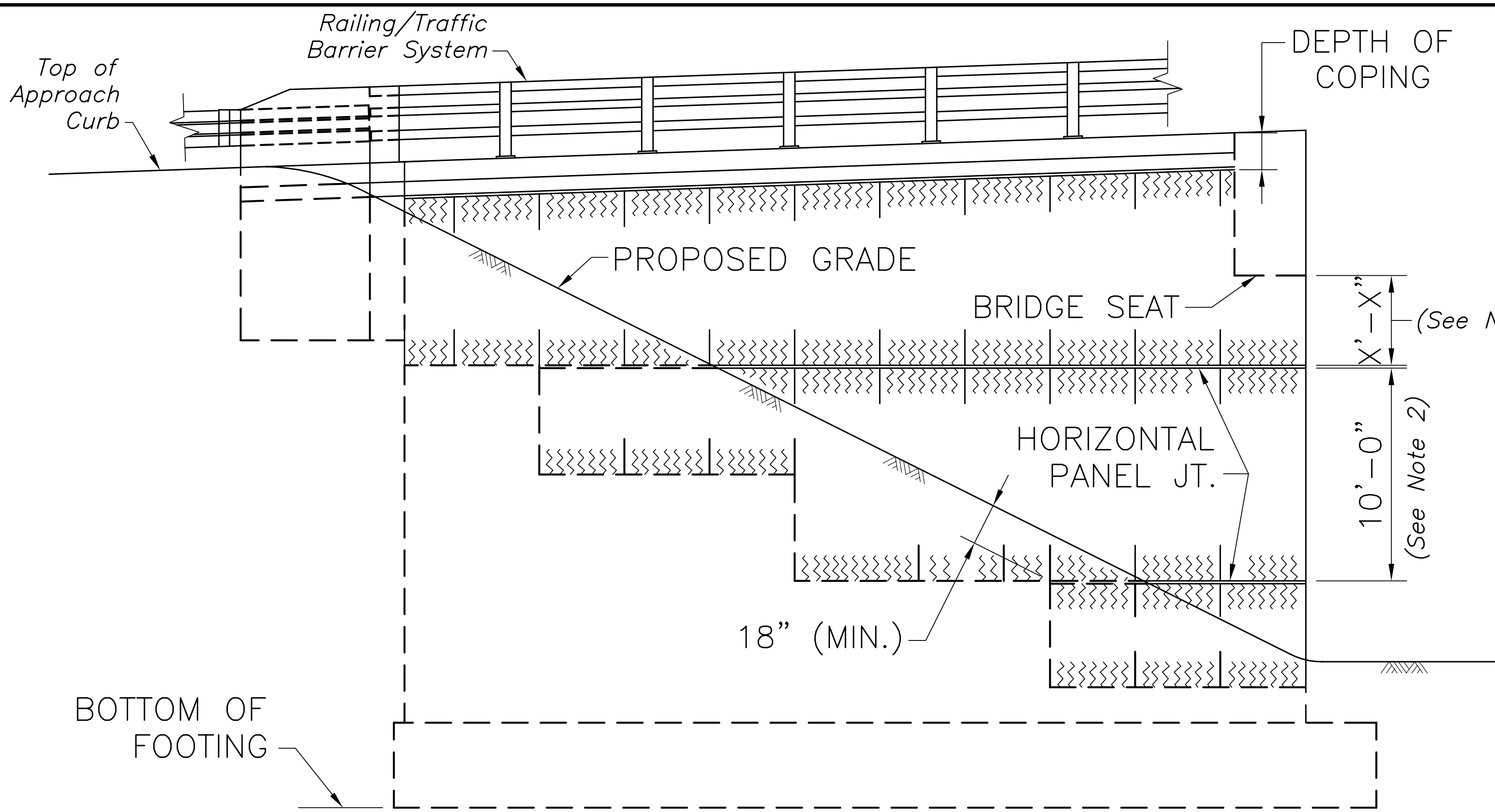
STEPPED–UP FOOTING DETAIL

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *This detail may be used for cantilever or gravity walls or a combination of cantilever and gravity walls.*
2. *For construction joints only, extend #5 @ 12" bars from higher footing into lower wall footing when cantilever walls are used. Provide proper embedment lengths on the Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	UPPER FOOTING ON LOWER FOOTING STEPPED–UP FOOTING	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.3.3**



NOTE:
HORIZONTAL PANEL JOINTS SHALL BE LEVEL.

ELEVATION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. *A detailed elevation view of the abutment and wingwalls shall be drawn to scale, without breaks, and shall include the above information and depiction of the striations. In addition it shall include all other relevant dimensions and elevations. See elevation view of splayed wingwalls for abutment details.*
2. *The nominal size of a typical striation form liner panel is 4'–0" W x 10'–0" H. These dimensions should be used as a guide in laying out the location of the construction, expansion, and horizontal panel joints.*
3. *Set horizontal panel joint a minimum of 4'–0" below the lowest point of the bridge seat. All other horizontal panel joints shall be dimensioned from this one. All joint lines shall be continuous across wingwalls and abutments.*

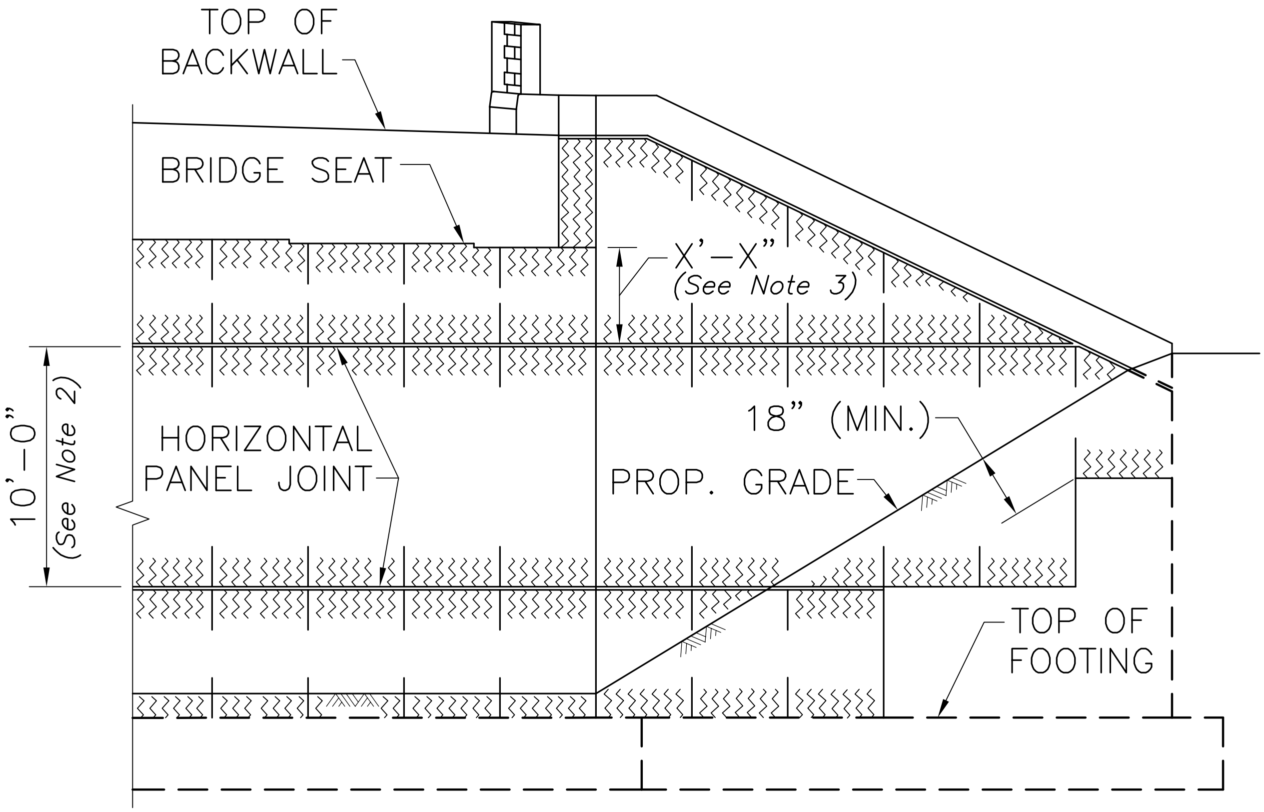
MASS HIGHWAY BRIDGE MANUAL

U–WINGWALLS

STRIATION DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.4.1



NOTE:
HORIZONTAL PANEL JOINTS SHALL BE LEVEL.

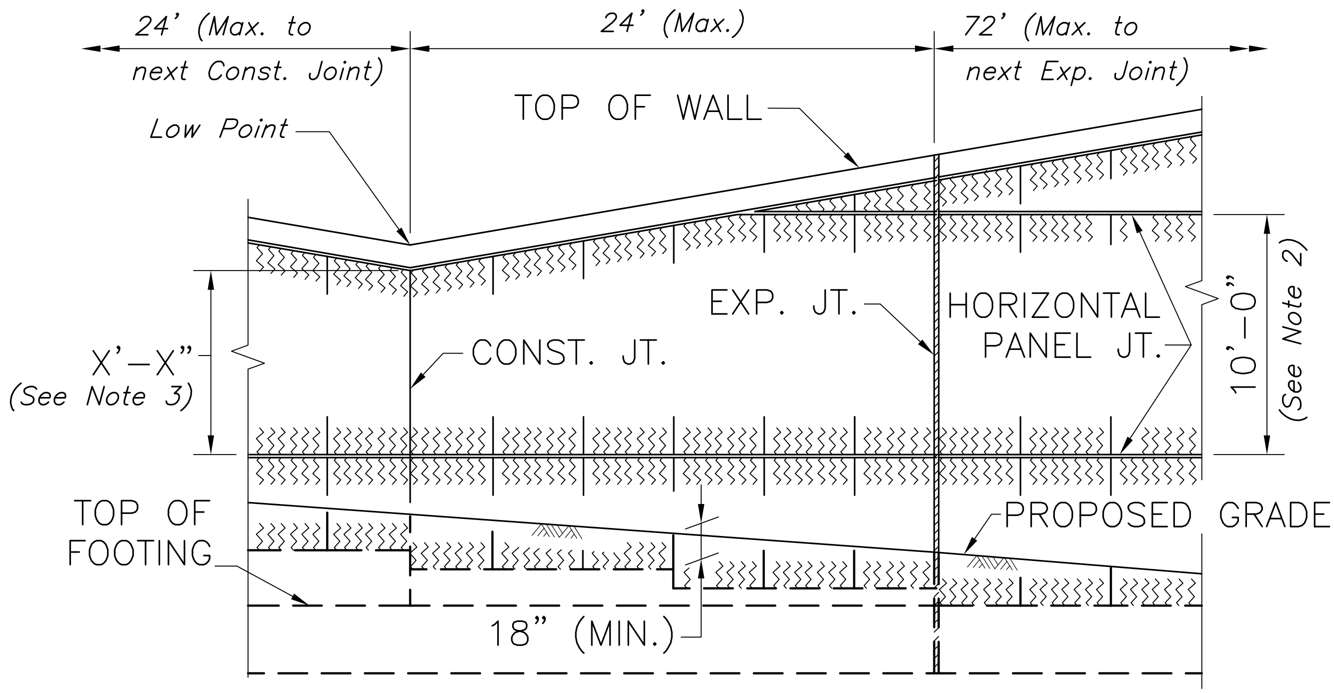
ELEVATION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. *A detailed elevation view of the abutment and wingwalls shall be drawn to scale, without breaks, and shall include the above information and depiction of the striations. In addition it shall include all other relevant dimensions and elevations.*
2. *The nominal size of a typical striation form liner panel is 4'–0" W x 10'–0" H. These dimensions should be used as a guide in laying out the location of the construction, expansion, and horizontal panel joints.*
3. *Set horizontal panel joint a minimum of 4'–0" below the lowest point of the bridge seat. All other horizontal panel joints shall be dimensioned from this one. All joint lines shall be continuous across wingwalls and abutment.*

MASS HIGHWAY BRIDGE MANUAL	ABUTMENT AND SPLAYED WINGWALLS STRIATION DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 3.4.2



NOTE:

HORIZONTAL PANEL JOINTS SHALL BE LEVEL.

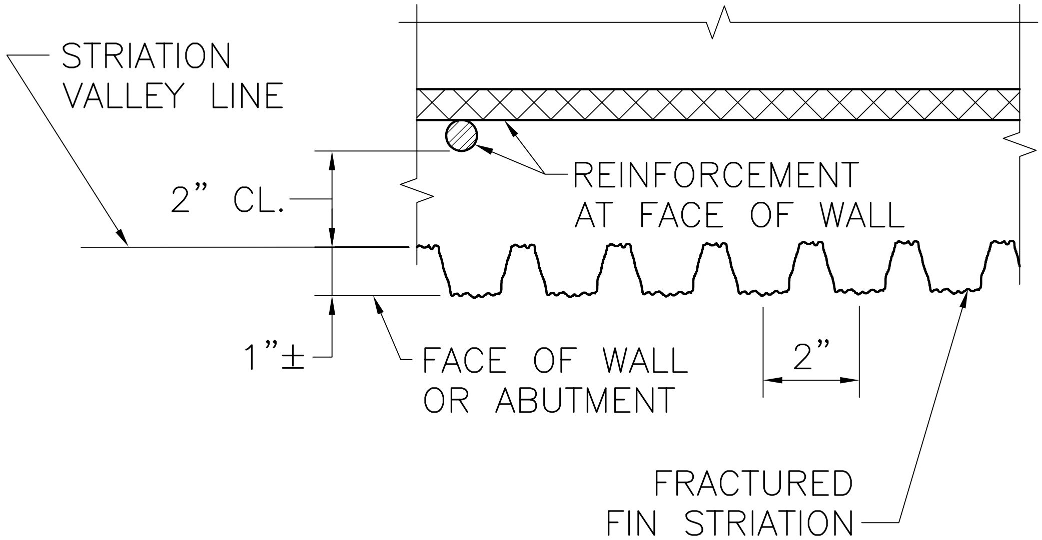
ELEVATION

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

1. *A detailed elevation view of a retaining wall shall be drawn to scale and shall include the above information and depiction of the striations. In addition, it shall include all other relevant dimensions and elevations.*
2. *The size of a nominal typical striation form liner panel is 4'–0" W x 10'–0" H. These dimensions should be used as a guide in laying out the location of the construction, expansion, and horizontal panel joints.*
3. *When a horizontal panel joint will not intercept the top of wall coping, set this horizontal joint a minimum of 4'–0" below the lowest point on the wall. Any smaller dimensions may cause the sloping coping lines to clash visually with the level hoizontal joint.*
4. *If a long retaining wall abuts or extends from a bridge abutment or wingwall, the horizontal joints should be continuous through all striated wall surfaces.*

MASS HIGHWAY BRIDGE MANUAL	LONG RETAINING WALLS STRIATION DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.4.3**



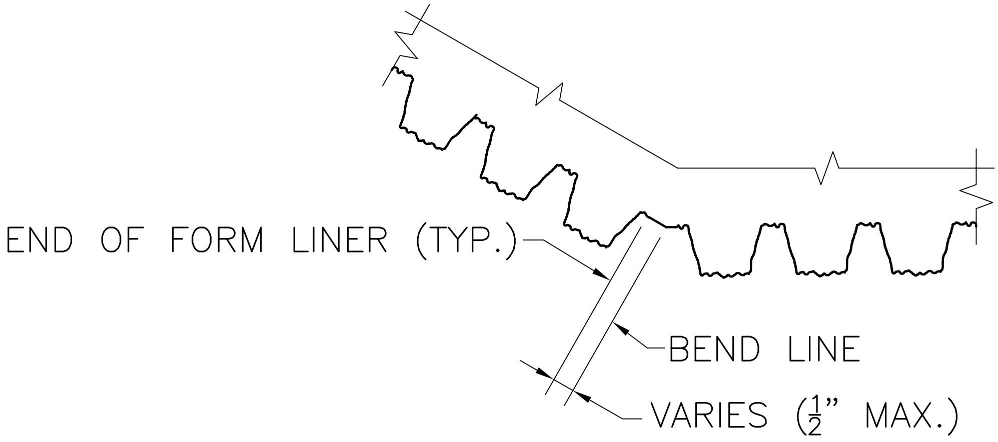
NOTES:

1. THE CONTRACTOR SHALL MAKE SURE THAT THE STRIATION FINS ARE PLUMB AND LINED UP VERTICALLY FROM PANEL TO PANEL FOR THE FULL HEIGHT OF THE WALL.

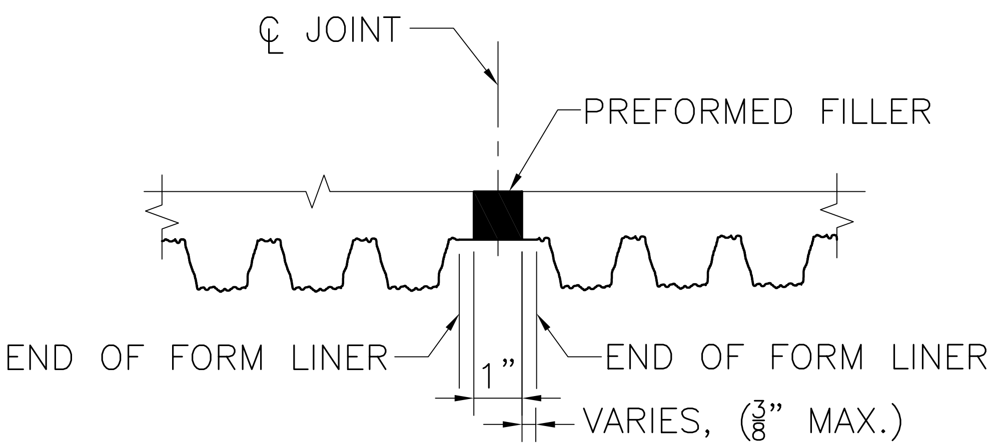
2. THE HORIZONTAL JOINT MAY BE OMITTED IF THE CONTRACTOR CAN DEMONSTRATE THAT THE FORM LINER PANELS CAN BE INSTALLED END TO END WITHOUT CREATING A VISIBLE SEAM IN THE FINAL CAST CONCRETE.

TYPICAL STRIATION DETAIL

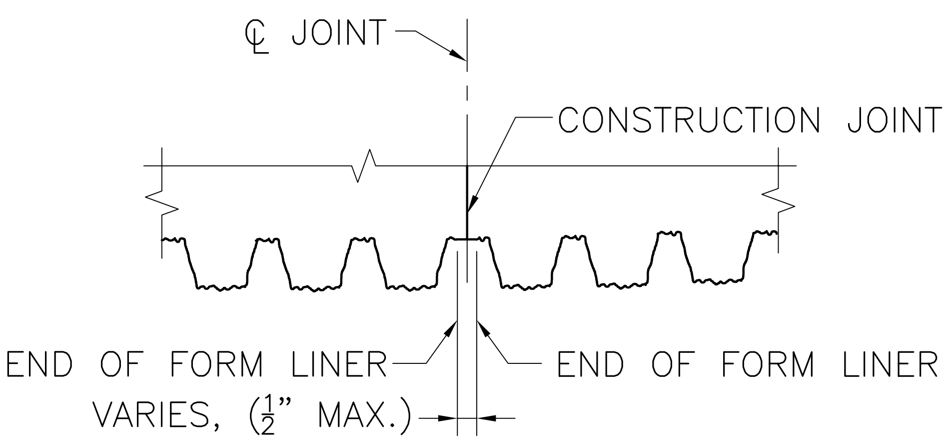
SCALE: 3" = 1'-0"



DETAIL AT WALL CORNER
SCALE: 3" = 1'–0"

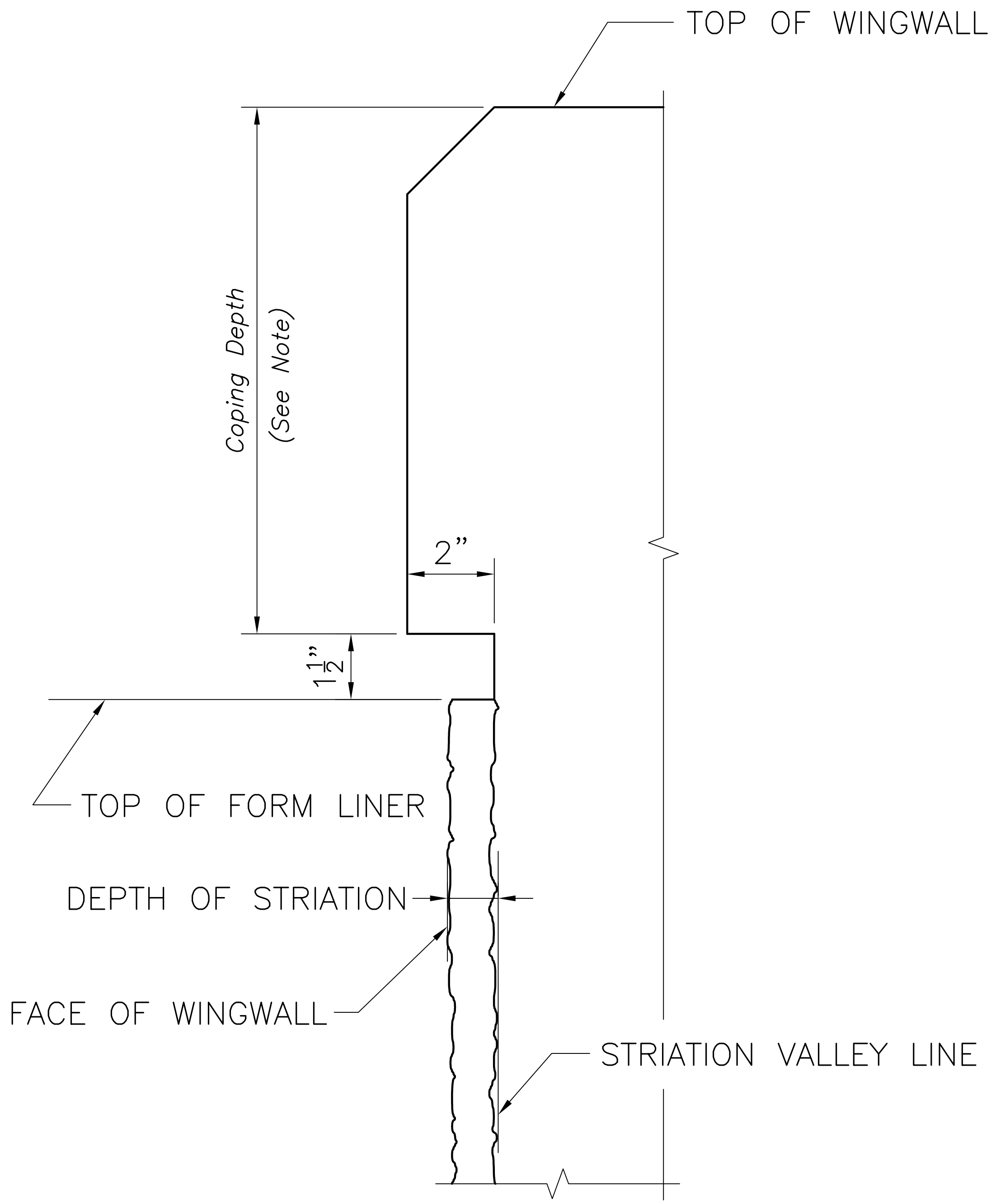


EXPANSION JOINT
SCALE: 3" = 1'–0"



CONSTRUCTION JOINT
SCALE: 3" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	DETAILS AT CORNERS AND JOINTS STRIATION DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.4.5**



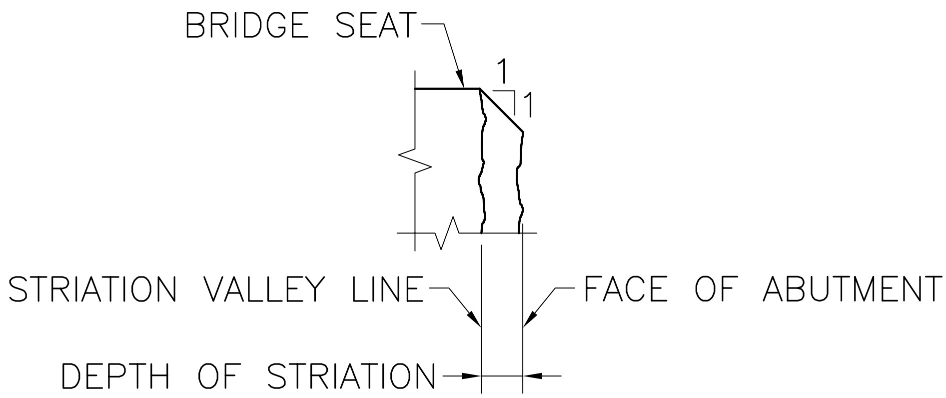
DETAIL AT TOP OF WINGWALL

SCALE: 3" = 1'-0"

NOTE:

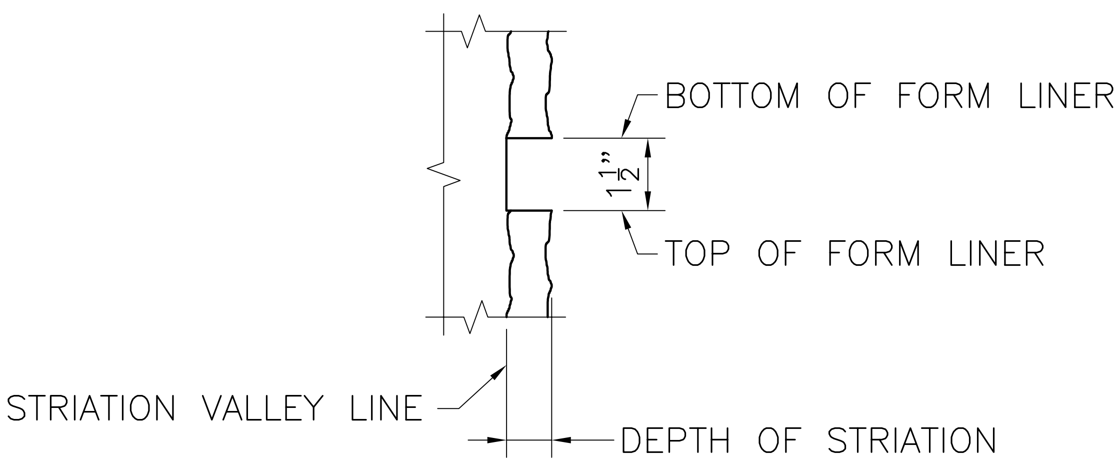
For Splayed Wingwalls, coping depth is 12" with 2" chamfer at the top. For U-Wingwalls, match the detail shown in the Top of Wingwall Details (Chapter 9, Railing/Traffic Barrier Systems) for the type of bridge rail used.

MASS HIGHWAY BRIDGE MANUAL	DETAIL AT TOP OF WINGWALL STRIATION DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.4.6**



DETAIL AT BRIDGE SEAT

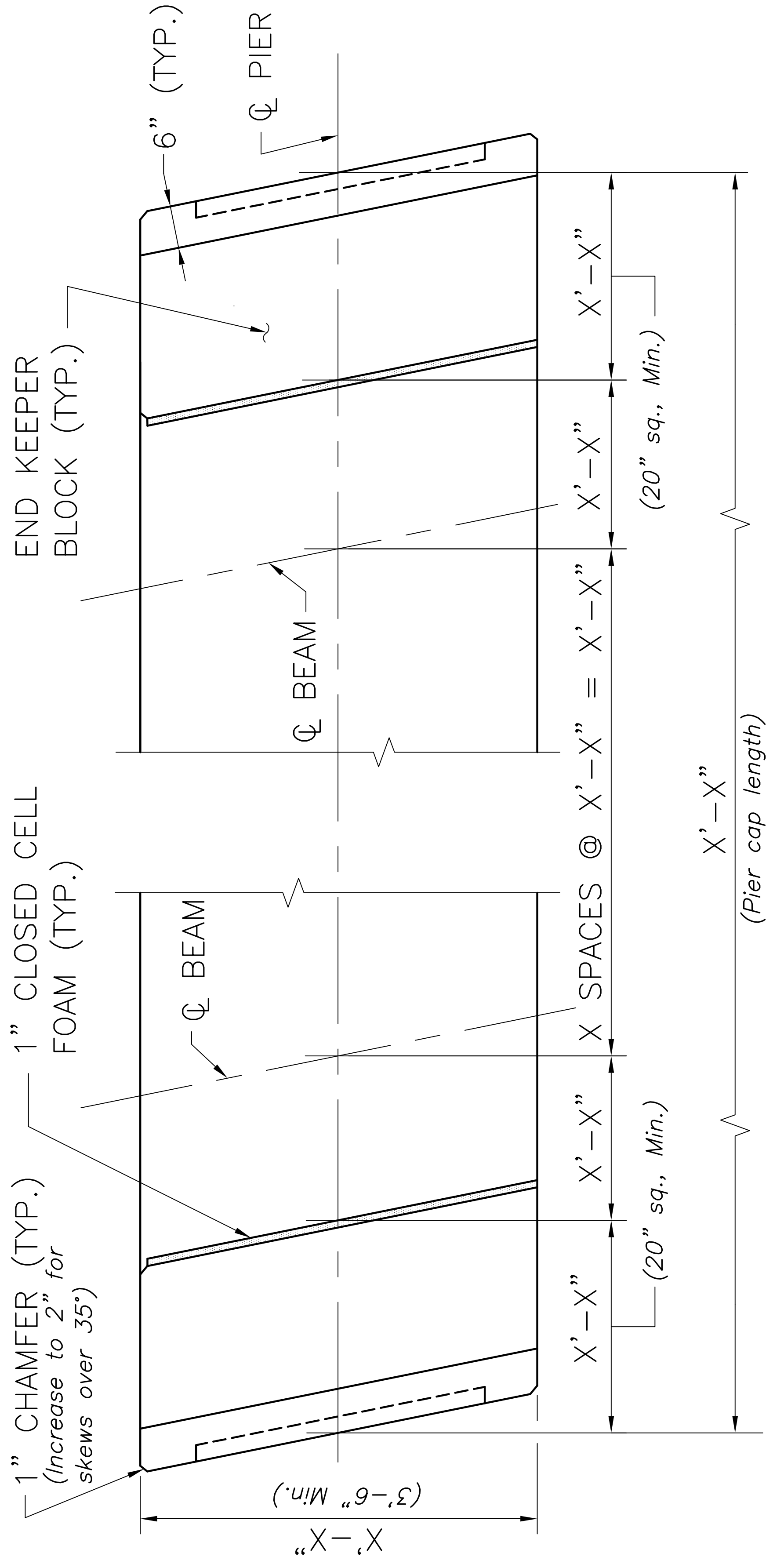
SCALE: 3" = 1'–0"



HORIZONTAL PANEL JOINT

SCALE: 3" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	MISCELLANEOUS DETAILS	DATE OF ISSUE MAY 2005
	STRIATION DETAILS	DRAWING NUMBER **3.4.7**



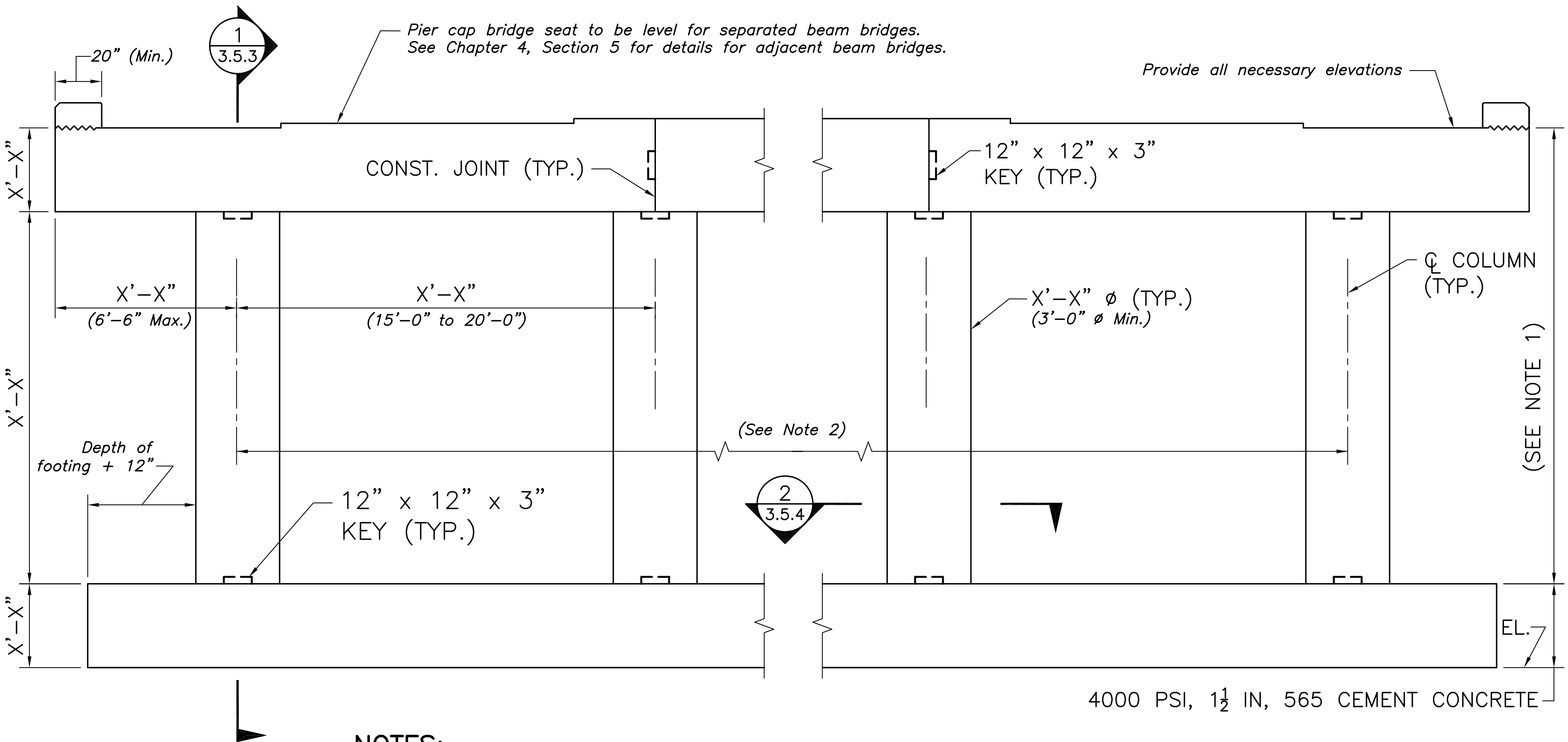
PLAN OF PIER

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. General plan view of pier shown. See Chapters 4, 5 & 6 for details.
2. Plan view of pier shall be drawn without breaks and to scale on the Construction Drawings. Include footing and all relevant dimensions, angles, survey information and North Arrow.

MASS HIGHWAY BRIDGE MANUAL	TYPICAL PLAN	DATE OF ISSUE MAY 2005
	PIER DETAILS	DRAWING NUMBER **3.5.1**



NOTES:

1. 4000 PSI, ¾ IN, 585 HP CEMENT CONCRETE. *(corrosive environments)*
   4000 PSI, ¾ IN, 610 CEMENT CONCRETE. *(non–corrosive environments)*

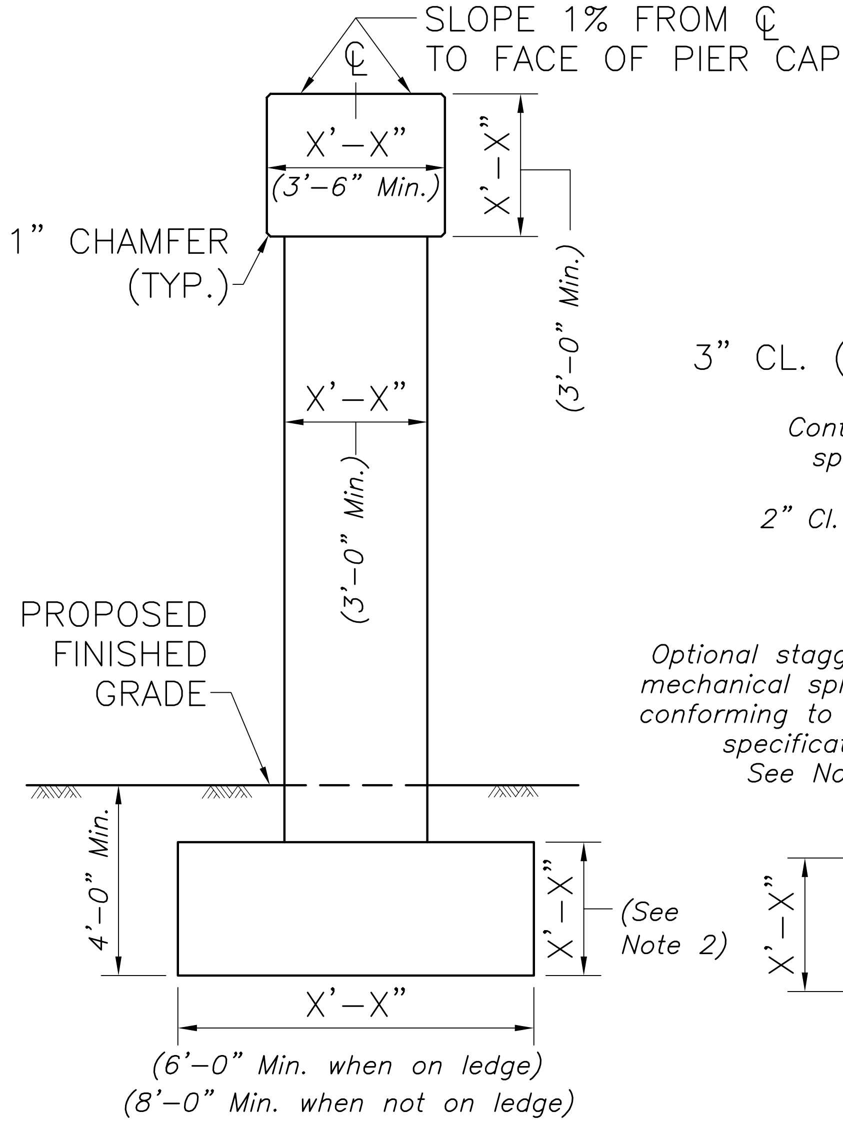
2. ALL KEYS TO BE SLIGHTLY TAPERED.

TRANSVERSE SECTION OF PIER

SCALE: ¼" = 1'–0"

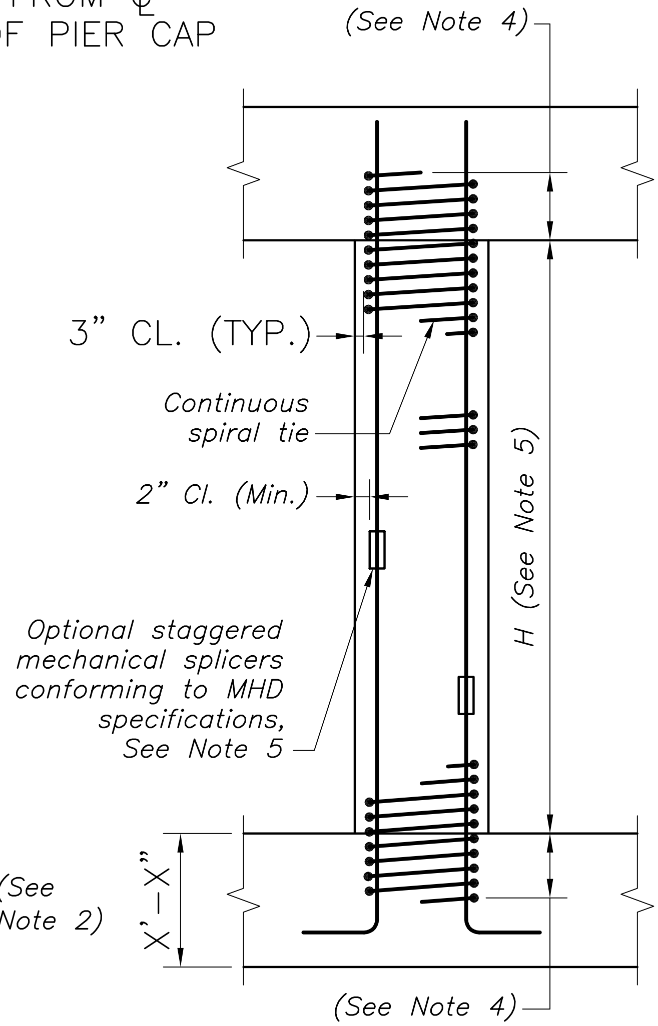
NOTES:

1. *The transverse section shall be drawn without breaks and to scale on Construction Drawings and all pier cap and footing reinforcement shall be included. Locate this section under the plan view of the pier.*
2. *If the dimension from center line to center line of exterior columns exceeds 80'–0", provide two (2) separate pier caps on continuous footing.*
3. *Provide crash wall or solid pier where required by railroad or hydraulics.*
4. *Bottom of pier cap should be level. However, if the height of one of the pier cap exceeds 1.5 times the height of the other end, bottom of the pier cap may be sloped to stay within these limits.*



SECTION 1

SCALE: $\frac{1}{4}$" = 1'–0"



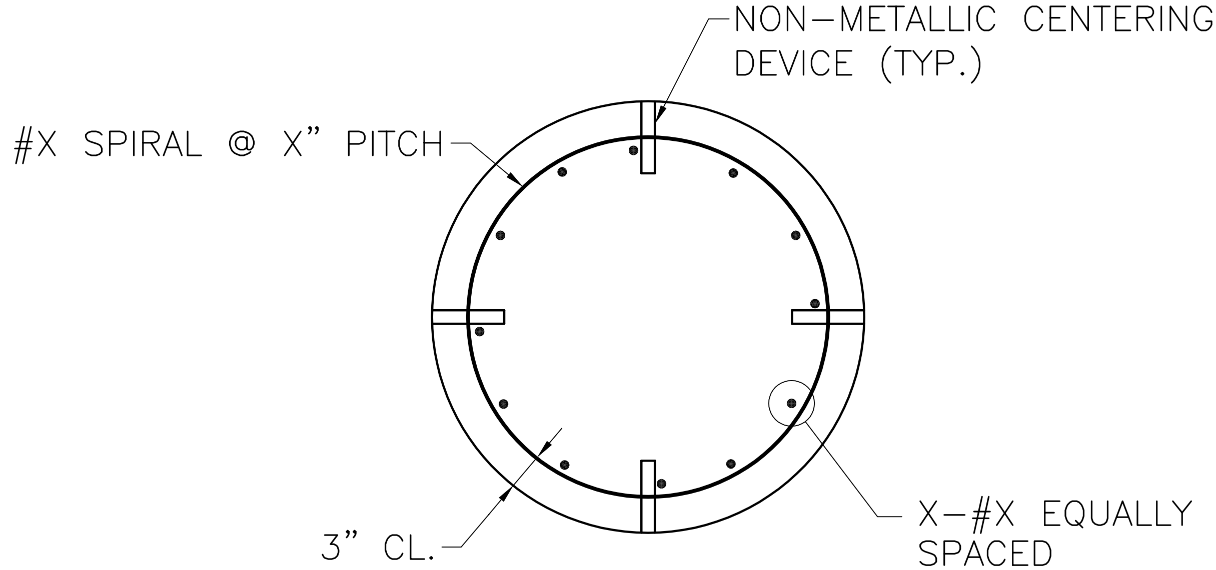
TYPICAL REINFORCEMENT

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *The vertical column section shall be included on the construction plans with all reinforcement labeled. Provide proper embedment lengths.*
2. *Maximum depth of footing shall be 3'–0" for footings on subsoil, 3'–6" for footings on piles, and 2'–6" for footings on ledge.*
3. *Use continuous footings where footing is on subsoil or piles. Use individual footings where footing is on ledge.*
4. *Extend spirals into footing and pier cap as required by AASHTO Seismic Design Specifications.*
5. *For H less than 30'–0", no lap splice is allowed. For H of 30'–0" or more splices are allowed in center half of column and shall conform to AASHTO Seismic Design Specifications. If mechanical splicers are used their effect on the column capacity should be accounted for in the column design.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL COLUMN VERTICAL SECTION PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.5.3**

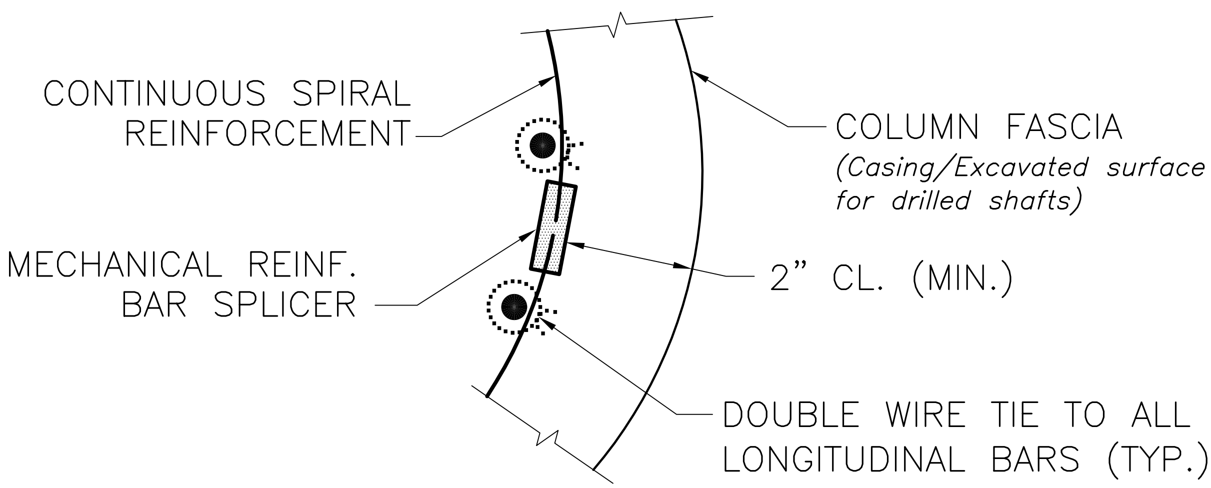


NOTE:
NON–METALLIC CENTERING DEVICES TO BE PLACED AT 1/4 POINTS IN COLUMN. DETAILS OF ALTERNATIVE CENTERING DEVICES MUST BE SUBMITTED TO AND APPROVED BY THE BRIDGE ENGINEER.

NOTE:
Include non–metallic centering device detail from Dwg. No. 3.6.10 on Construction Drawings.

SECTION 2

SCALE: $\frac{3}{4}$" = 1'–0"

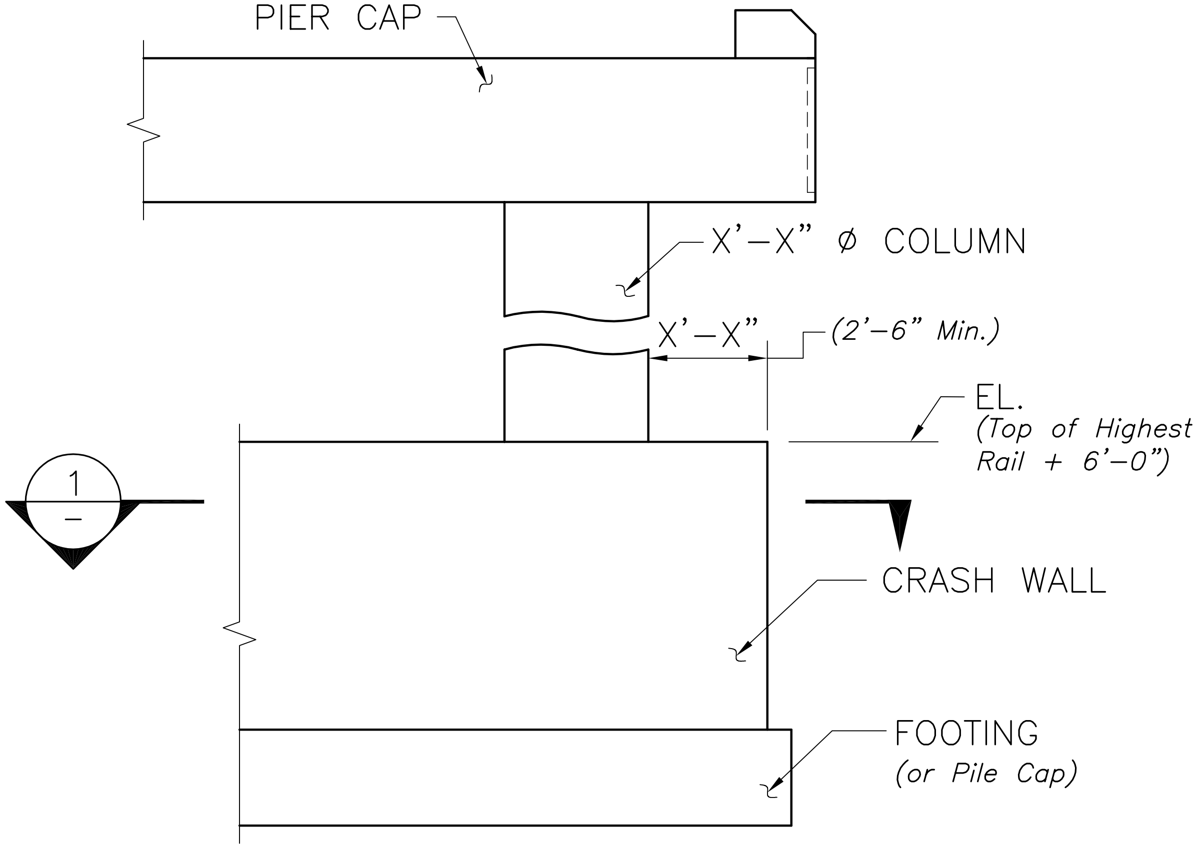


SPIRAL REINFORCEMENT SPLICE DETAIL

NOT TO SCALE

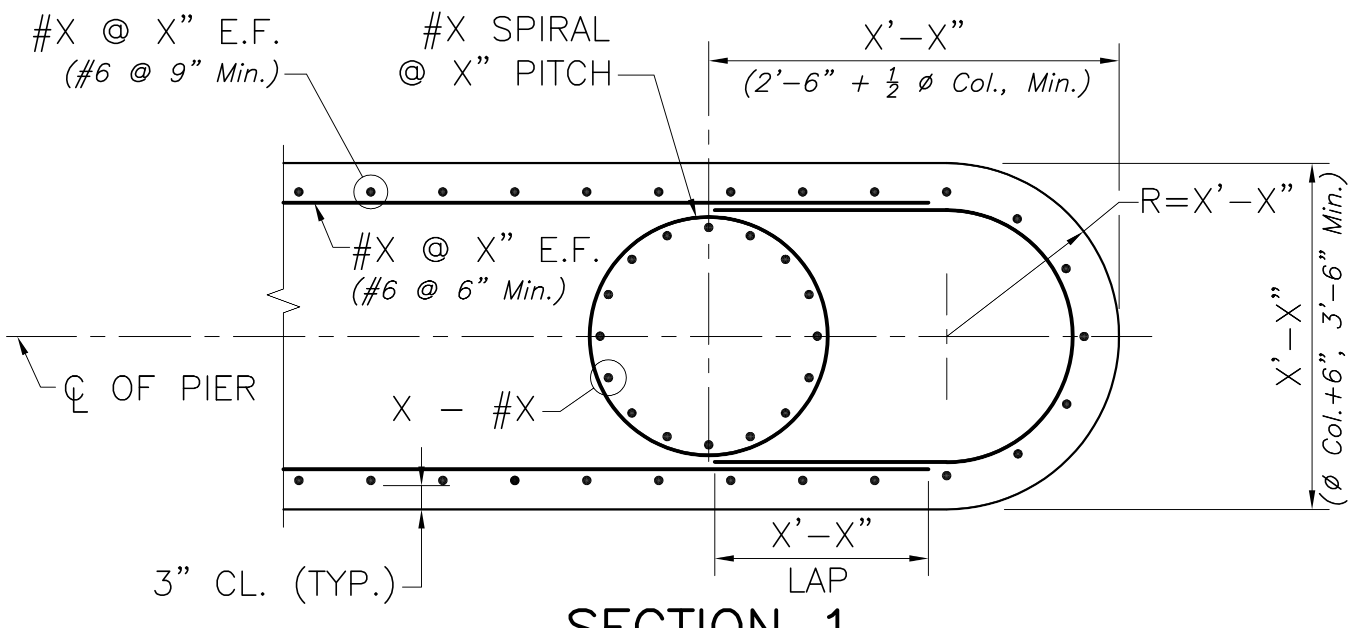
NOTE:
This detail is also applicable to the drilled shafts. (See Note 9 on Dwg. No. 3.6.11)

MASS HIGHWAY BRIDGE MANUAL	COLUMN SECTION & SPIRAL REINFORCEMENT SPLICE PIER DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: 3.5.4



ELEVATION OF PIER

SCALE: $\frac{1}{4}$" = 1'–0"



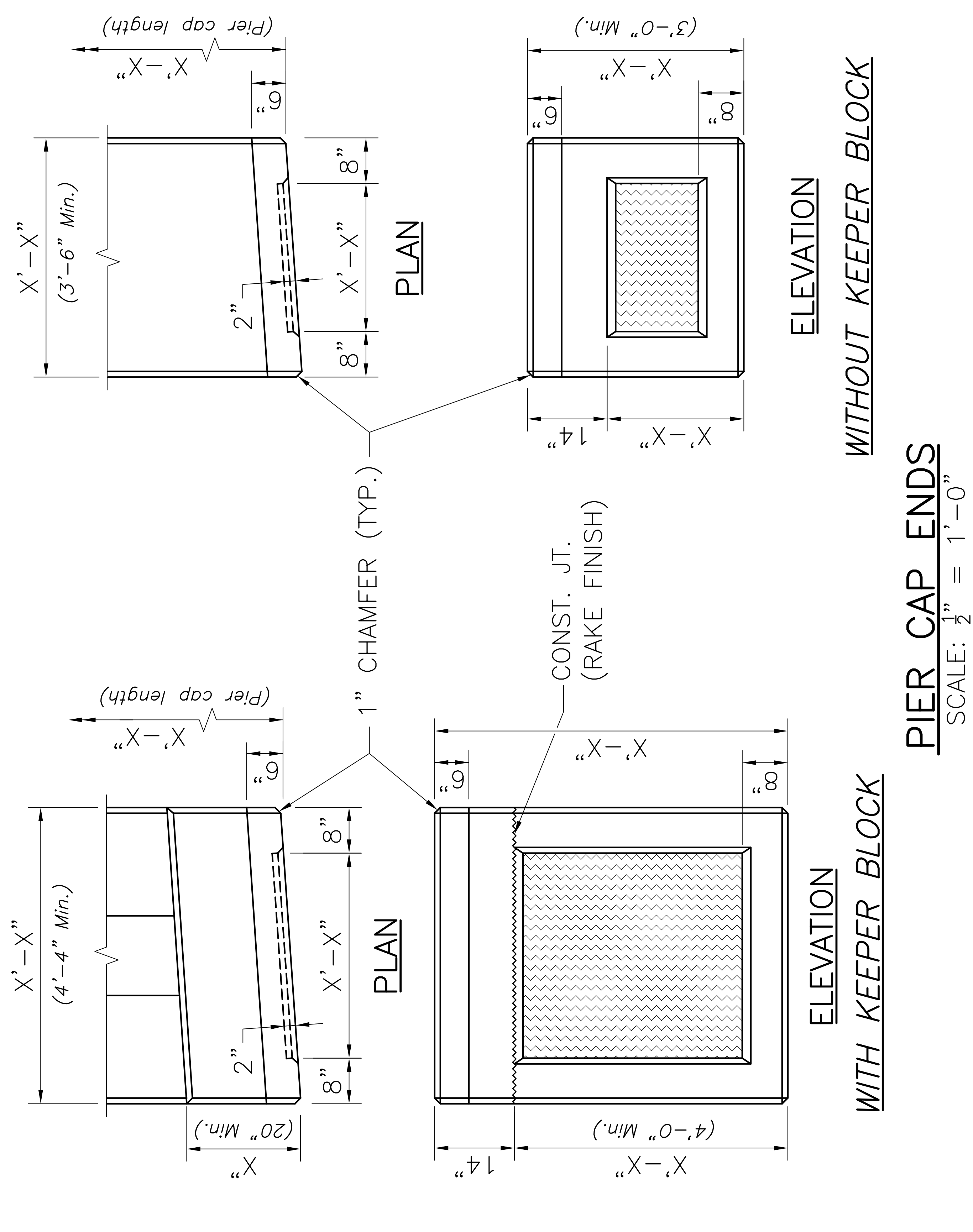
SECTION 1

SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

Details shown above shall be included with all other information shown on Dwg. No. 3.5.2.

MASS HIGHWAY BRIDGE MANUAL	CRASH WALL DETAILS	DATE OF ISSUE: MAY 2005
	PIER DETAILS	DRAWING NUMBER: **3.5.5**



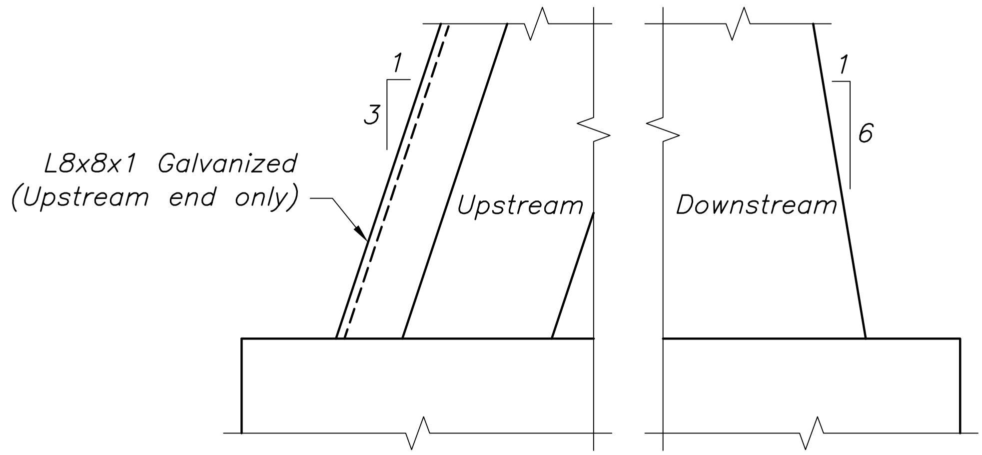
MASS HIGHWAY BRIDGE MANUAL

PIER CAP ENDS

PIER DETAILS

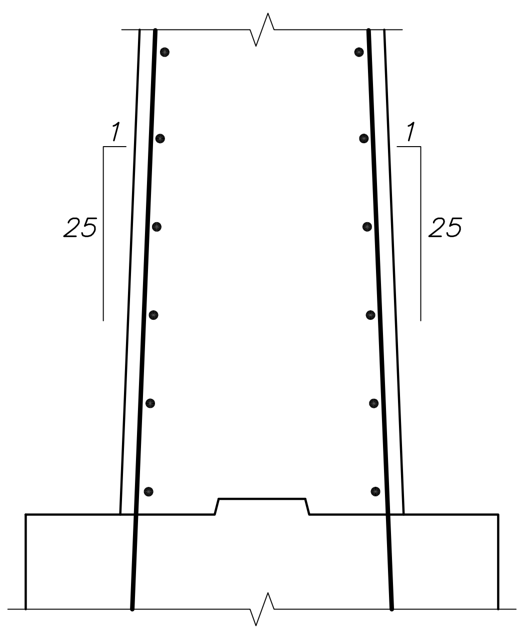
DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.5.6

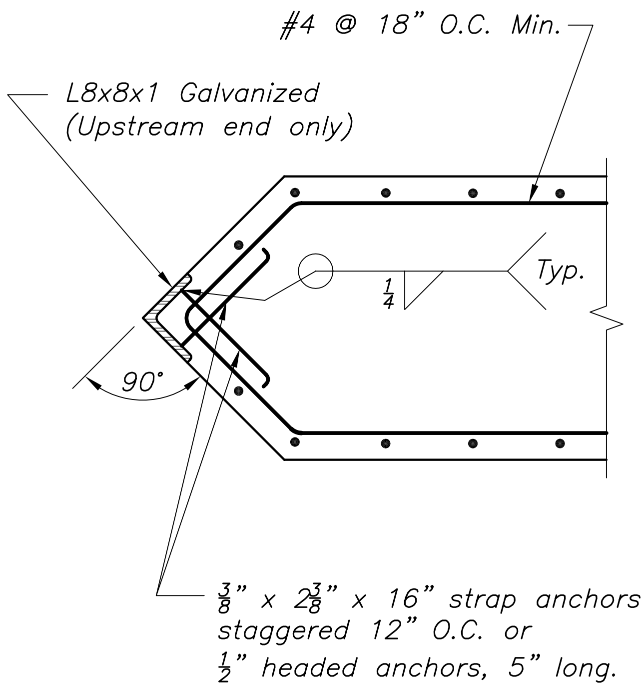


NOTE:
Upstream noses to have galvanized steel L8x8x1 from footing to 2'–0" above design flood water.

ELEVATION



SECTION



NOSE DETAIL

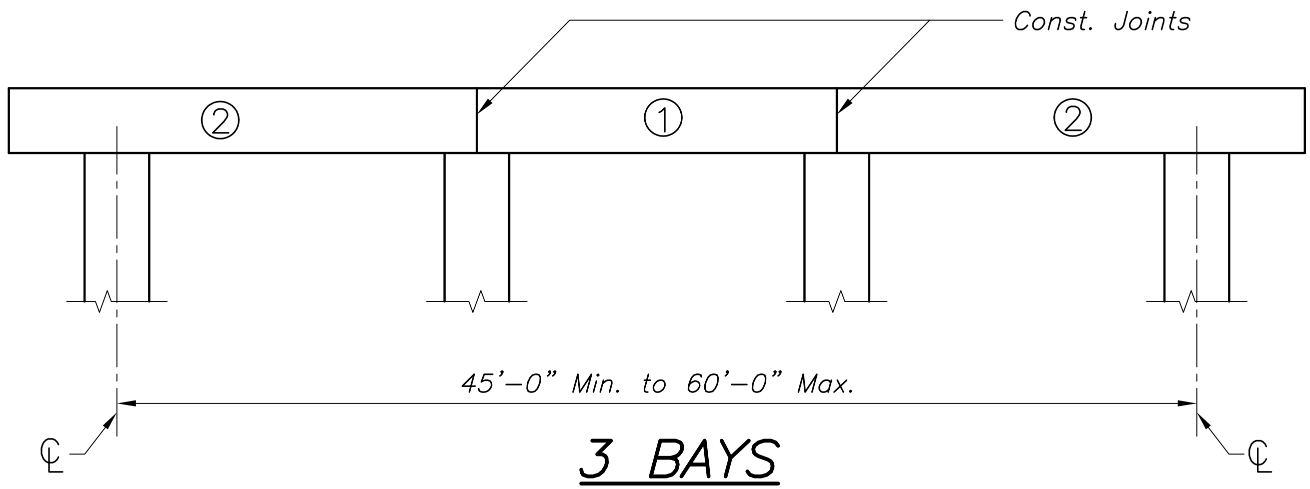
MASS HIGHWAY
BRIDGE MANUAL

MODIFICATIONS FOR RIVER PIERS

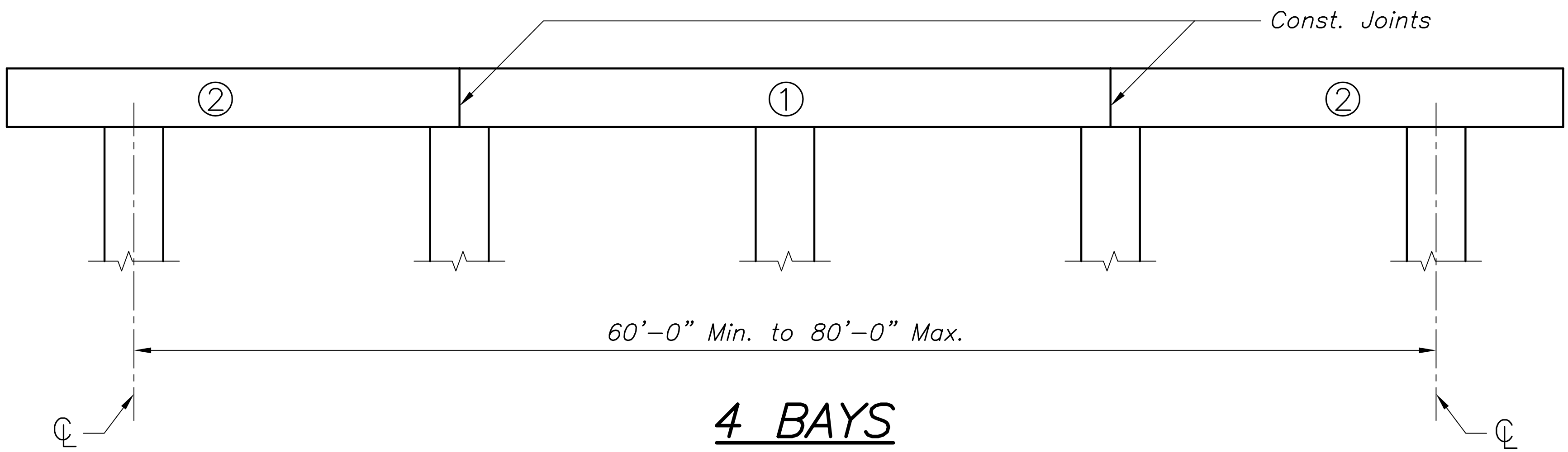
PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.5.7



3 BAYS



4 BAYS

NOTES:

1. Place segments ① first. Place segments ② not less than 24 hours after the completion of placement segments ①. Forms to be stripped as prescribed in the specifications. Note the placement sequence and 24 hour minimum set time on the construction plans.
2. For 5 or more bays over 80'–0", see Note 2 on Dwg. No. 3.5.2.

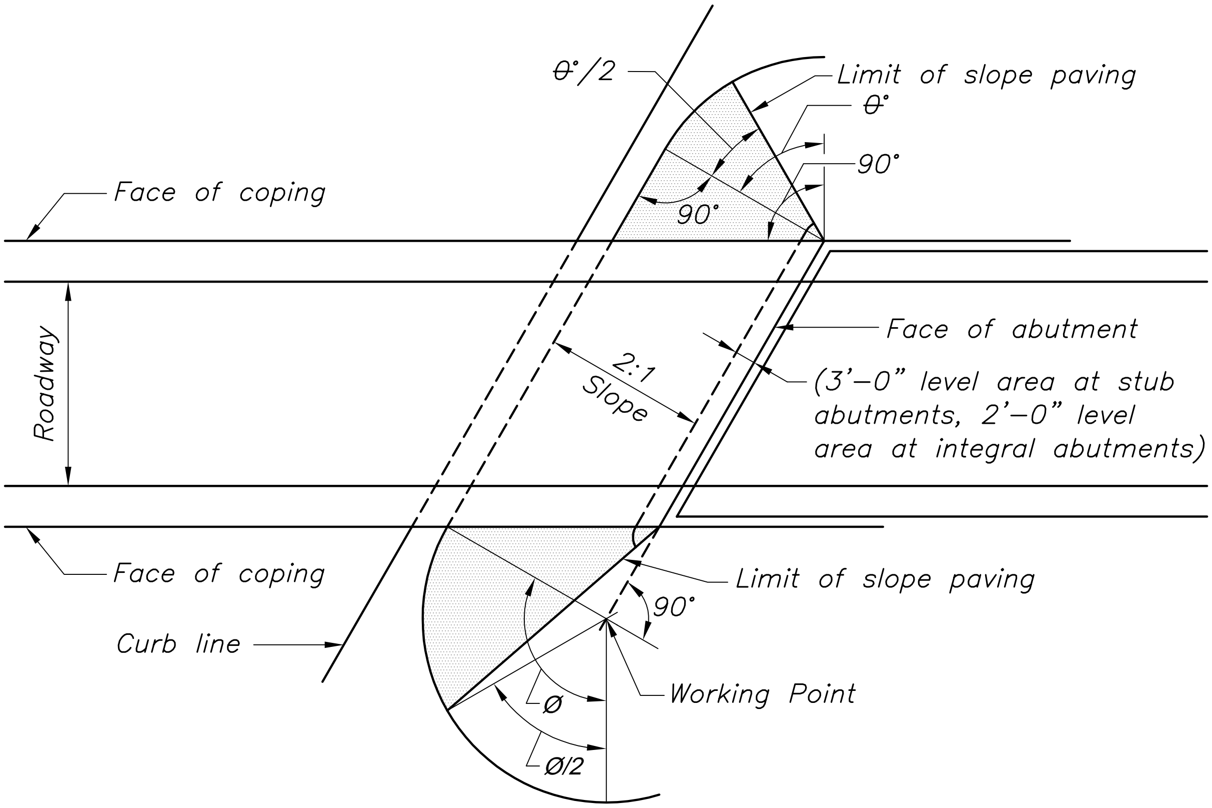
MASS HIGHWAY BRIDGE MANUAL

PIER CAP PLACEMENT SEQUENCE

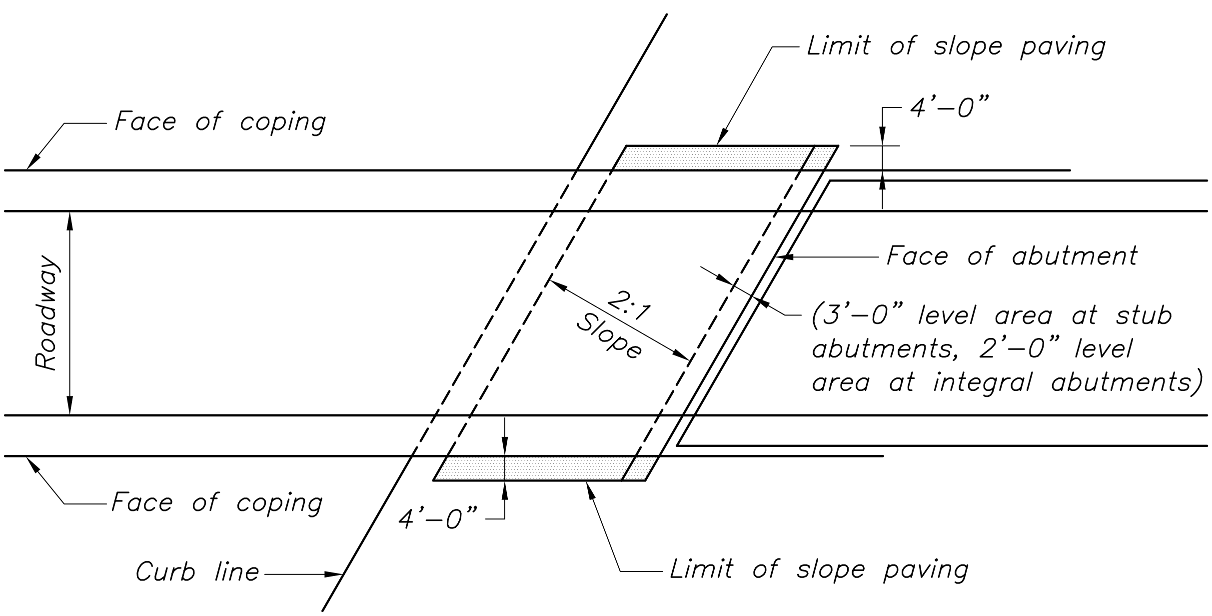
PIER DETAILS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **3.5.8**



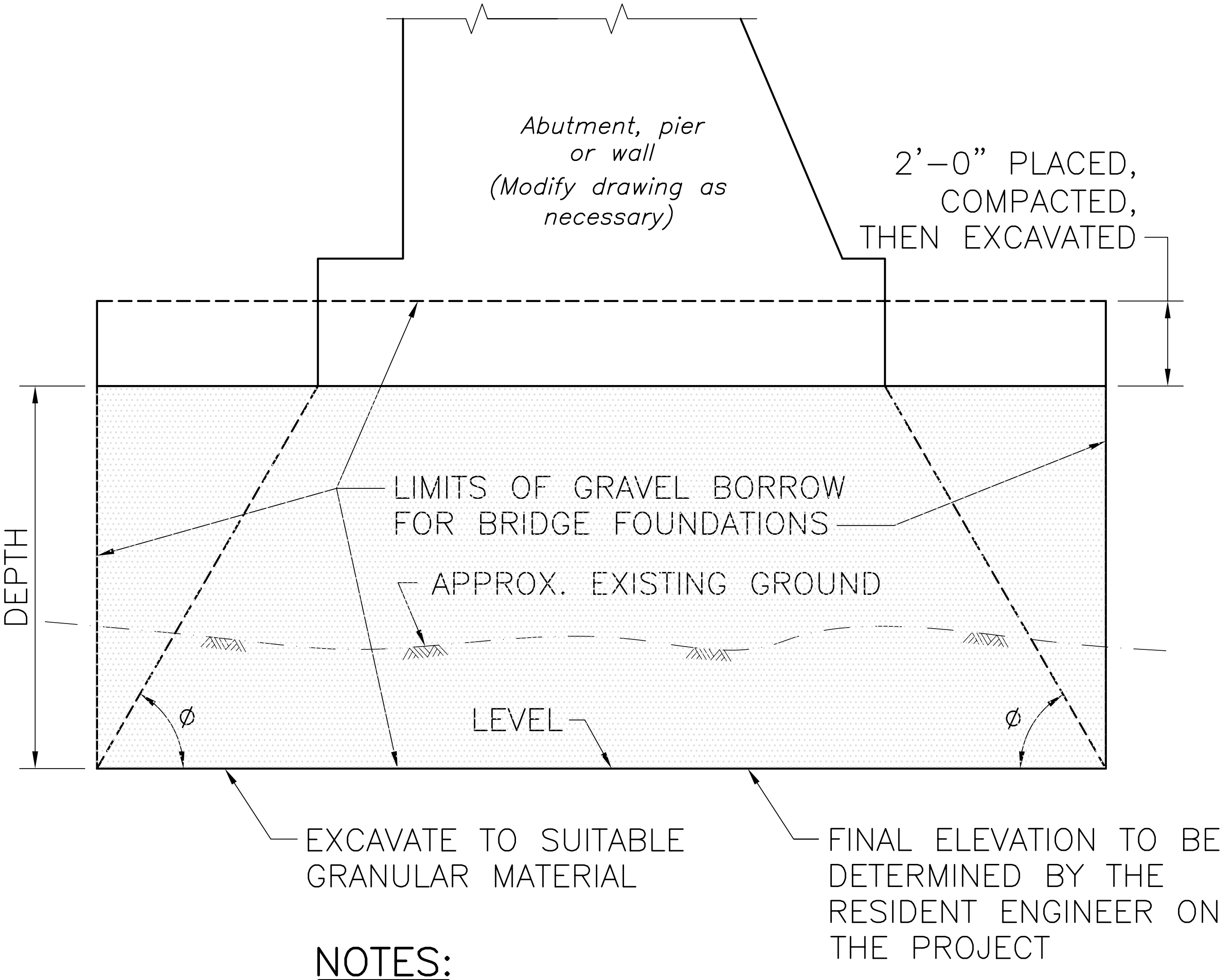
BRIDGE ROADWAY ON FILL SECTION



BRIDGE ROADWAY OVER CUT SECTION

NOTE:
Include the limits of special slope paving on the Construction Drawings where applicable.

MASS HIGHWAY BRIDGE MANUAL	LIMITS OF SPECIAL SLOPE PAVING FOUNDATIONS AND FILL	DATE OF ISSUE MAY 2005 DRAWING NUMBER 3.6.1



NOTES:

1. Ø = 45° FOR DEPTH OF 5'–0" OR LESS.
   Ø = 60° FOR DEPTH OVER 5'–0".

2. SAME TREATMENT IS TO BE USED AT ENDS OF WALLS, PIERS, AND ABUTMENTS.

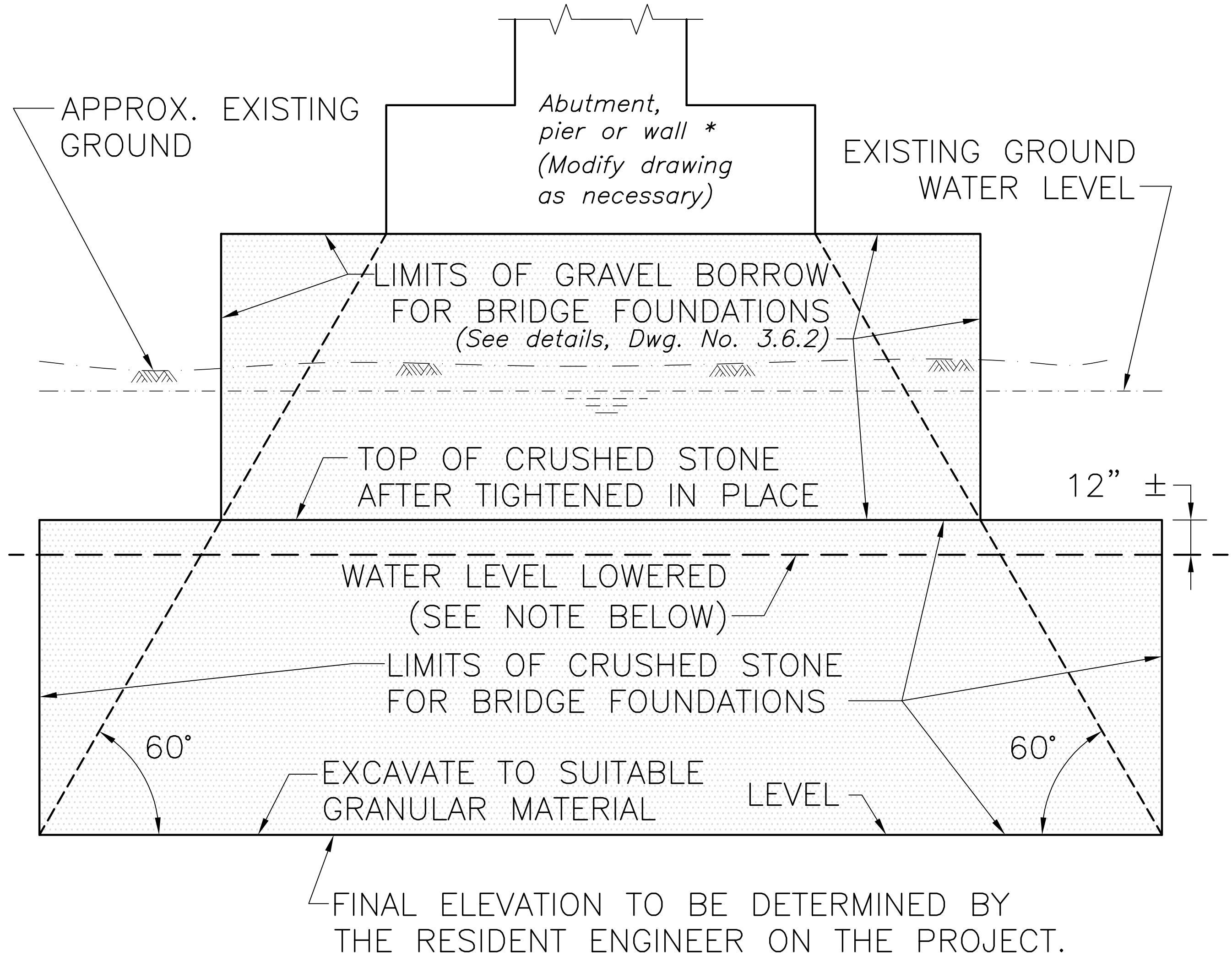
LIMITS OF GRAVEL BORROW FOR BRIDGE FOUNDATIONS

NOT TO SCALE

NOTES:

1. *Do not use where bridge abutment or retaining wall is subjected to unprotected stream flow.*
2. *Refer to Bridge Manual Part 1, Section 3.2.5, for direction regarding Bearing Resistance.*
3. *Gravel Borrow For Bridge Foiundations must be installed in the dry. Use water control where required.*

MASS HIGHWAY BRIDGE MANUAL	GRAVEL BORROW FOR BRIDGE FOUNDATIONS FOUNDATIONS AND FILL	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.6.2**



NOTE:

LOWER WATER LEVEL AS MUCH AS POSSIBLE WITHOUT DISTURBING THE GRANULAR SOIL (SIDES AND BOTTOM) AND TIGHTEN THE CRUSHED STONE IN PLACE (SEE STANDARD SPECIFICATIONS).

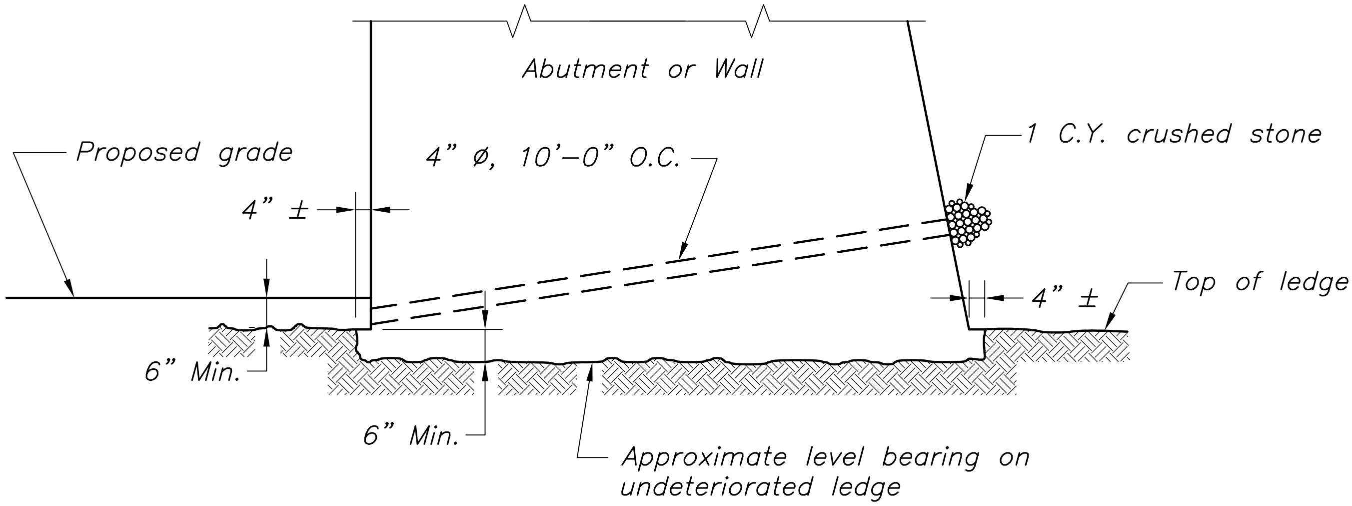
LIMITS OF CRUSHED STONE FOR BRIDGE FOUNDATIONS

NOT TO SCALE

NOTES:

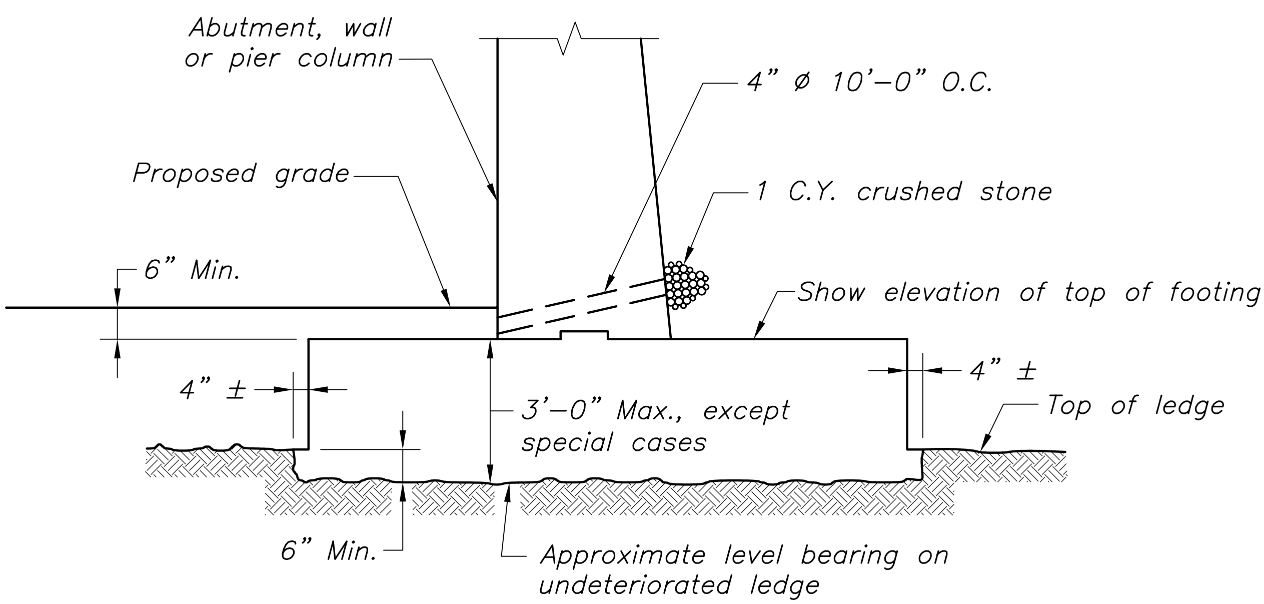
1. ** Do not use for water crossing.*
2. *Indicate maximum factored soil pressure below crushed stone.*
3. *The pressure on the granular material below the crushed stone will govern.*

MASS HIGHWAY BRIDGE MANUAL	CRUSHED STONE FOR BRIDGE FOUNDATIONS FOUNDATIONS AND FILL	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.6.3**



GRAVITY ABUTMENT OR GRAVITY WALL

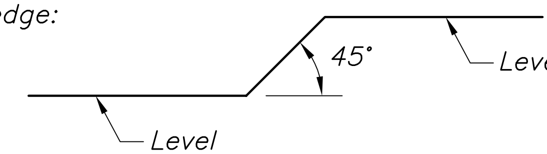
NOT TO SCALE



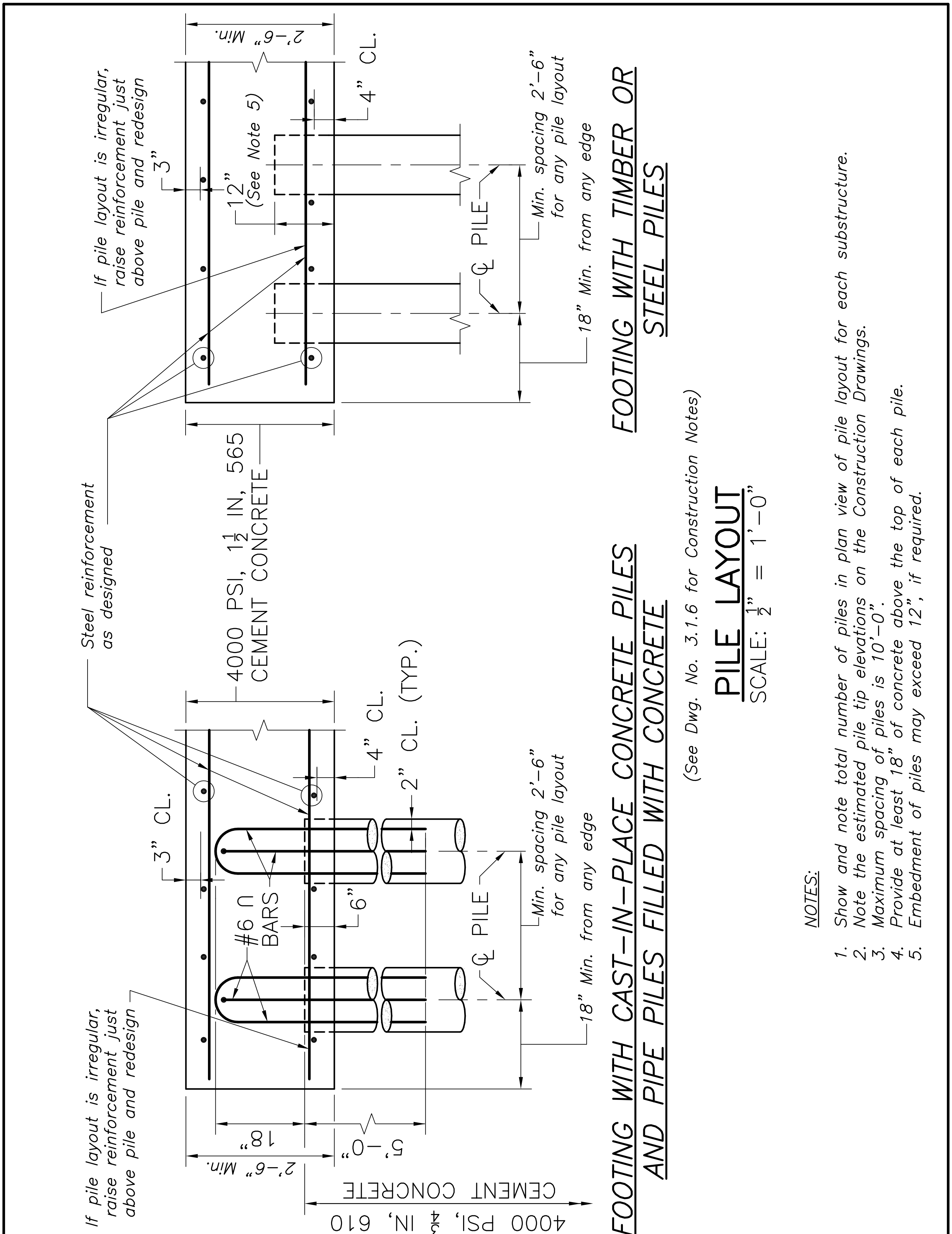
CANTILEVER ABUTMENT OR CANTILEVER WALL

NOT TO SCALE

NOTE:
Bottom of abutment or wall shall be stepped along its length to conform with ledge:



MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR FOOTINGS ON LEDGE FOUNDATIONS AND FILL	DATE OF ISSUE MAY 2005 DRAWING NUMBER 3.6.4

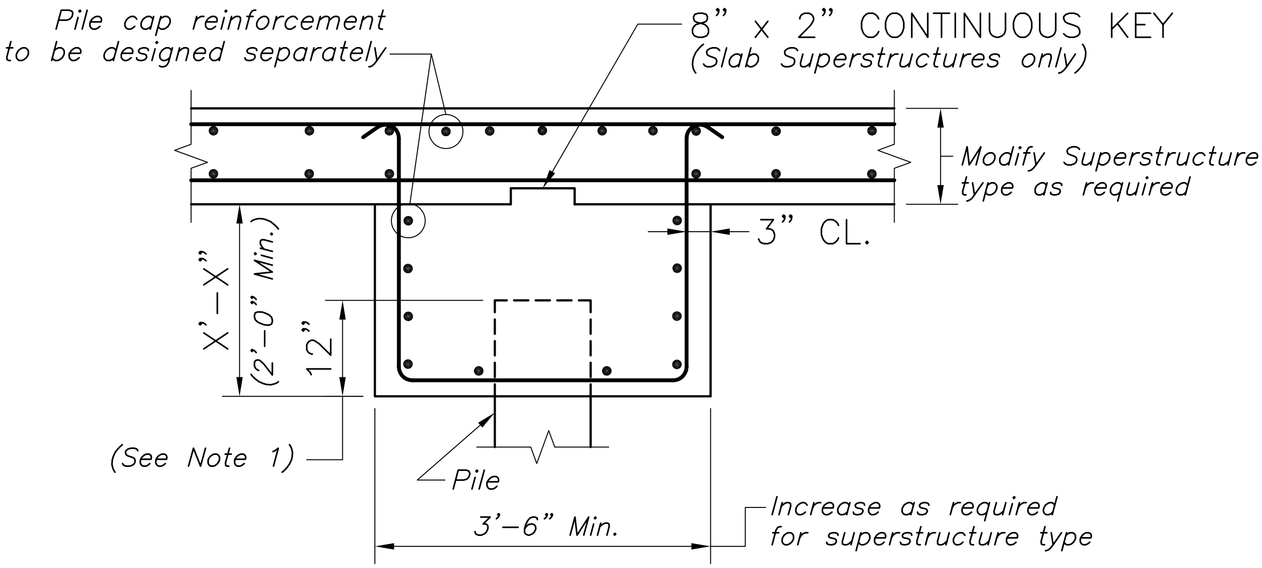


MASS HIGHWAY
BRIDGE MANUAL

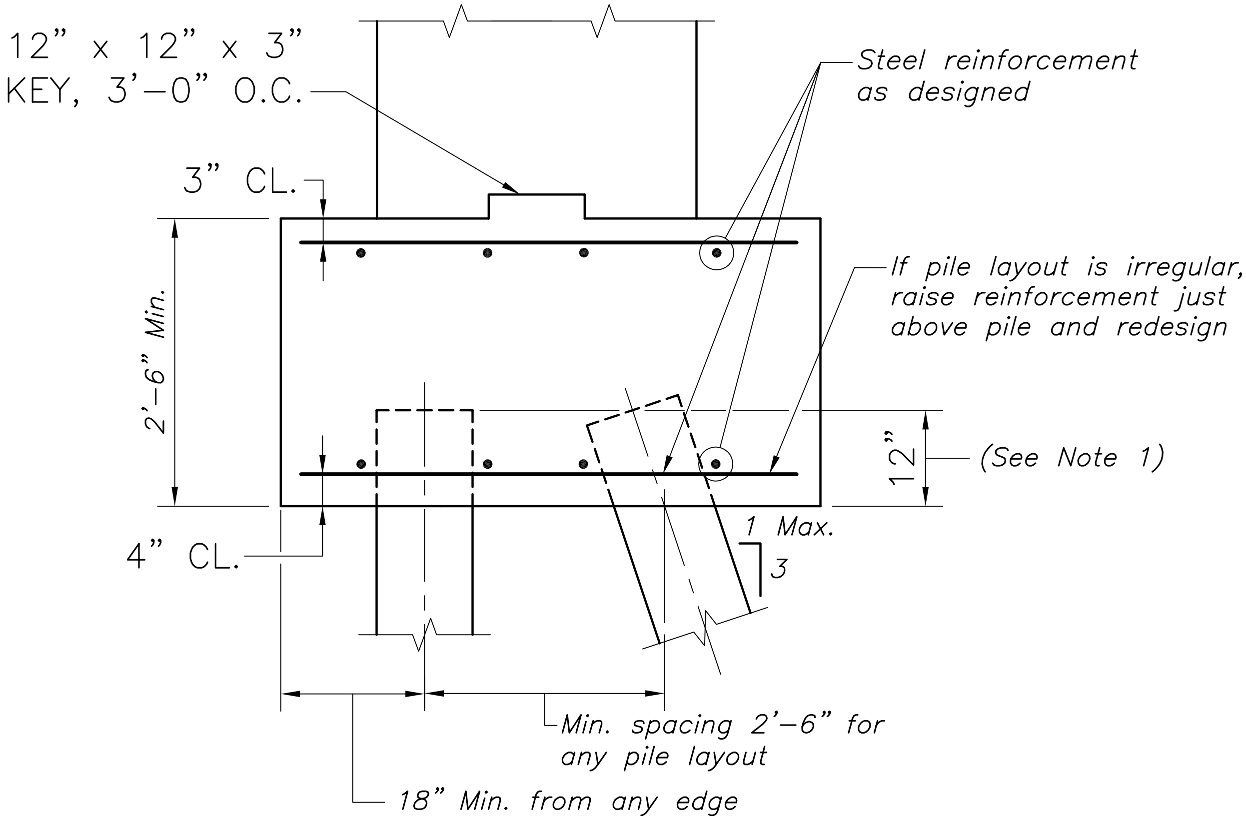
PILE DETAILS
LONGITUDINAL LAYOUT
FOUNDATIONS AND FILL

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.6.5



PILE CAP FOR PILE BENT



FOOTING WITH BATTERED PILES

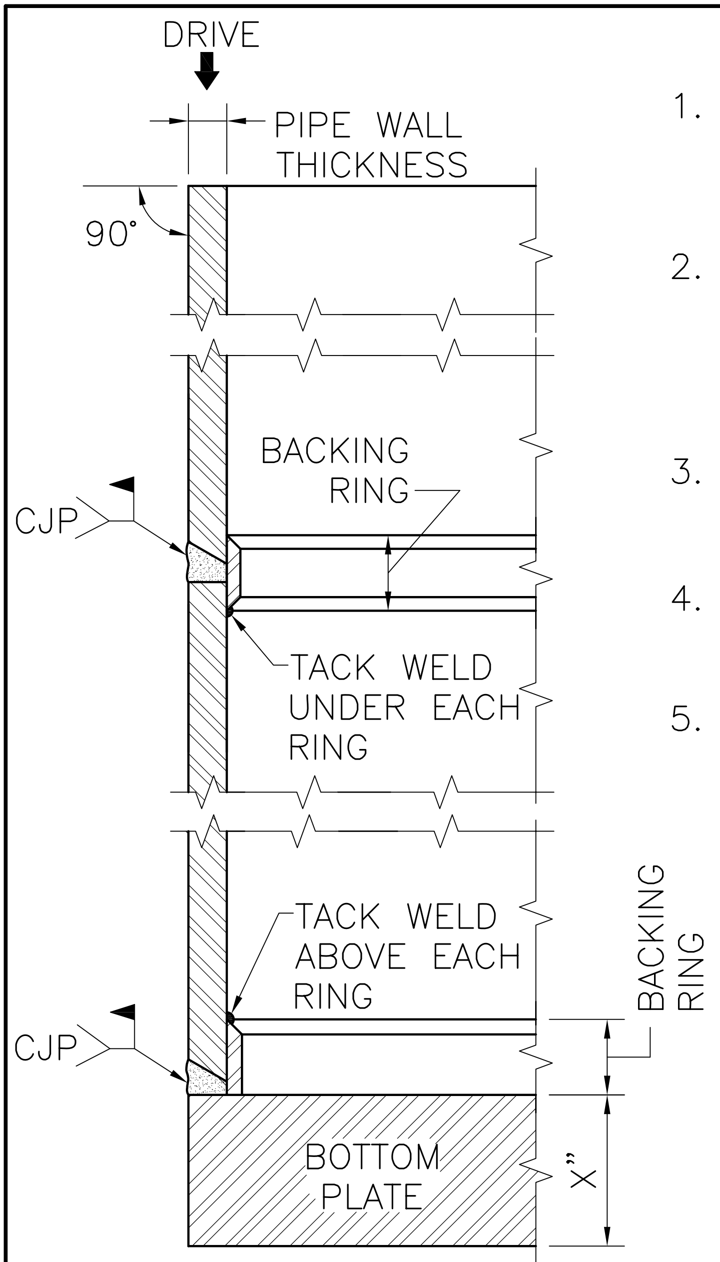
PILE LAYOUT

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Embedment of piles may exceed 12", if required.*
2. *Provide at least 18" of concrete above the top of each pile.*
3. *Maximum spacing of piles is 10'–0".*

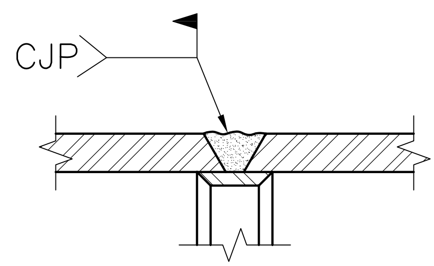
MASS HIGHWAY BRIDGE MANUAL	PILE DETAILS TRANSVERSE LAYOUT FOUNDATIONS AND FILL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.6.6**



PILE SECTION

NOTES:

1. BACKING RING DETAILS SHALL BE CONSISTENT WITH APPROVED WELDING PROCEDURE SPECIFICATIONS.
2. ROOT BASE SHALL BE DEPOSITED TO WITHIN 1" OF BACKING RING SPACER PINS. SPACER PINS SHALL THEN BE REMOVED AND PASS COMPLETED.
3. ALL WELDS SHALL BE SMOOTH. REINFORCEMENT SHALL NOT EXCEED $\frac{1}{8}$".
4. WELDING SHALL CONFORM TO THE AWS D1.1 STRUCTURAL WELDING CODE – STEEL.
5. FOR FLAT WELD POSITION USE THE FOLLOWING WELD:



PILE SPLICE AND BOTTOM PLATE DETAILS

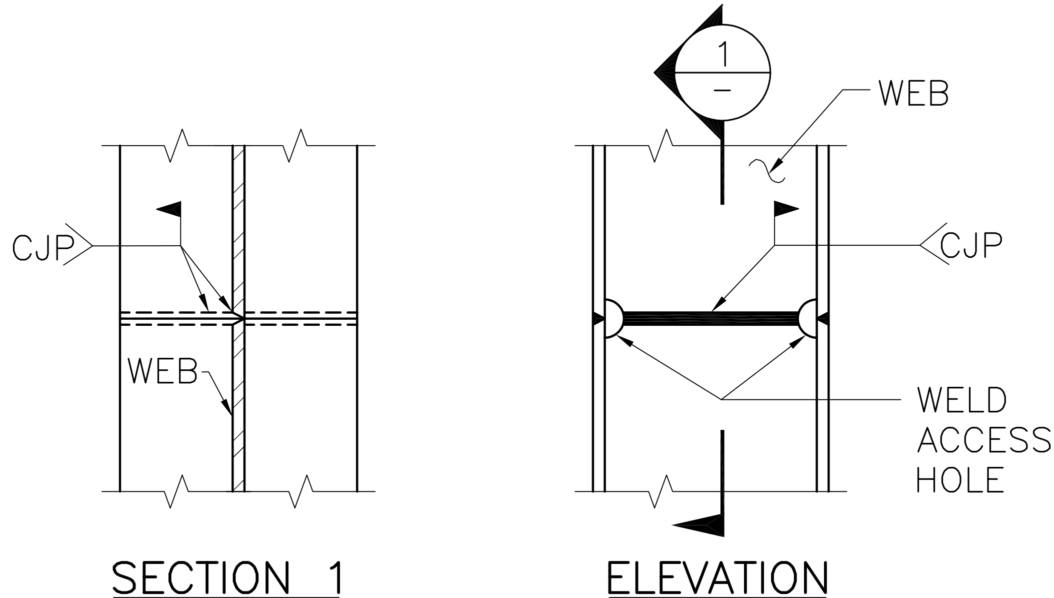
NOT TO SCALE

NOTE:

For piles subject to significant bending moment, add the following note on the Construction Drawings:

IF THE SPLICE LOCATION OCCURS WITHIN X FEET FROM THE BOTTOM OF ABUTMENT (*modify location as required*), ALL WELDS SHALL BE INSPECTED USING ULTRASONIC TESTING IN ACCORDANCE WITH THE BRIDGE WELDING CODE, ANSI/AASHTO/AWS D1.5. WELDS IN THIS LOCATION WILL BE CONSIDERED TO BE IN TENSION. TECHNICIANS PERFORMING THE TESTING SHALL HAVE PASSED THE PRACTICAL EXAM ADMINISTERED BY THE NEW YORK STATE DEPARTMENT OF TRANSPORTATION.

MASS HIGHWAY BRIDGE MANUAL	PIPE PILE SPLICE AND BOTTOM PLATE FOUNDATIONS AND FILL	DATE OF ISSUE: FEBRUARY 2007 DRAWING NUMBER: **3.6.7**



NOTES:

1. ALL WELDS SHALL BE COMPLETE PENETRATION AND SHALL CONFORM TO THE ANSI/AASHTO/AWS BRIDGE WELDING CODE, D1.5.

2. WELDING PROCEDURE SPECIFICATIONS MUST BE APPROVED BY THE ENGINEER PRIOR TO WELDING.

3. WHENEVER POSSIBLE ALL PILES SHALL BE SPLICED ON THE GROUND IN THE FLAT POSITION.

4. WEB SHALL BE COPED TO ALLOW FOR COMPLETE PENETRATION WELDING OF FLANGES.

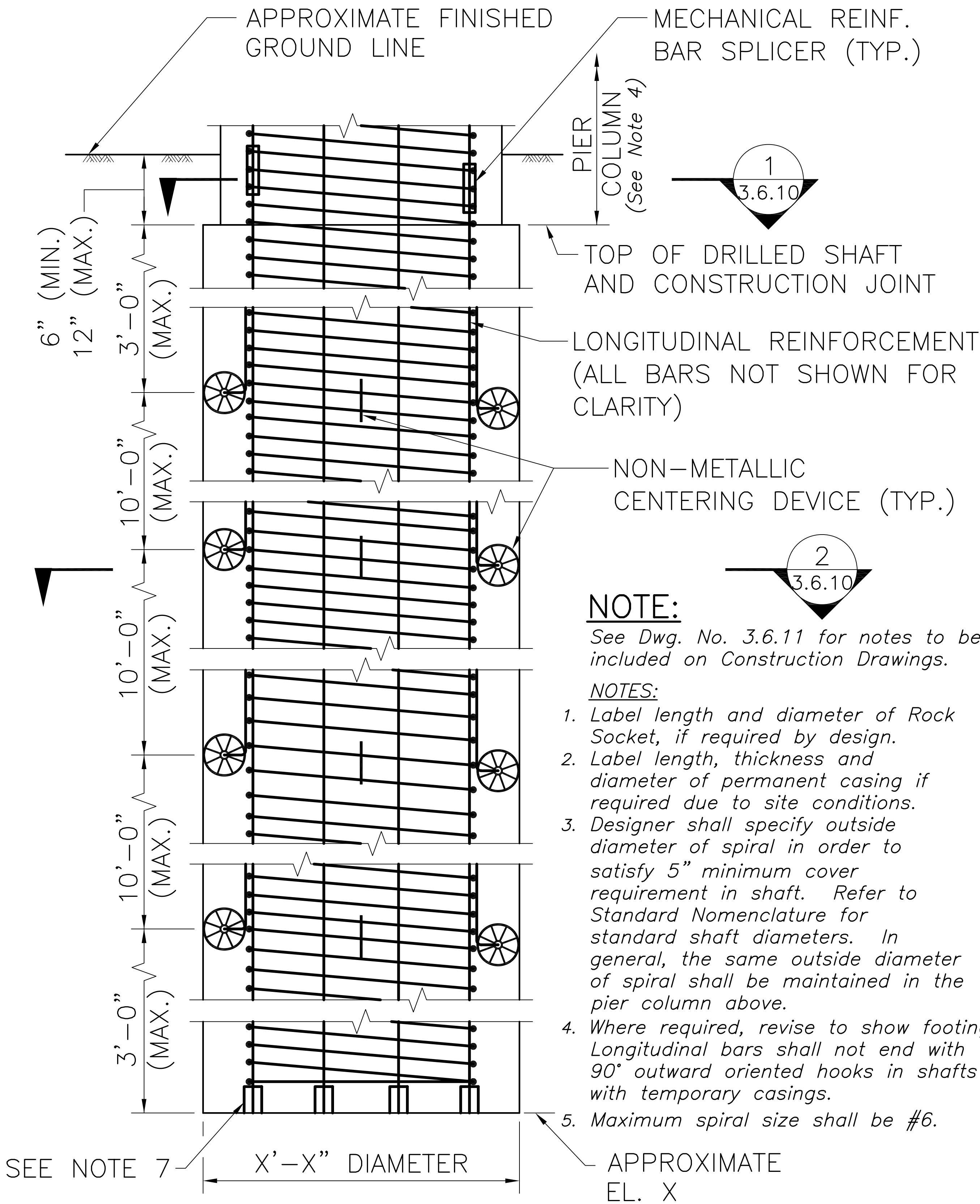
5. WELDED MECHANICAL PILE SPLICERS MAY BE USED PROVIDED THAT COMPLETE DETAILS AND WELDING PROCEDURES HAVE BEEN REVIEWED AND APPROVED BY THE ENGINEER.

H–PILE SPLICE DETAILS

NOT TO SCALE

NOTES:

1. *For piles subject to significant bending moment, add the following note on the plans:*
   IF THE SPLICE LOCATION OCCURS WITHIN X FEET FROM THE BOTTOM OF THE ABUTMENT (*modify location as required*), ALL WELDS SHALL BE INSPECTED USING ULTRASONIC TESTING IN ACCORDANCE WITH THE BRIDGE WELDING CODE, ANSI/AASHTO/AWS D1.5. WELDS IN THIS LOCATION WILL BE CONSIDERED TO BE IN TENSION. TECHNICIANS PERFORMING THE TESTING SHALL HAVE PASSED THE PRACTICAL EXAM ADMINISTERED BY THE NEW YORK STATE DEPARTMENT OF TRANSPORTATION.
2. *Pile splice details shall be shown on Construction Drawings of all bridges requiring steel piles.*



NOTE:

See Dwg. No. 3.6.11 for notes to be included on Construction Drawings.

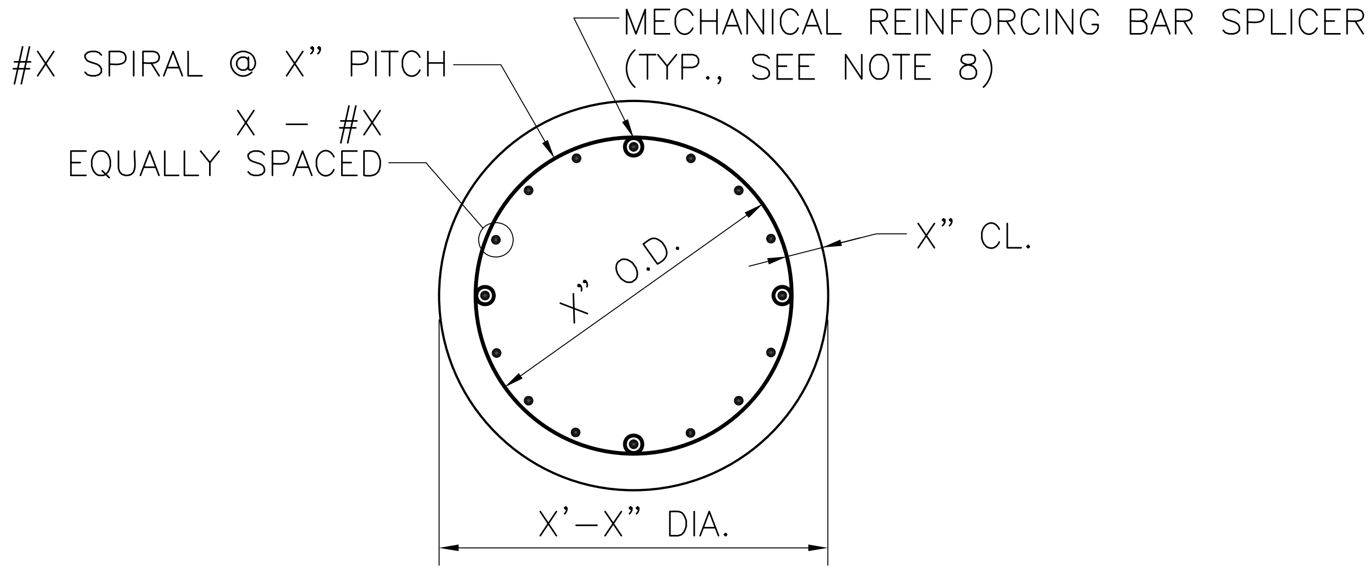
NOTES:

1. *Label length and diameter of Rock Socket, if required by design.*
2. *Label length, thickness and diameter of permanent casing if required due to site conditions.*
3. *Designer shall specify outside diameter of spiral in order to satisfy 5" minimum cover requirement in shaft. Refer to Standard Nomenclature for standard shaft diameters. In general, the same outside diameter of spiral shall be maintained in the pier column above.*
4. *Where required, revise to show footing. Longitudinal bars shall not end with 90° outward oriented hooks in shafts with temporary casings.*
5. *Maximum spiral size shall be #6.*

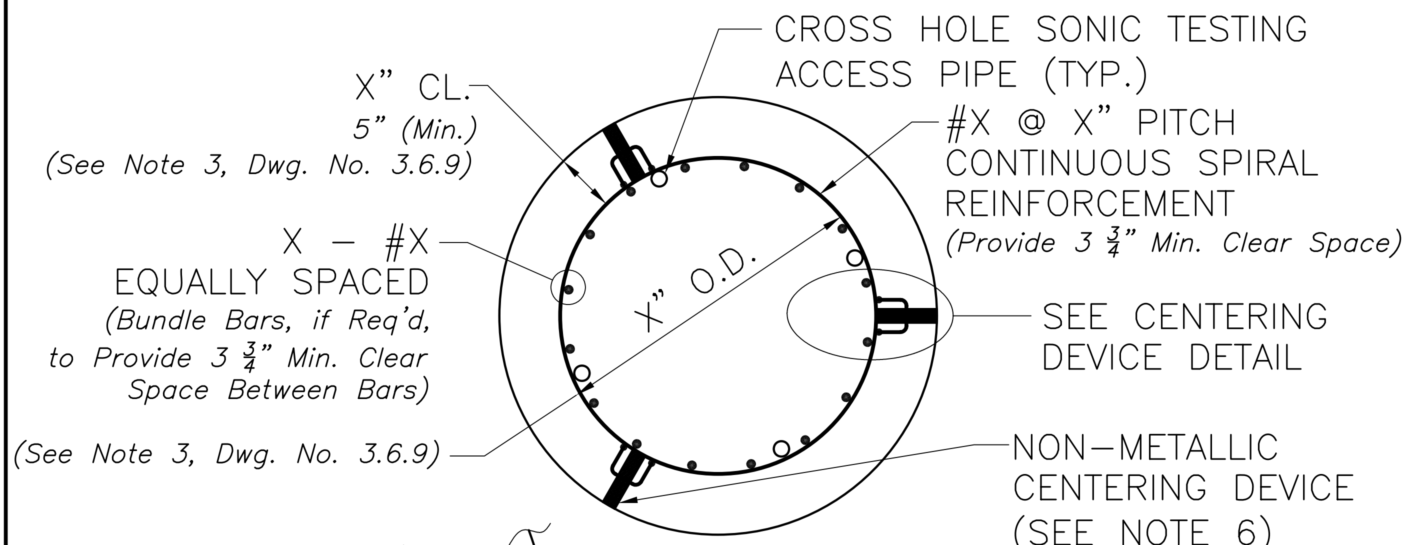
DRILLED SHAFT — VERTICAL SECTION

SCALE: $\frac{3}{4}$" = 1'-0"

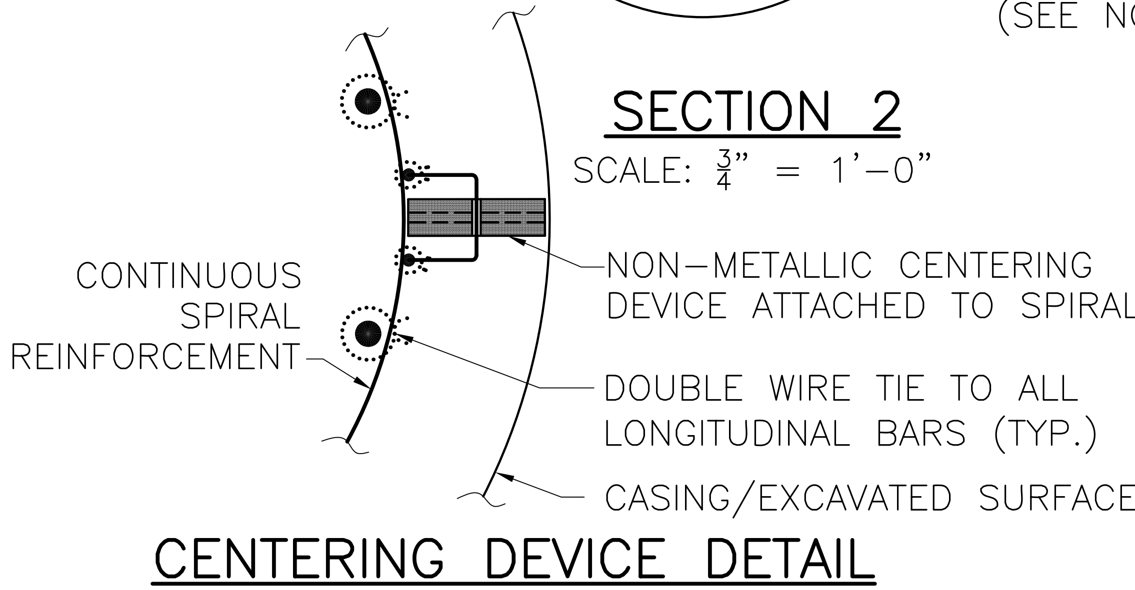
MASS HIGHWAY BRIDGE MANUAL	DRILLED SHAFT VERTICAL SECTION FOUNDATIONS AND FILL	DATE OF ISSUE: FEBRUARY 2007 DRAWING NUMBER: **3.6.9**



SECTION 1
SCALE: $\frac{3}{4}$" = 1'–0"



SECTION 2
SCALE: $\frac{3}{4}$" = 1'–0"



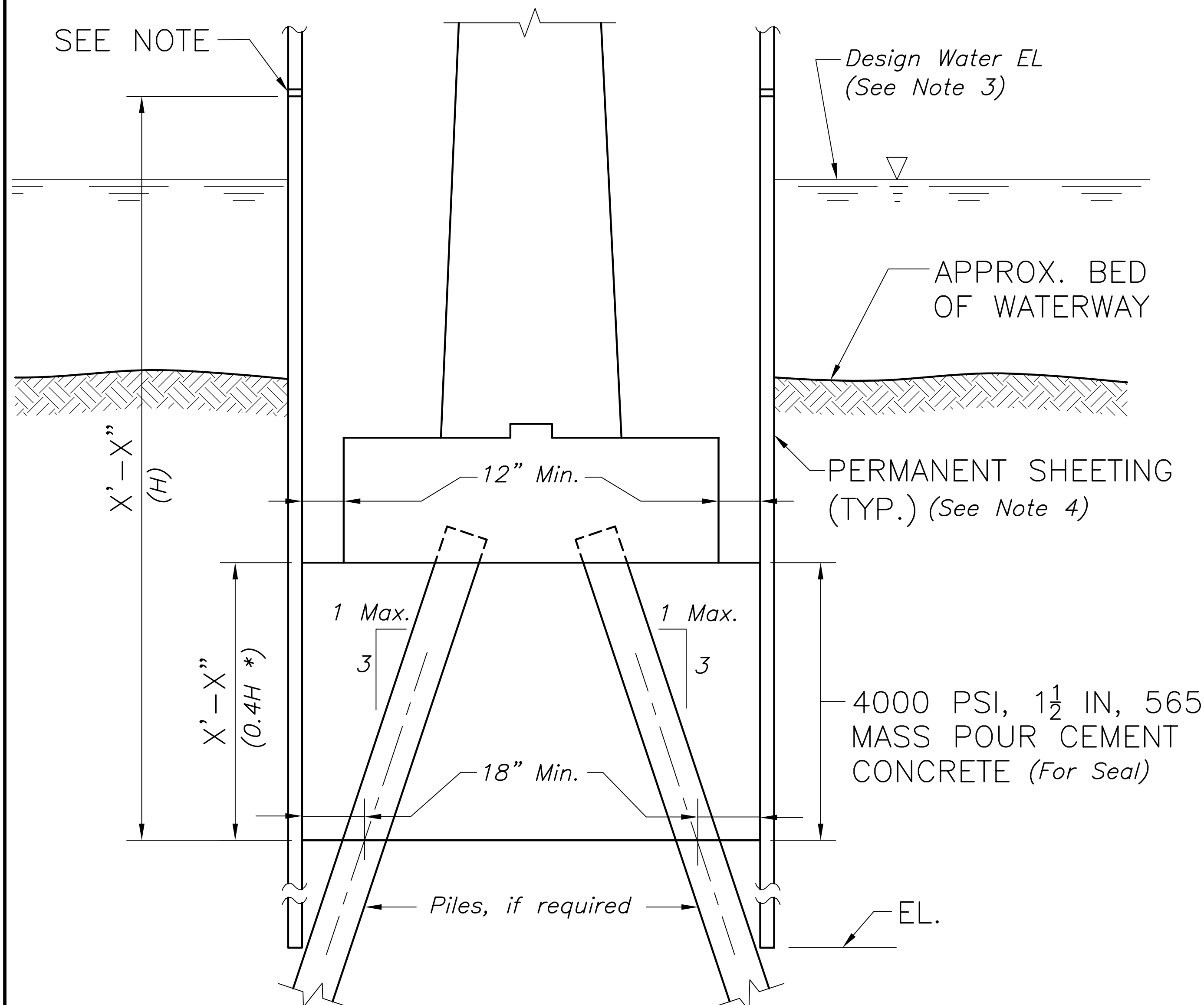
CENTERING DEVICE DETAIL
NOT TO SCALE

MASS HIGHWAY BRIDGE MANUAL	DRILLED SHAFT SECTIONS AND DETAILS FOUNDATIONS AND FILL	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **3.6.10**

NOTES:

1. DRILLED SHAFT CONCRETE SHALL BE 4000 PSI, $\frac{3}{8}$ IN, 660 CEMENT CONCRETE. *(Drilled shaft concrete shall have the same compressive strength as the pier column concrete. Modify as required.)*

   THE CLEAR SPACING BETWEEN STEEL REINFORCEMENT BARS SHALL BE AT LEAST $3\frac{3}{4}$".
2. THE FACTORED GEOTECHNICAL DESIGN CAPACITY PER SHAFT IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE GEOTECHNICAL CAPACITY OF X KIPS AND A GEOTECHNICAL PERFORMANCE FACTOR 0.XX. THE FACTORED AXIAL DESIGN LOAD PER SHAFT IS X KIPS (GROUP I LOAD). *(specify the Group Load Number that produces the maximum axial load)* THE FACTORED STRUCTURAL CAPACITY PER SHAFT IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE STRUCTURAL CAPACITY OF X KIPS AND A STRUCTURAL PERFORMANCE FACTOR 0.XX.
3. CENTERING DEVICES SHALL BE CONSTRUCTED OF AN APPROVED NON–METALLIC DURABLE MATERIAL.
4. THE NON–METALLIC CENTERING DEVICES SHALL BE OF ADEQUATE SIZE TO INSURE A MINIMUM 5" ANNULAR SPACE BETWEEN THE OUTSIDE OF THE REINFORCEMENT CAGE AND THE SIDES OF THE EXCAVATED HOLE OR INSIDE OF CASING.
5. THERE SHALL BE A MINIMUM OF 3 GROUPS OF NON–METALLIC CENTERING DEVICES FOR SHAFTS LESS THAN 26'–0" IN LENGTH.
6. NON–METALLIC CENTERING DEVICES SHALL BE PLACED AT A MAXIMUM SPACING OF 2'–6" AROUND THE CIRCUMFERENCE OF THE SHAFT.
7. EACH LONGITUDINAL BAR SHALL BE SUPPORTED BY A 3" HIGH BOLSTER OF APPROVED NON–METALLIC DURABLE MATERIAL.
8. SPLICES OF LONGITUDINAL REINFORCEMENT SHALL BE ARRANGED IN GROUPS OF TWO DIAGONALLY OPPOSITE PAIRS THAT ARE STAGGERED VERTICALLY AT LEAST 12" ON CENTER.
9. IF SPLICING OF SPIRAL REINFORCEMENT IS NECESSARY, A MINIMUM OF 2" CLEARANCE SHALL BE PROVIDED BETWEEN THE OUTSIDE SURFACE OF MECHANICAL REINFORCING BAR SPLICERS AND THE DRILLED SHAFT CASING OR EXCAVATED SURFACE. *(Refer to Dwg. No. 3.5.4 and provide spiral splice detail on the Construction Drawings)*
10. WELDING OF THE REINFORCEMENT BARS SHALL NOT BE PERMITTED WITHOUT THE WRITTEN APPROVAL OF THE ENGINEER. WELDING OF LONGITUDINAL REINFORCEMENT SHALL NOT BE PERMITTED.



NOTE:
CONTRACTOR SHALL PROVIDE PRESSURE RELIEF PORTS LOCATED 2'–0" ABOVE DESIGN WATER LEVEL.

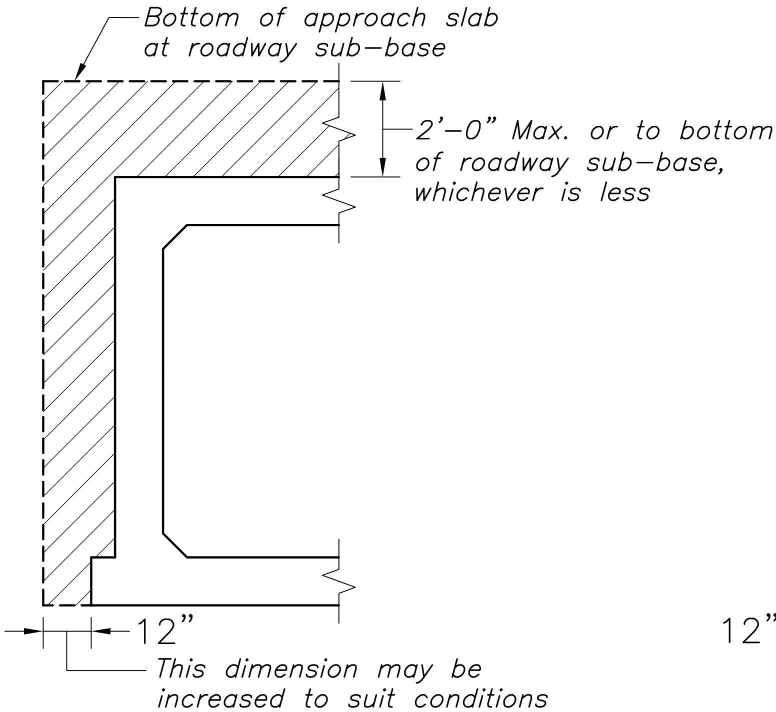
SEAL FOR COFFERDAM

SCALE: $\frac{1}{4}$" = 1'–0"

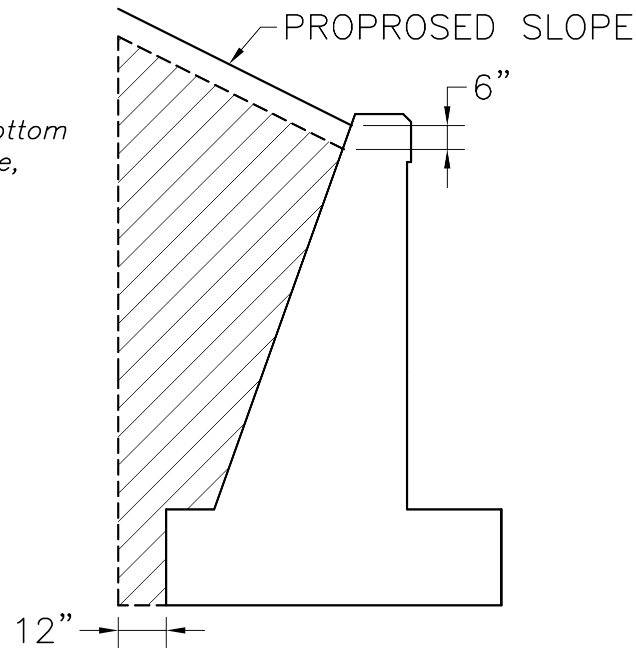
NOTES:

1. ** Denotes thickness of concrete seal based on hydraulic uplift figured to bottom of seal. Can reduce thickness by weight of piles and pile friction.*
2. *When piles are not required or when scouring is probable, steel sheeting shall be left in place and anchored to seal with Z bars. Indicate the elevation of where the sheeting shall be cut off on the plans.*
3. *For tidal areas, use the average of observed high tides for seal design.*
4. *Adequate embedment shall be provided below the bottom of seal to prevent boiling. Engineer shall check for interference between cofferdam sheeting and battered piles.*
5. *Mass pour concrete requires a Special Provision.*

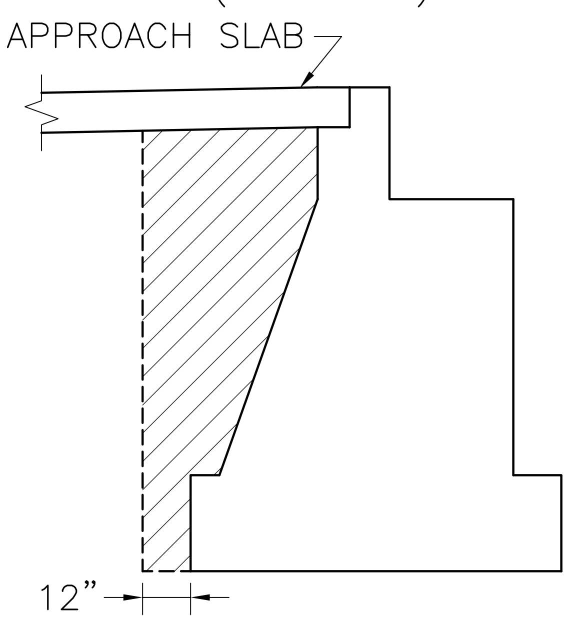
MASS HIGHWAY BRIDGE MANUAL	COFFERDAM DETAILS FOUNDATIONS AND FILL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.6.12**



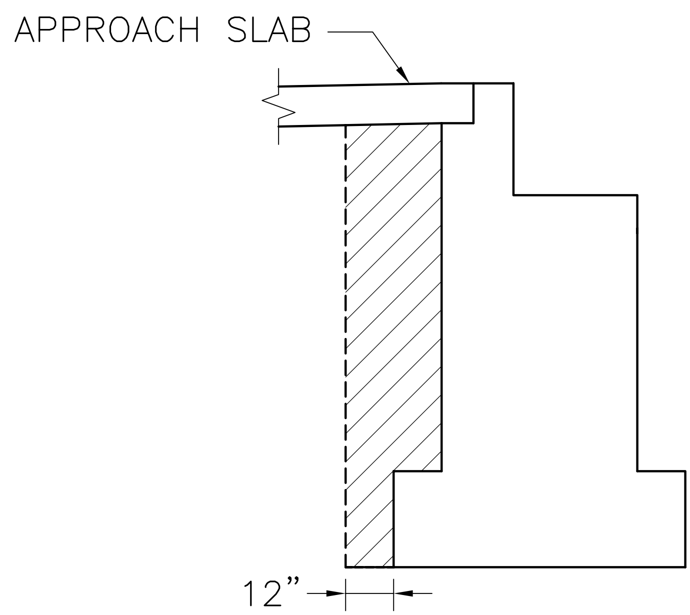
BOX CULVERT
(OR FRAME)



WINGWALL



ABUTMENT



STUB ABUTMENT

NOTE:
HATCHED AREA INDICATES LIMITS OF GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES.

LIMITS OF GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES

SCALE: $\frac{1}{4}$" = 1'–0"

NOTE:
See Drawing No. 12.4.2 for Integral Abutments.

MASS HIGHWAY BRIDGE MANUAL	GRAVEL BORROW BACKFILL STRUCTURES AND PIPES FOUNDATIONS AND FILL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.6.13**

NOTES:

1. PRE-DRILL X" DIAMETER HOLES TO THE SPECIFIED ELEVATIONS. PRE-DRILLED HOLES SHALL BE WITHIN 2% OF PLUMB.

2. DRILL X" DIAMETER ROCK SOCKET INTO COMPETENT BEDROCK TO THE ESTIMATED TIP ELEVATIONS. THE MINIMUM LENGTH OF ROCK SOCKET IS X FEET.

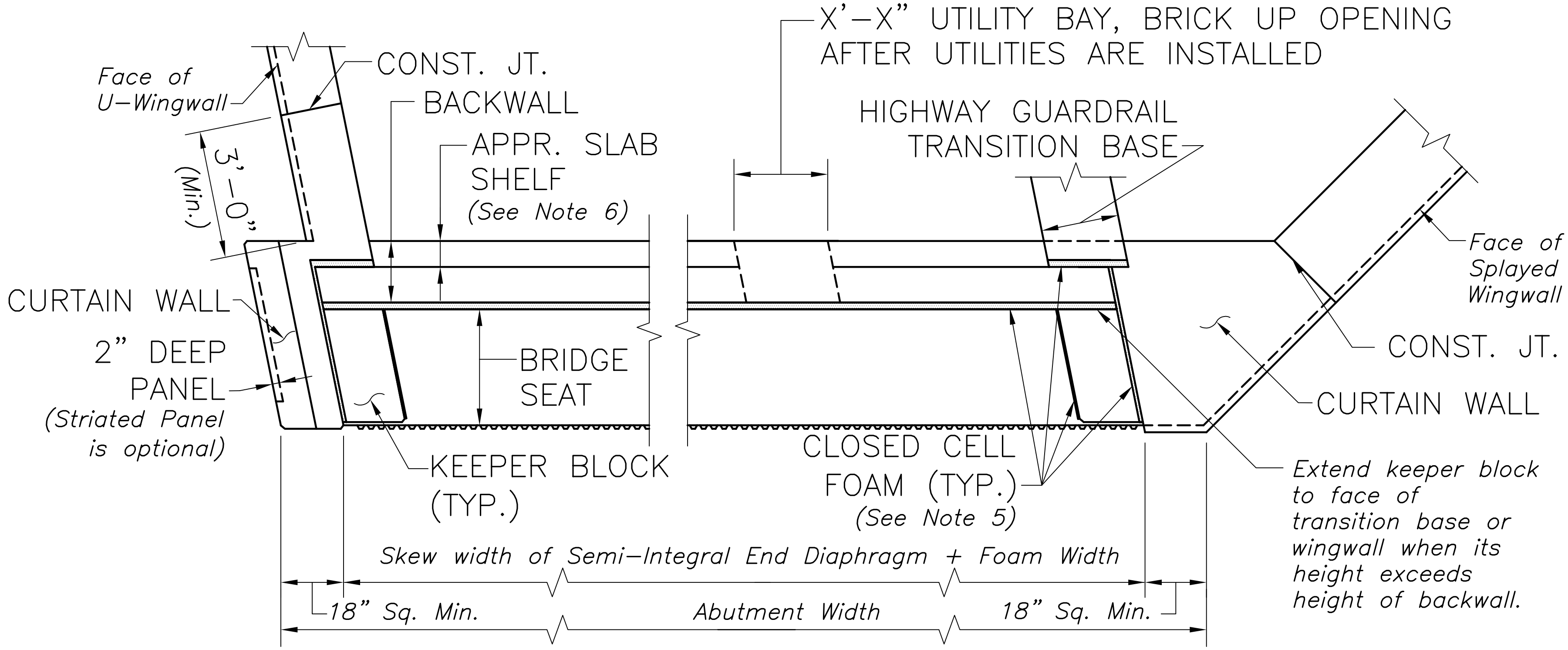
3. PLACE, CENTRALIZE, AND SECURE PILE IN PRE-DRILLED HOLE WITHIN 3" OF PLAN POSITION IN THE HORIZONTAL PLANE AT THE TOP OF PILE ELEVATION.

4. PLACE 2500 PSI, $\frac{3}{4}$ IN, 470 CEMENT CONCRETE TO FILL THE ENTIRE X FEET OF ROCK SOCKET. AFTER PLACEMENT OF CONCRETE, FILL THE SECTION FROM TOP OF ROCK SOCKET TO BOTTOM OF ABUTMENT WITH CRUSHED STONE CONFORMING TO M2.01.6. REMOVE ANY CASING WITHIN TOP 8 (EIGHT) FEET OF THE PILE. *(include this note for Integral Abutments only)*

5. THE FACTORED AXIAL LOAD PER PILE IS X KIPS (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest axial load)* THE FACTORED STRUCTURAL CAPACITY PER PILE IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE STRUCTURAL CAPACITY OF X KIPS, AN ECCENTRICITY FACTOR OF 0.XX *(omit if not applicable)* AND A STRUCTURAL PERFORMANCE FACTOR OF 0.XX.

6. THE FACTORED GEOTECHNICAL DESIGN CAPACITY PER PILE IS X KIPS AND IS A PRODUCT OF ULTIMATE GEOTECHNICAL CAPACITY OF X KIPS AND A GEOTECHNICAL PERFORMANCE FACTOR OF 0.XX.

7. THE CONTRACTOR SHALL SUBMIT A PILE SCHEDULE AND PILE INSTALLATION PLAN FOR REVIEW AND APPROVAL OF THE ENGINEER.



BRIDGE WITHOUT UTILITY BAY
BRIDGE WITH U–WINGWALLS

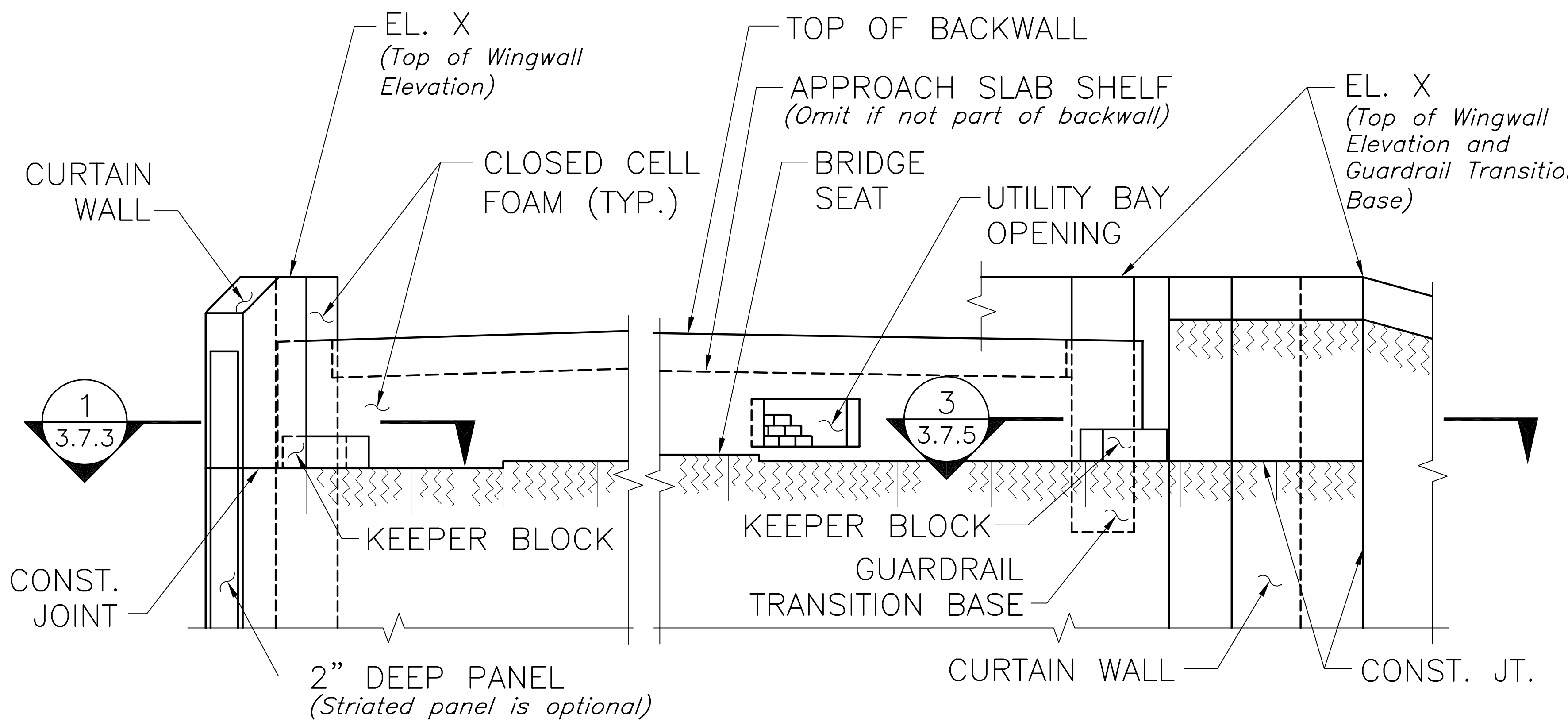
BRIDGE WITH UTILITY BAY
BRIDGE WITH SPLAYED WINGWALLS

ABUTMENT PLAN

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Above drawing is based on the Abutment Details for stringer depths 3'–6" and less. Modify as required for the abutment type being used.*
2. *Utility bay may be used with either U–Wingwalls or Splayed Wingwalls.*
3. *Remainder of abutment has been omitted for clarity. See Dwg. No. 3.1.1 for additional required dimensions and details.*
4. *Abutment plan shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant working points, dimensions, angles, survey information and North Arrow.*
5. *For required thickness of closed cell foam, refer to the Abutment Details for the type of end diaphragm being used. Specify thickness on the Abutment Plan.*
6. *The approach slab and approach slab shelf shall be omitted from the Abutment Plan View when they are incorporated into the End Diaphragm (See Abutment Details for stringer depths greater than 3'–6").*



BRIDGE WITHOUT UTILITY BAY
BRIDGE WITH U-WINGWALLS

BRIDGE WITH UTILITY BAY
BRIDGE WITH SPLAYED WINGWALLS

ABUTMENT ELEVATION

SCALE: $\frac{1}{4}$" = 1'-0"

NOTES:

1. *Above drawing is based on the Abutment Details for stringer depths 3'-6" and less. Modify as required for the abutment type being used.*
2. *Utility bay may be used with either U-Wingwalls or Splayed Wingwalls.*
3. *Remainder of abutment has been omitted for clarity. See Dwg. No. 3.1.2 for additional required dimensions and details.*
4. *Abutment elevation shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant elevations.*

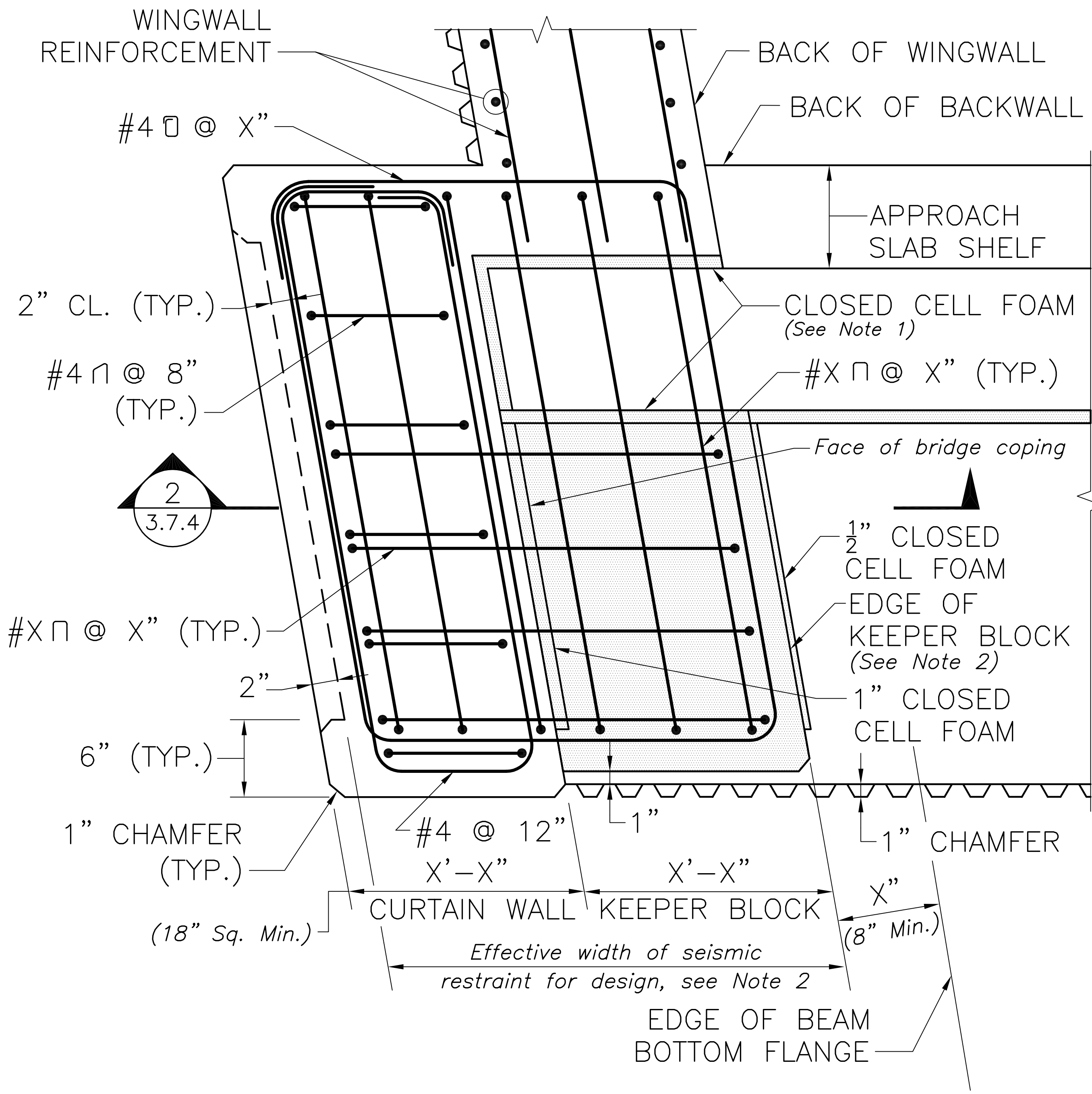
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL ABUTMENT ELEVATION

BRIDGE SEAT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
3.7.2



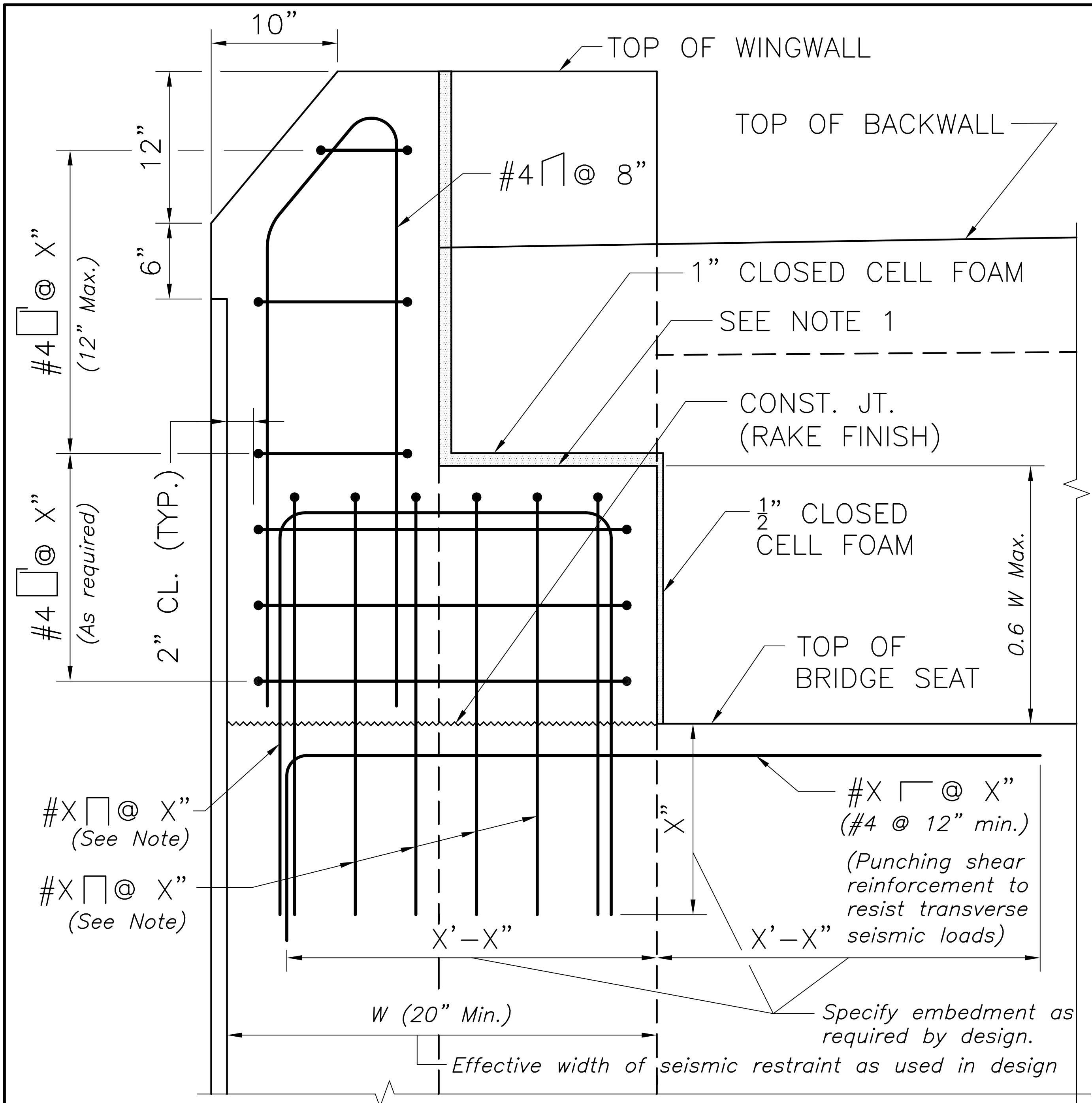
SECTION 1

SCALE: 1" = 1'–0"

NOTES:

1. *Detail shown is for stringer depths 3'–6" and less. Modify drawing and provide closed cell foam as required for the abutment type being used.*
2. *Edge of keeper block shall not extend beyond the line of the back of wingwall. The curtain wall and keeper block can be combined for the design of the seismic restraint. If the width is still not sufficient, use intermediate abutment keeper blocks.*

MASS HIGHWAY BRIDGE MANUAL	HORIZONTAL SECTION ABUTMENT W/ U–WINGWALL BRIDGE SEAT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.3**



NOTES:

1. TOP OF KEEPER BLOCK SHALL BE TROWELED SMOOTH PARALLEL TO PROFILE GRADE.
2. ABUTMENT REINFORCEMENT BELOW CONSTRUCTION JOINT HAS BEEN OMITTED FOR CLARITY.

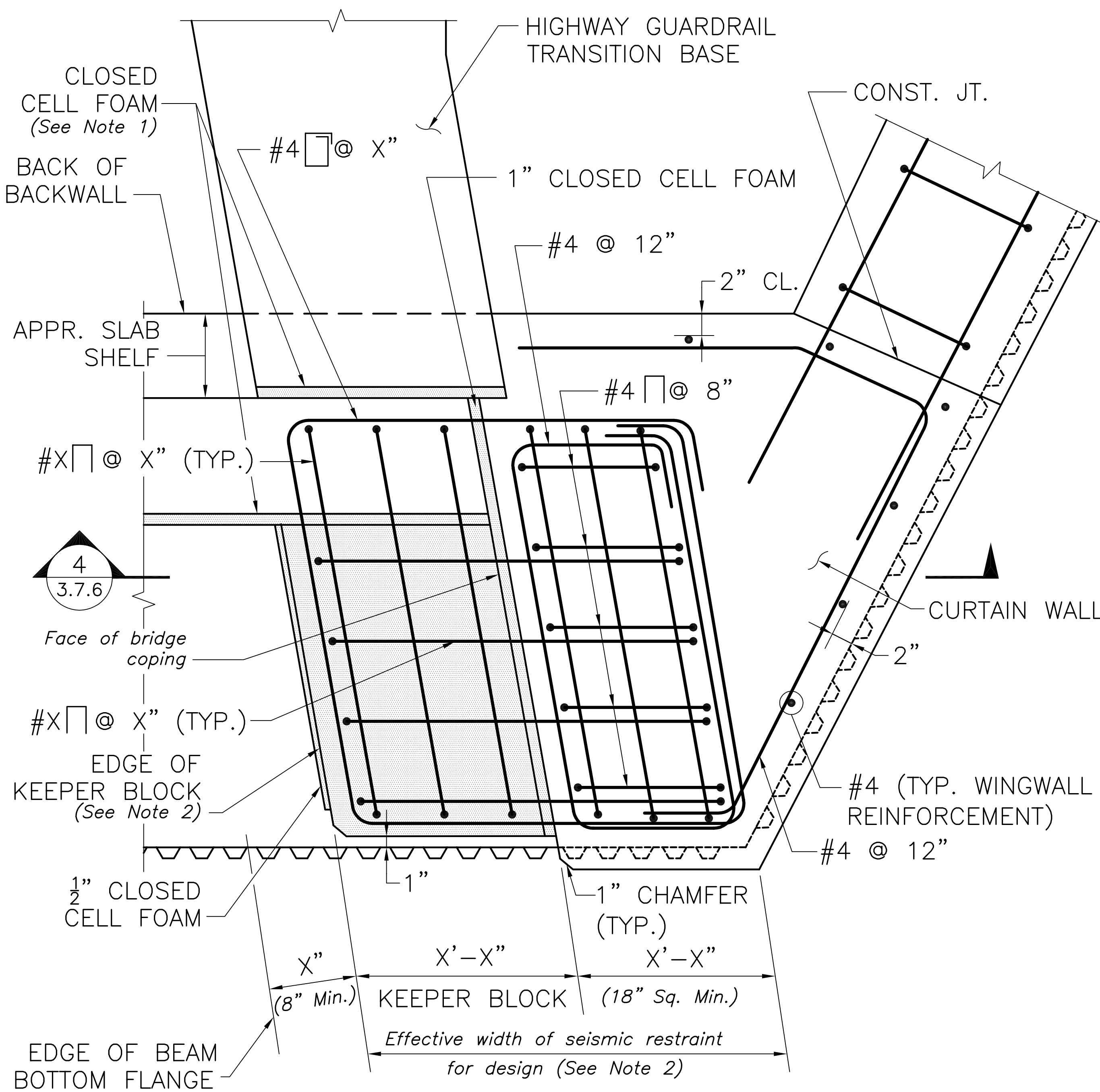
SECTION 2

SCALE: 1" = 1'–0"

NOTE:

Design as shear friction reinforcement to resist transverse seismic loads. Reinforcement configuration shown is conceptual. The Designer will modify the arrangement or add additional hoops as required by the actual design.

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION ABUTMENT W/ U–WINGWALL BRIDGE SEAT DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: 3.7.4



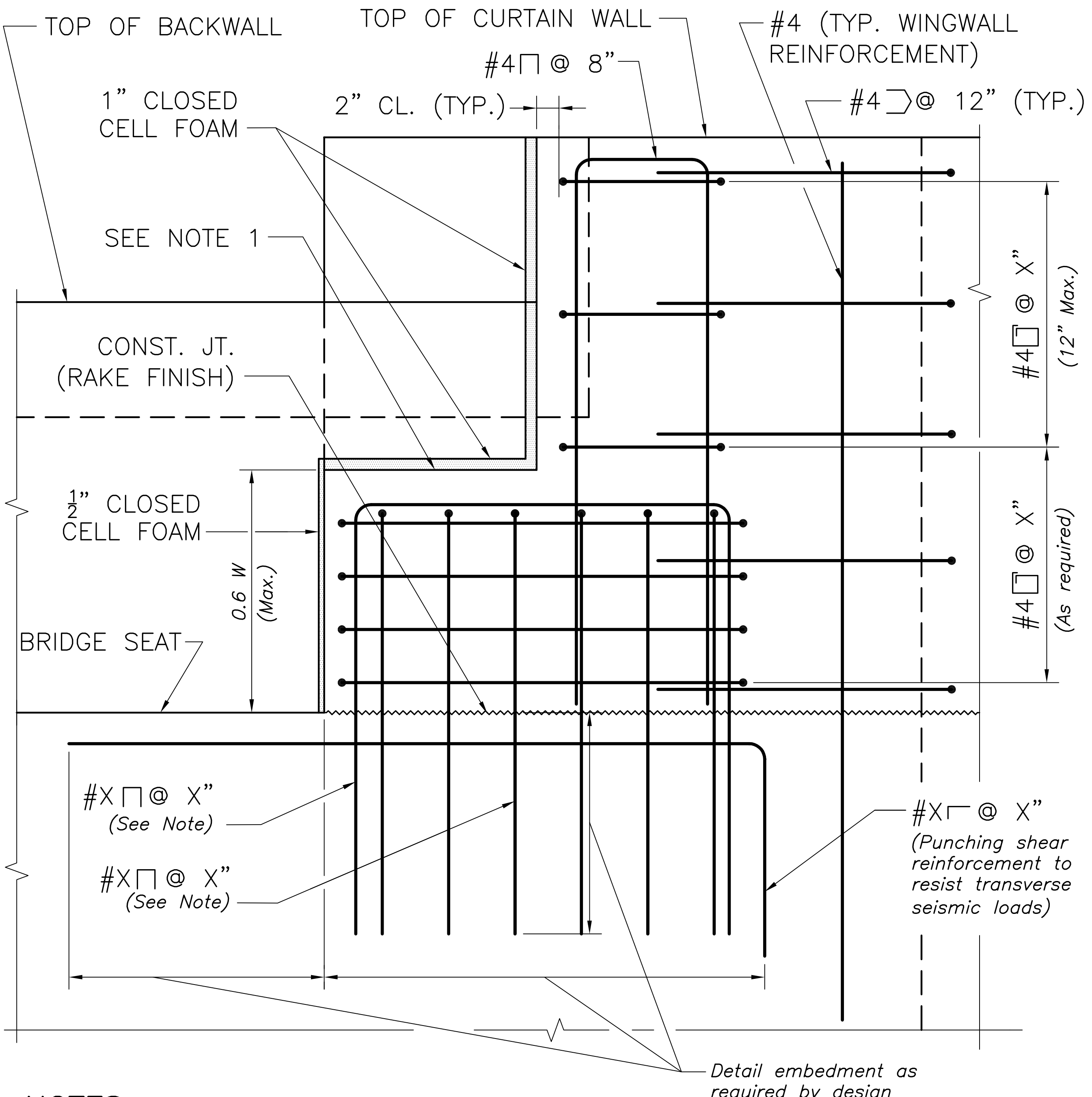
SECTION 3

SCALE: 1" = 1'-0"

NOTES:

1. *Detail shown is for stringer depths 3'-6" and less. Modify drawing and provide closed cell foam as required for the abutment type used.*
2. *Edge of keeper block shall not extend beyond the Highway Guardrail Transition base. The curtain wall and keeper block can be combined for the design of the seismic restraint. If the width is still not sufficient, use intermediate abutment keeper blocks.*

MASS HIGHWAY BRIDGE MANUAL	HORIZONTAL SECTION AT SPLAYED WINGWALL BRIDGE SEAT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.5**



NOTES:

1. TOP OF KEEPER BLOCK SHALL BE TROWELED SMOOTH PARALLEL TO PROFILE GRADE.

2. ABUTMENT REINFORCEMENT BELOW CONSTRUCTION JOINT HAS BEEN OMITTED FOR CLARITY.

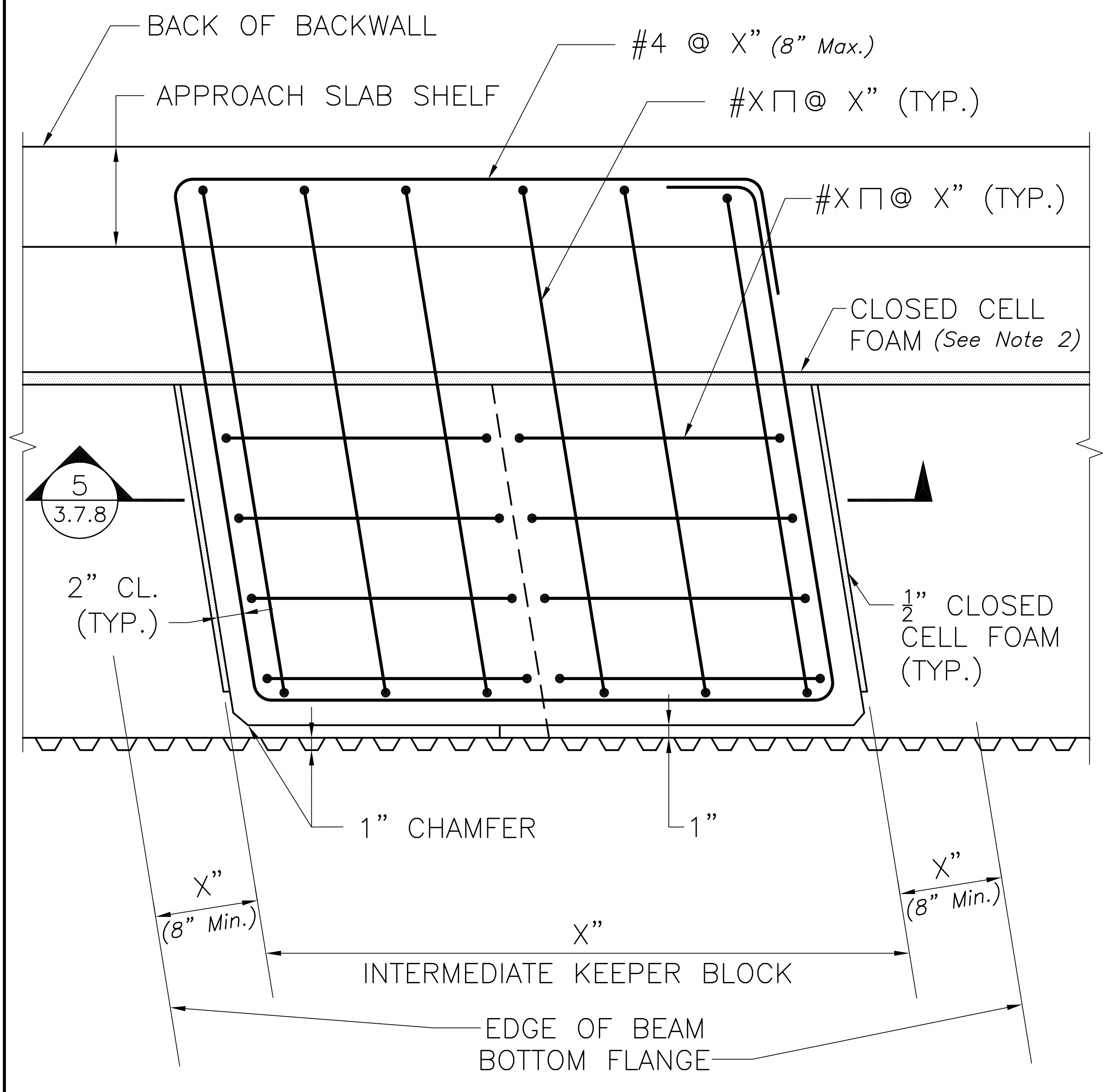
SECTION 4

SCALE: 1" = 1'-0"

NOTE:

Design as shear friction reinforcement to resist transverse seismic loads. Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement or add additional hoops as required by the actual design.

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION AT SPLAYED WINGWALL BRIDGE SEAT DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **3.7.6**



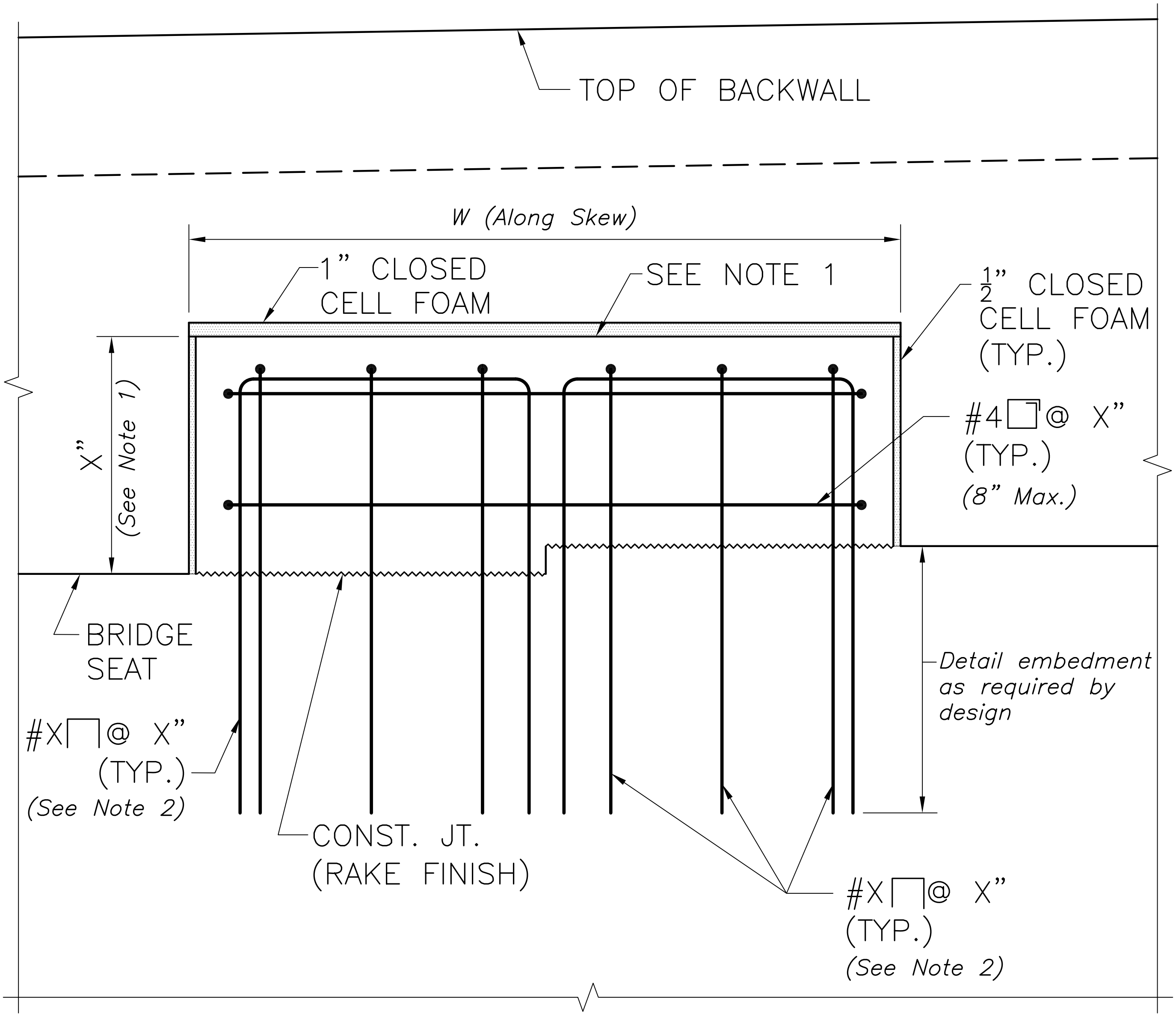
INTERMEDIATE ABUTMENT KEEPER BLOCK

SCALE: 1" = 1'–0"

NOTES:

1. *Intermediate keeper blocks are only used when the standard seismic restraints are insufficient. Avoid locating an intermediate keeper block in a utility bay. The sides of the intermediate keeper block are to be parallel with the adjacent beams.*
2. *Detail shown is for stringer depths 3'–6" and less. Modify drawing and provide closed cell foam as required for the abutment type used.*

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE KEEPER BLOCK – PLAN SECTION BRIDGE SEAT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.7**



NOTES:

1. TOP OF KEEPER BLOCK SHALL BE TROWELED SMOOTH PARALLEL TO PROFILE GRADE.

2. ABUTMENT REINFORCEMENT BELOW CONSTRUCTION JOINT HAS BEEN OMITTED FOR CLARITY.

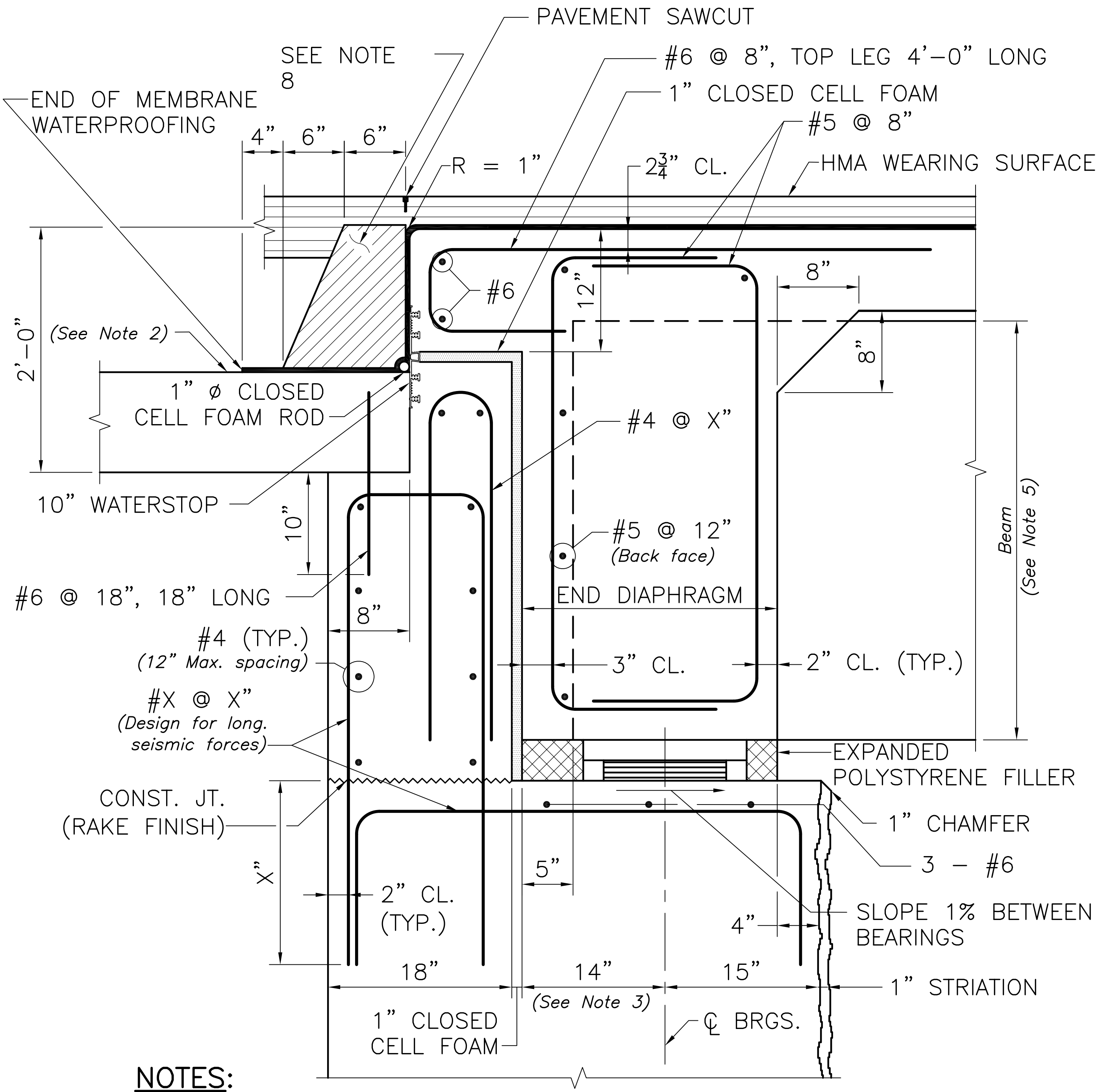
SECTION 5

SCALE: 1" = 1'–0"

NOTES:

1. *Height of keeper block: H $\leqslant$ W/3*
2. *Design as shear friction reinforcement to resist transverse seismic loads. Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement or add hoops as required by actual design.*

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE KEEPER BLOCK – VERTICAL SECTION BRIDGE SEAT DETAILS	DATE OF ISSUE: FEBRUARY 2007 DRAWING NUMBER: **3.7.8**



NOTES:

(See Dwg. No. 3.7.13 for Notes to be included on Construction Drawings)

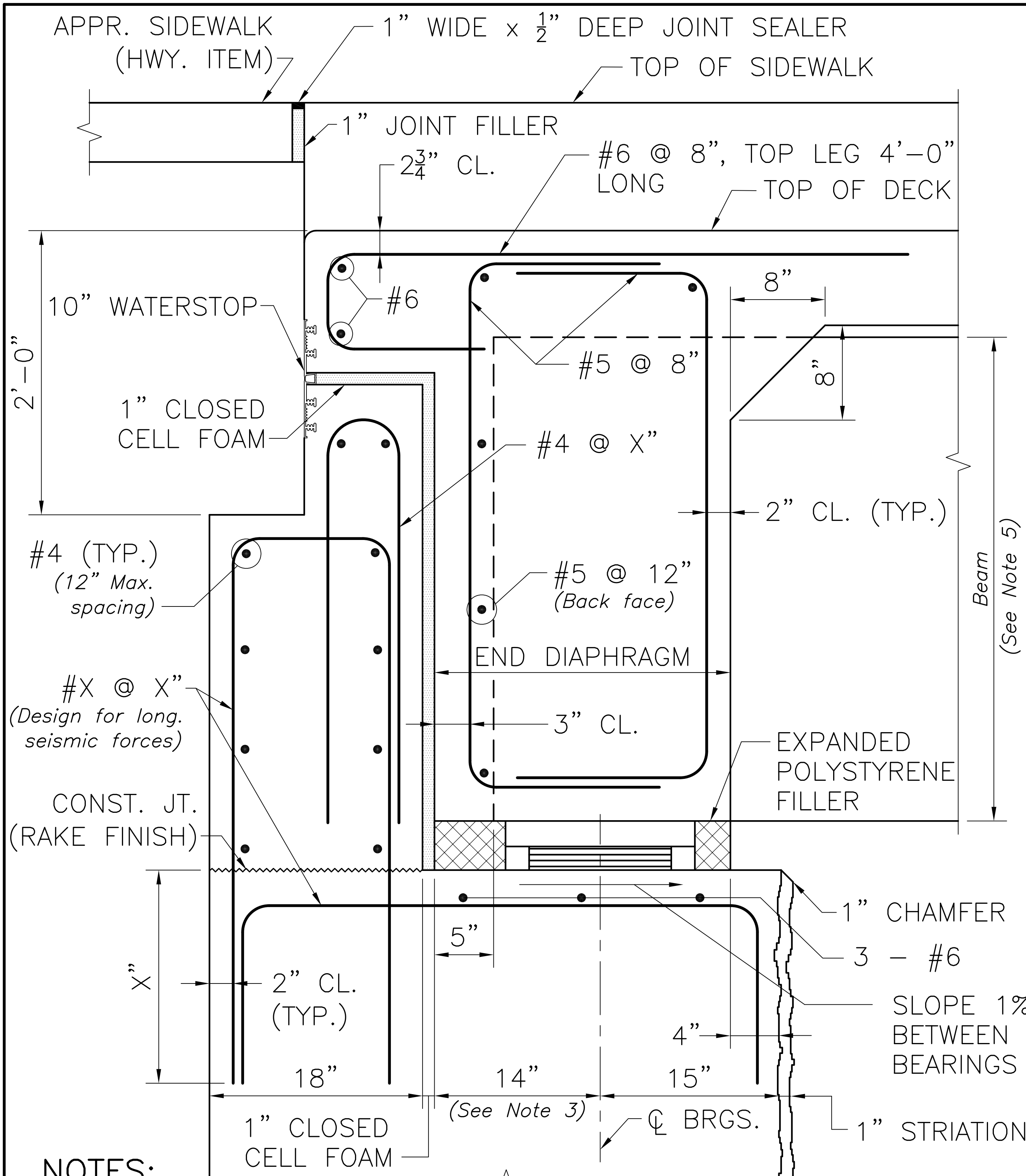
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *This detail is limited to ½" of one way thermal movement. There is no skew angle limit. Otherwise, use Roadway Section with Joint Details.*
2. *This detail is to be used with Approach Slab Type I.*
3. *If the bearing exceeds 16" in diameter, set this dimension equal to Bearing Dia./2 + 6". See Chapter 6 for additional modifications to this dimension required for the NEBT beams.*
4. *For bridges with exposed concrete decks, modify this detail as shown on Dwg. No. 3.7.12.*
5. *Modify above detail for the beam type used.*
6. *Contact Bridge Engineer to obtain detail modifications needed if using Spray Applied Membrane System.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION STRINGER DEPTH ⩽ 3'–6" END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.9**



NOTES:

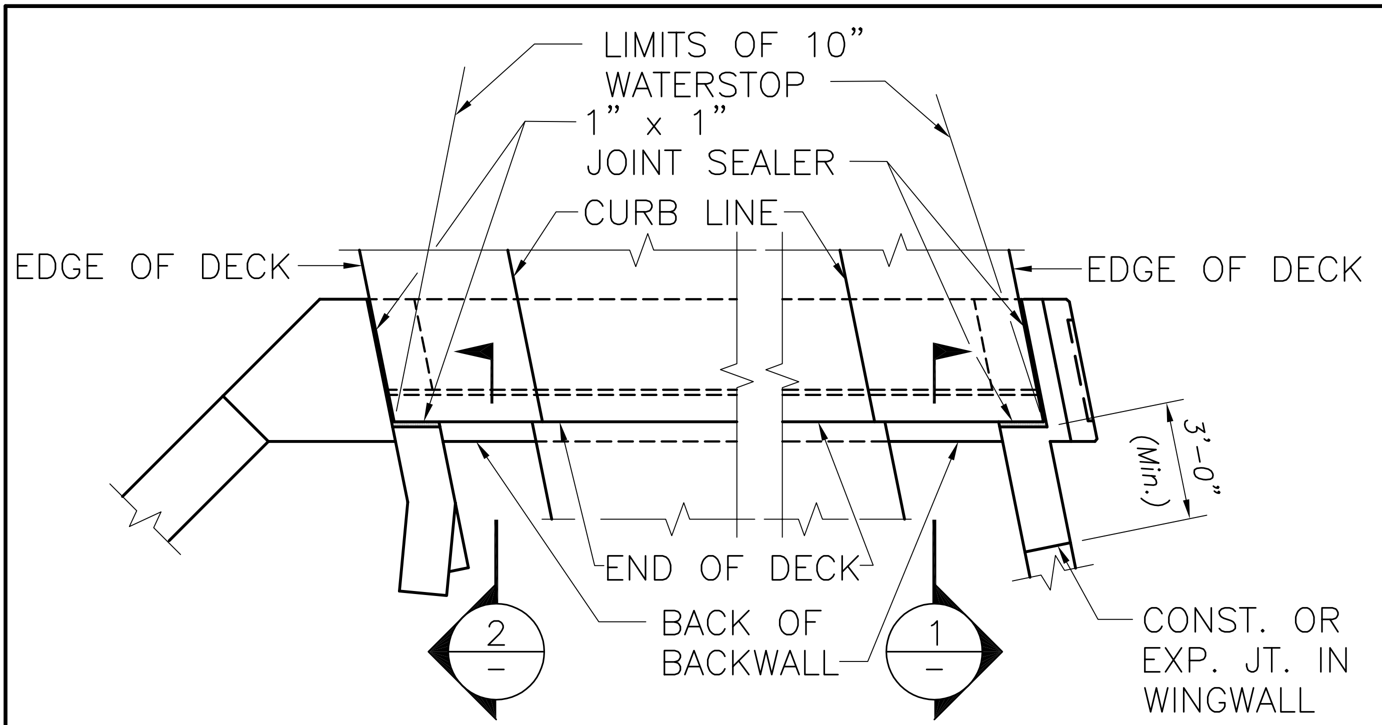
(See Dwg. No. 3.7.13 for notes to be included on Construction Drawings)

DETAILS AT ABUTMENT – SIDEWALK SECTION

SCALE: 1" = 1'–0"

NOTES:
See Dwg. No. 3.7.9 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK SECTION STRINGER DEPTH ⩽ 3'–6" END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.10**

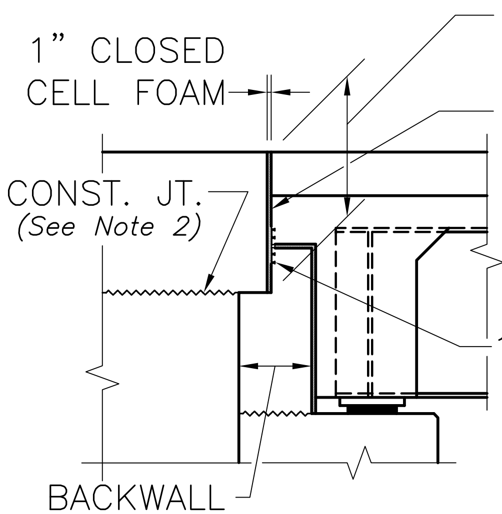


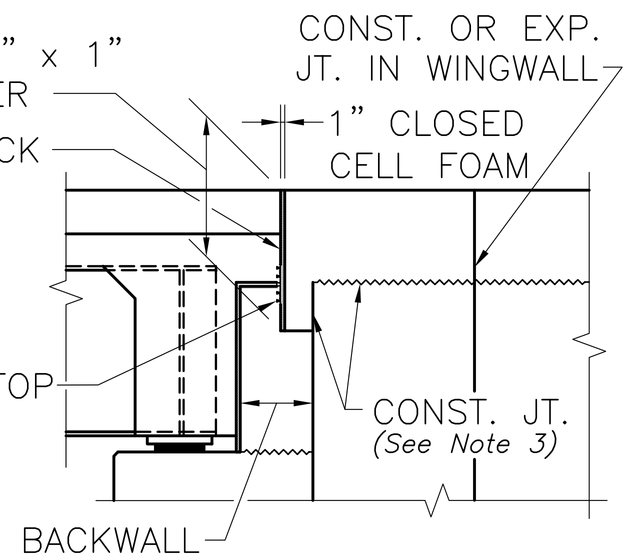
BRIDGE WITH SPLAYED WINGWALLS

BRIDGE WITH U-WINGWALLS

END OF DECK PLAN

SCALE: $\frac{1}{4}$" = 1'-0"





SECTION 2

SCALE: $\frac{1}{4}$" = 1'-0"

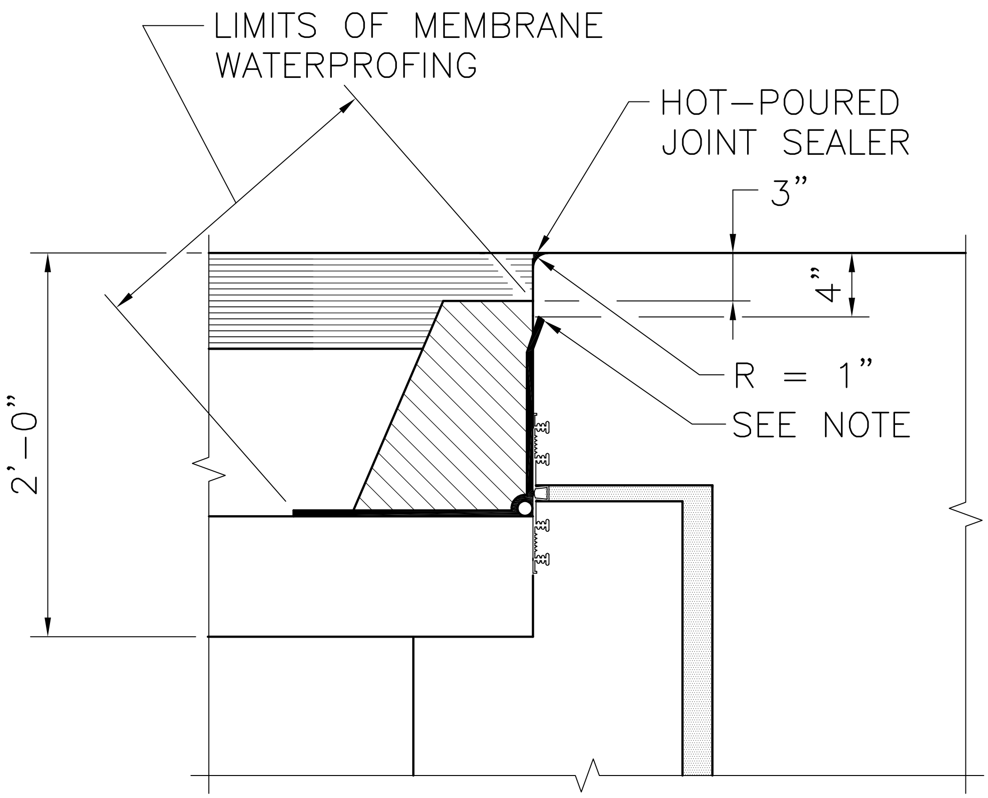
SECTION 1

SCALE: $\frac{1}{4}$" = 1'-0"

NOTES:

1. *Sidewalk details shown, Safety Curb is similar. Railing/barrier omitted for clarity.*
2. *The details shown in Section 2 may be included with the Highway Guardrail Transition Details. Set the construction joint at the top of the approach slab shelf.*
3. *For those copings where Chapter 9 does not specify a construction joint, set the construction joint at the top of the striation groove.*

MASS HIGHWAY BRIDGE MANUAL	END OF DECK PLAN STRINGER DEPTH ≤ 3'-6" END OF DECK DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.11**



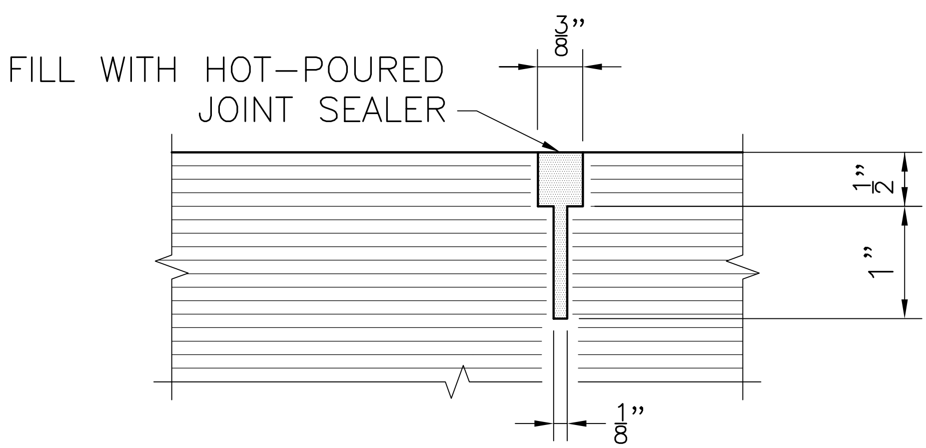
NOTE:

TUCK AND NAIL END OF MEMBRANE WATERPROOFING INTO A TAPERED $\frac{1}{2}$" DEEP x 2" HIGH POCKET. FILL POCKET WITH JOINT SEALER.

(Add this note to the other Details At Abutment Construction Notes)

DETAILS AT ABUTMENT FOR EXPOSED CONCRETE DECKS

SCALE: 1" = 1'–0"



PAVEMENT SAWCUT DETAIL

NOT TO SCALE

MASS HIGHWAY BRIDGE MANUAL	EXPOSED DECK AND PAVEMENT SAWCUT DETAILS END OF DECK DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.12**

ROADWAY/SIDEWALK SECTION NOTES:

(Include these Notes with details shown on Dwg. No.'s 3.7.9 and 3.7.10)

1. ALL REINFORCEMENT SHOWN IN THIS DETAIL SHALL BE COATED EXCEPT FOR THE APPROACH SLAB REINFORCEMENT.

2. ALL BACKWALL CONCRETE ABOVE THE CONSTRUCTION JOINT LOCATED AT THE BRIDGE SEAT SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE. THE CONSTRUCTION JOINT SHALL BE GIVEN A RAKE FINISH WITH A $\frac{1}{4}$" MINIMUM AMPLITUDE.

3. TOP OF BACKWALL SHALL BE TROWELED SMOOTH PARALLEL TO THE PROFILE GRADE.

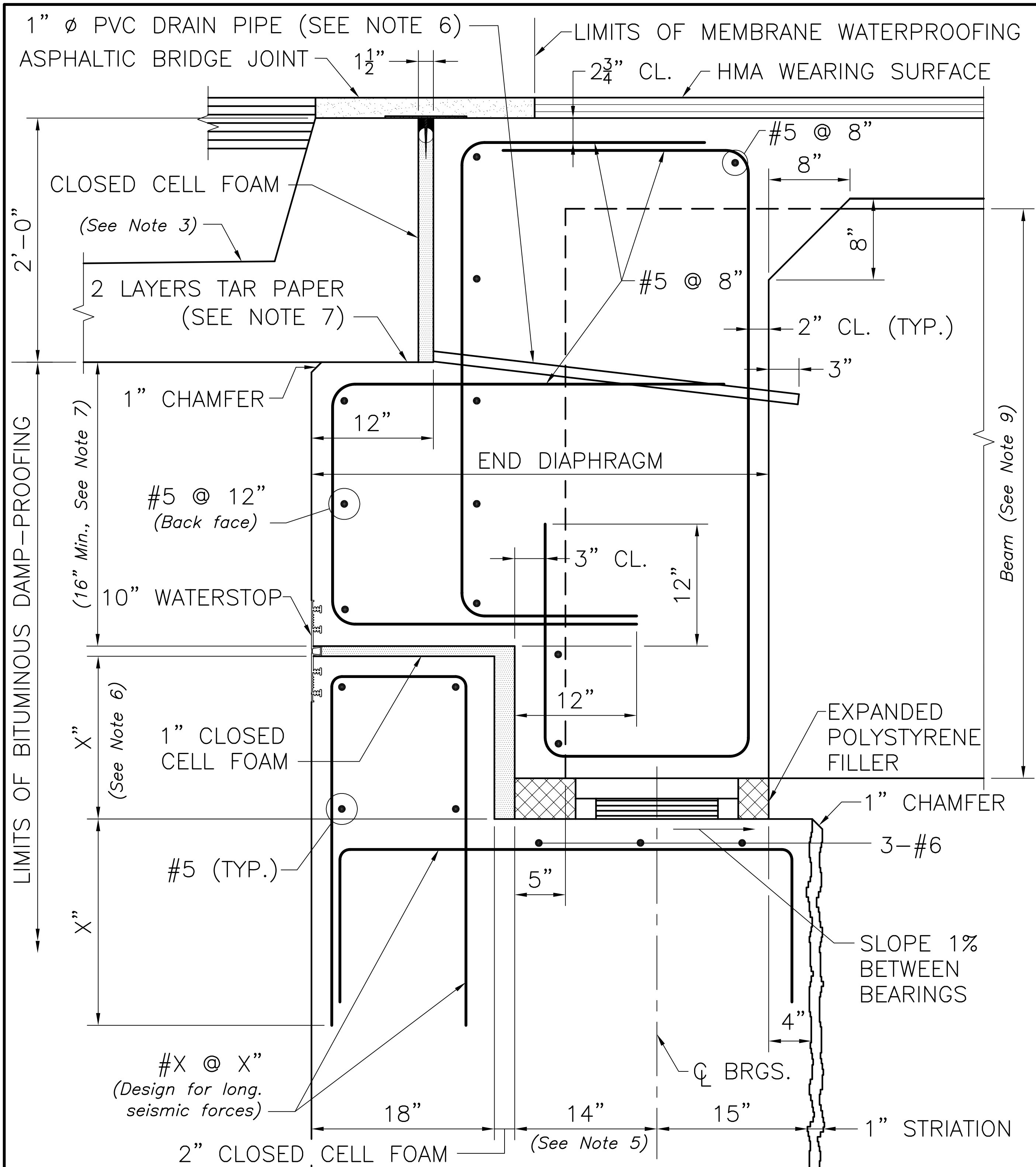
4. THE BACKWALL, KEEPER BLOCK, AND CURTAIN WALL CONCRETE MUST BE PLACED AND SUFFICIENTLY CURED PRIOR TO PLACING THE END DIAPHRAGM CONCRETE.

5. THE END DIAPHRAGM CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE AND SHALL BE PLACED MONOLITHICALLY WITH THE DECK.

6. PRIOR TO PLACING THE END DIAPHRAGM CONCRETE, CLOSED CELL FOAM OF THE SPECIFIED THICKNESSES SHALL BE ATTACHED WITH ADHESIVE TO ALL SURFACES OF THE BACKWALL, KEEPER BLOCKS, AND CURTAIN WALLS AS SHOWN ON THE PLANS. EXPANDED POLYSTYRENE FILLER SHALL BE PLACED UNDER THE BEAM BOTTOM FLANGE AND THE BOTTOM OF THE END DIAPHRAGM SHALL BE FORMED AS SPECIFIED. THE CONTRACTOR SHALL INSURE THAT ALL ABUTMENT CONCRETE IS PROPERLY LINED. END DIAPHRAGM CONCRETE MUST NOT COME IN DIRECT CONTACT WITH ABUTMENT CONCRETE.

7. DRAPE MEMBRANE WATERPROOFING OVER CLOSED CELL FOAM BACKER ROD.

8. PROTECTIVE COURSE TO BE HOT MIX ASPHALT DENSE BINDER COURSE FOR BRIDGES, PLACED IN 2" LAYERS AND COMPACTED WITH A MECHANICAL HAND-GUIDED TAMPER WITHIN 12 HOURS AFTER PLACING MEMBRANE WATERPROOFING.



NOTES:

(See Dwg. No. 3.7.18 for Notes to be included on Construction Drawings)

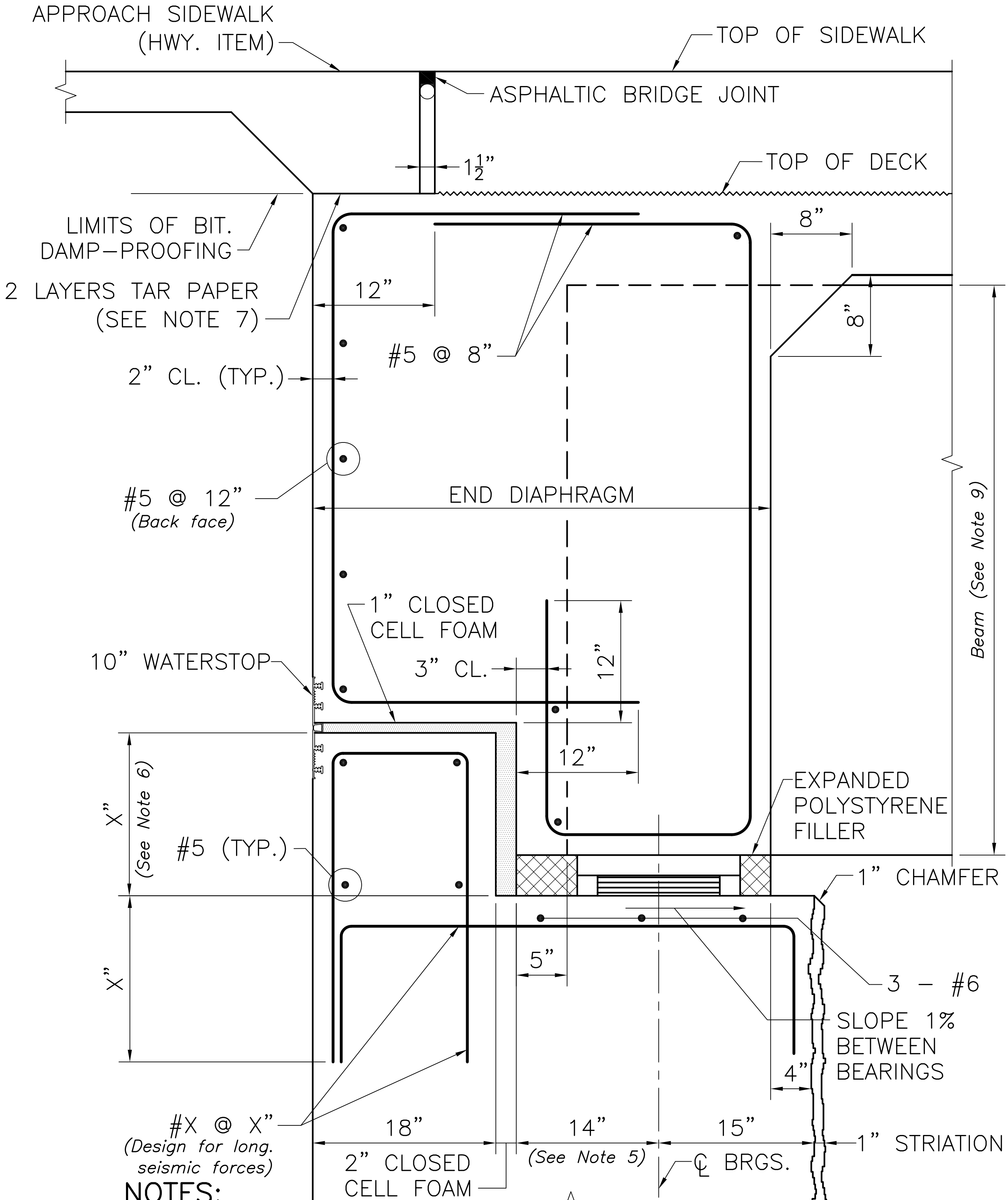
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *This detail shall be used when one way thermal movement ≤ 1" and skew angle ≤ 30°.*
2. *See Dwg. No. 3.7.17 for Designer Notes.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION STRINGER DEPTH > 3'–6" END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.14**



NOTES:

(See Dwg. No. 3.7.18 for Notes to be included on Construction Drawings)

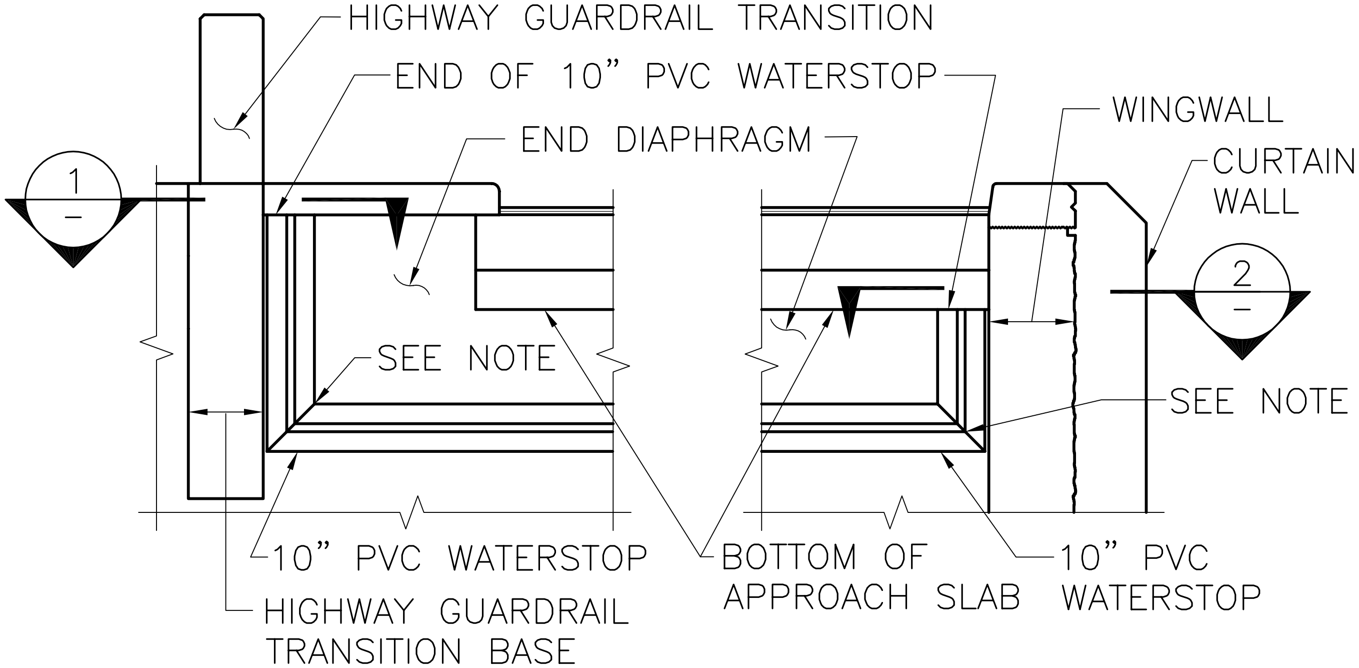
DETAILS AT ABUTMENT – SIDEWALK SECTION

SCALE: 1" = 1'–0"

NOTES:

See Dwg. No. 3.7.17 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK SECTION STRINGER DEPTH > 3'–6" END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.15**



BRIDGES WITH SIDEWALK OR WITH SPLAYED WINGWALLS

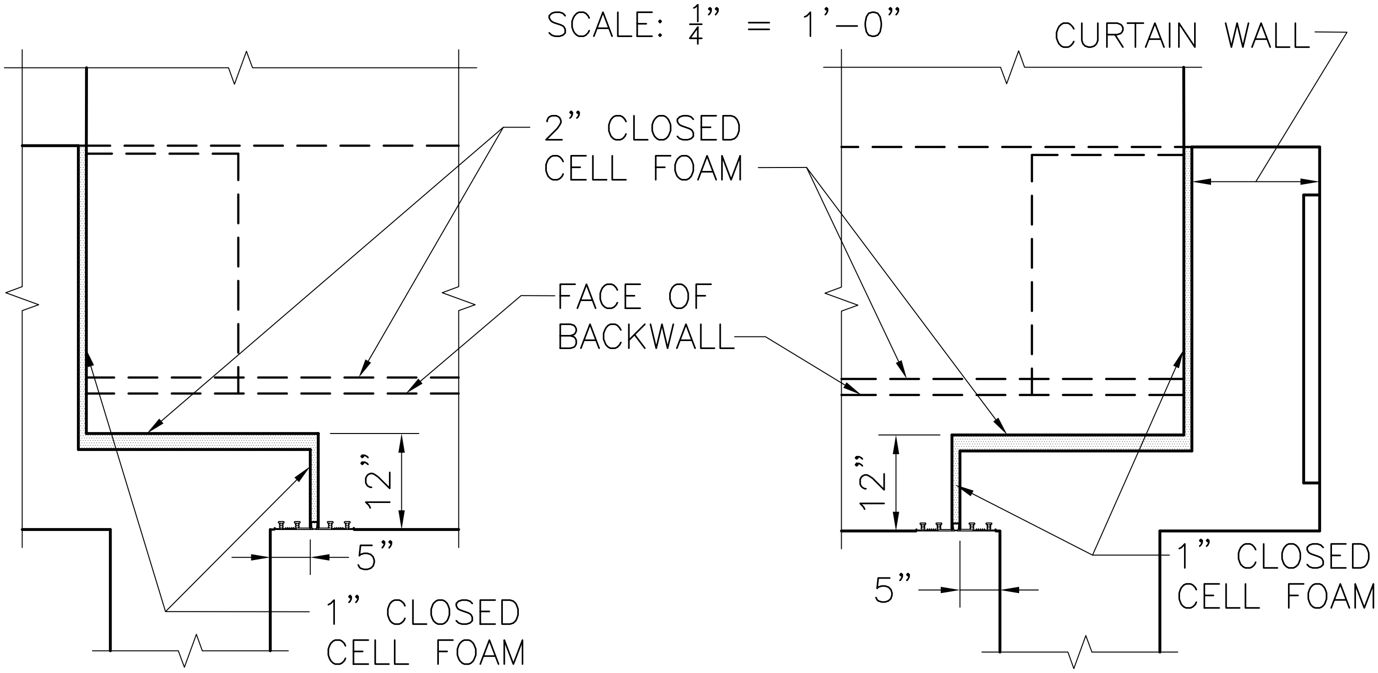
BRIDGES WITH SAFETY CURBS OR WITH U-WINGWALLS

NOTE:

FACTORY SPLICED MITERED CORNER FOR CONTINUITY OF WATERSTOP.
FIELD SPLICES REQUIRE THE APPROVAL OF THE ENGINEER.

END OF DECK ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"



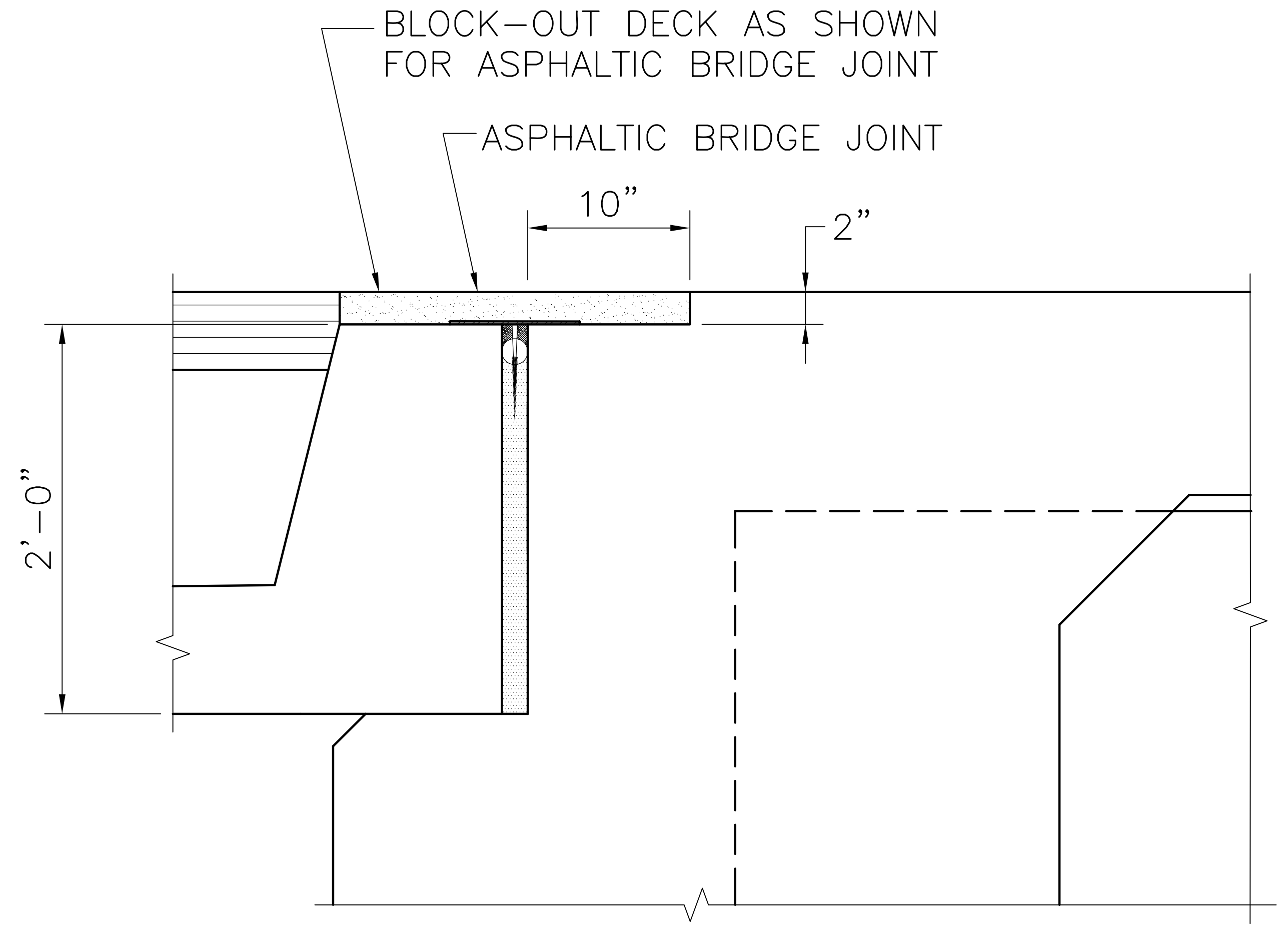
SECTION 1

SCALE: $\frac{1}{2}$" = 1'–0"

SECTION 2

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	END OF DECK ELEVATION STRINGER DEPTH > 3'–6" END OF DECK DETAILS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **3.7.16**



DETAILS AT ABUTMENT FOR EXPOSED CONCRETE DECK

SCALE: 1" = 1'-0"

NOTES:

1. *Designer Notes listed here are for the details at abutment Dwg. No.'s 3.7.14 and 3.7.15.*
2. *This detail is limited to 1" of one-way thermal movement and a skew angle less than or equal to 30°. Otherwise, use detail shown on Drawing No. 3.7.19.*
3. *This detail is to be used with Approach Slab Type II.*
4. *Bridges with HMA wearing surface require the use of deck drains.*
5. *If the bearing exceeds 16" in diameter, set this dimension equal to Bearing Dia./2 + 6". See Chapter 6 for additional modifications to this dimension required for NEBT beams.*
6. *Minimum dimension is equal to Total Height of Bearing Assembly + 12".*
7. *Designer shall verify this minimum dimension when laying out the abutment, but do not show it on the Construction Drawings.*
8. *For bridges with exposed concrete decks, modify this detail as shown on Dwg. No. 3.7.17.*
9. *Modify the detail for the beam type used.*

MASS HIGHWAY BRIDGE MANUAL	EXPOSED CONCRETE DECK DETAILS & DESIGNER NOTES END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.17**

ROADWAY/SIDEWALK SECTION NOTES:

(Include these Notes with details shown on Dwg. No.'s 3.7.14 and 3.7.15)

1. ALL REINFORCEMENT SHOWN IN THIS DETAIL SHALL BE COATED, EXCEPT FOR THE APPROACH SLAB REINFORCEMENT.

2. TOP OF BACKWALL SHALL BE TROWELED SMOOTH PARALLEL TO THE PROFILE GRADE.

3. KEEPER BLOCK AND CURTAIN WALL CONCRETE MUST BE PLACED AND SUFFICIENTLY CURED PRIOR TO PLACING THE END DIAPHRAGM CONCRETE.

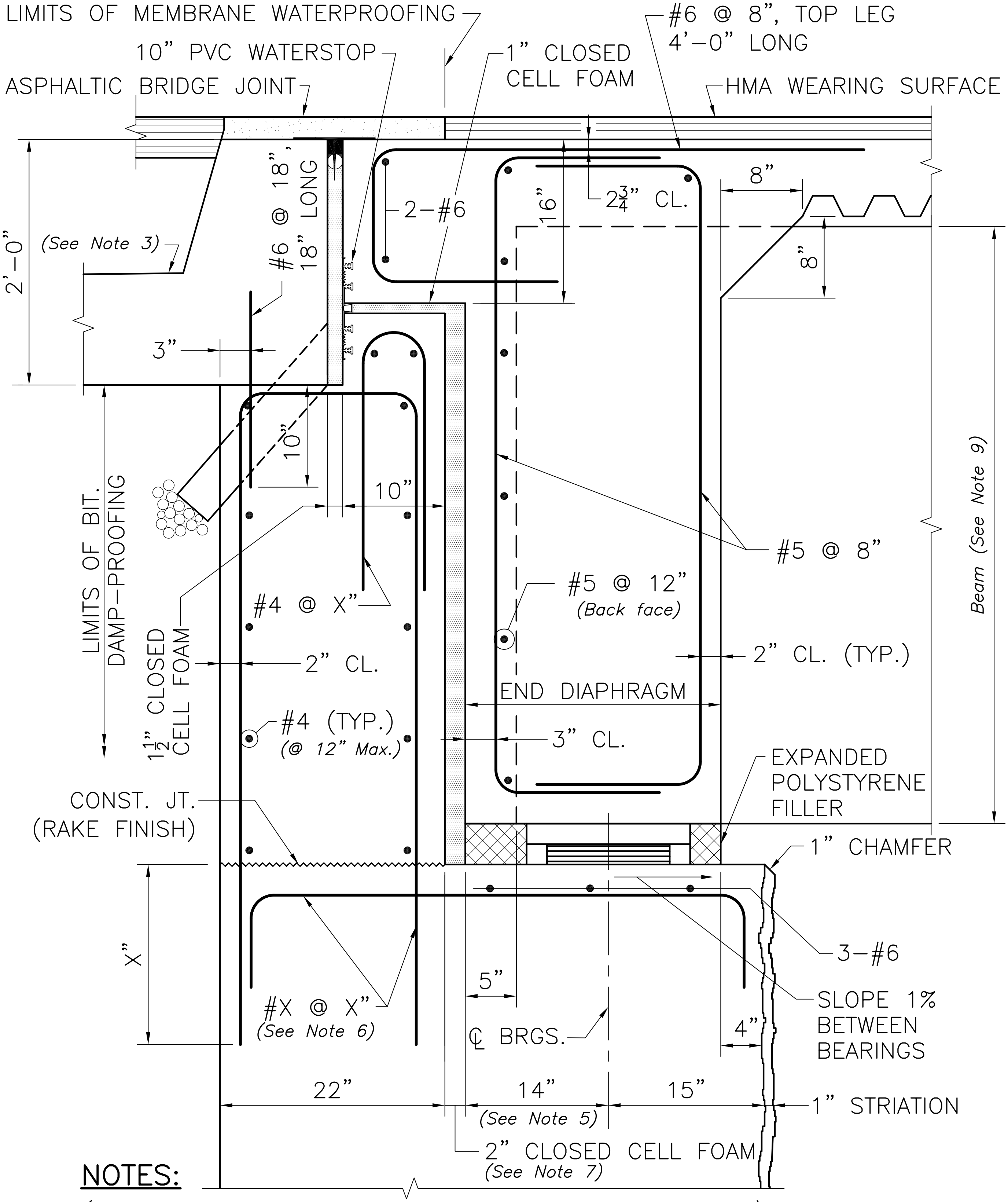
4. THE END DIAPHRAGM CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE AND SHALL BE PLACED MONOLITHICALLY WITH THE DECK.

5. PRIOR TO PLACING THE END DIAPHRAGM CONCRETE, CLOSED CELL FOAM OF THE SPECIFIED THICKNESSES SHALL BE ATTACHED WITH ADHESIVE TO ALL SURFACES OF THE BACKWALL, KEEPER BLOCKS AND CURTAIN WALLS AS SHOWN ON THE PLANS. EXPANDED POLYSTYRENE FILLER SHALL BE PLACED UNDER THE BEAM BOTTOM FLANGE AND THE BOTTOM OF THE END DIAPHRAGM SHALL BE FORMED AS SPECIFIED. THE CONTRACTOR SHALL INSURE THAT ALL ABUTMENT CONCRETE IS PROPERLY LINED. END DIAPHRAGM CONCRETE MUST NOT COME IN DIRECT CONTACT WITH THE ABUTMENT CONCRETE.

6. THE 1" ⌀ PVC DRAIN PIPES SHALL BE PLACED AT LOW POINTS OF THE APPROACH SLAB SHELF AND SHALL BE SLOPED A MINIMUM 5% TOWARDS THE FRONT FACE OF THE END DIAPHRAGM.

7. TOP OF APPROACH SLAB SHELF AND SIDEWALK SEAT SHALL BE TROWELED SMOOTH AND HAVE 2 LAYERS OF TAR PAPER APPLIED PRIOR TO PLACING THE APPROACH SLAB AND SIDEWALK CONCRETES.

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION NOTES STRINGER DEPTH > 3'-6" END OF DECK DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.18**



NOTES:

(See Dwg. No. 3.7.23 for Notes to be included on Construction Drawings)

DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'-0"

NOTES:

1. This detail shall be used when one way thermal movement ≤ 1" and skew angle ≤ 30°.
2. See Dwg. No. 3.7.21 for Designer Notes.

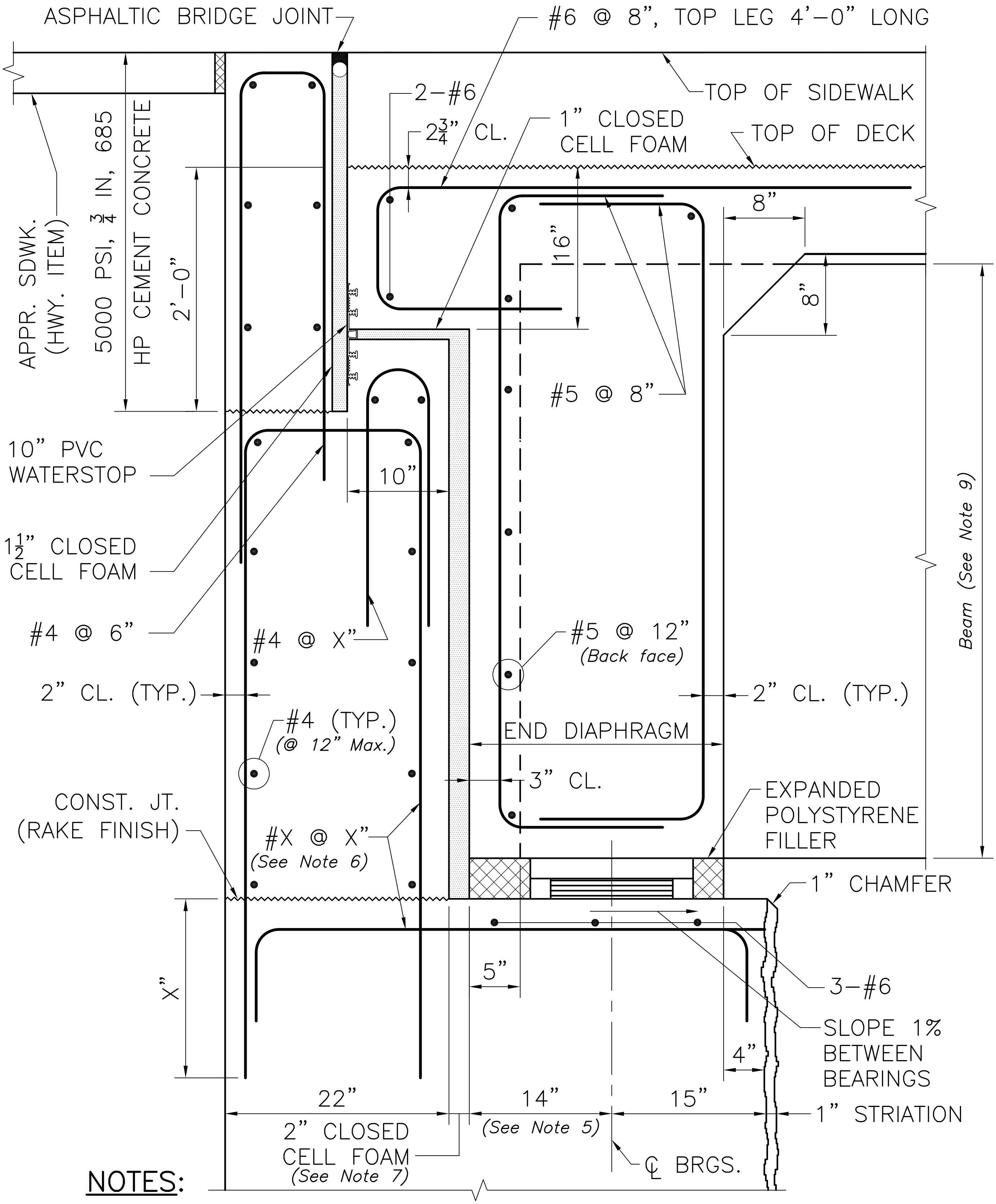
MASS HIGHWAY BRIDGE MANUAL

ROADWAY SECTION WITH ASPHALTIC BRIDGE JOINT

END OF DECK DETAILS

DATE OF ISSUE: NOVEMBER 2010

DRAWING NUMBER: 3.7.19



NOTES:

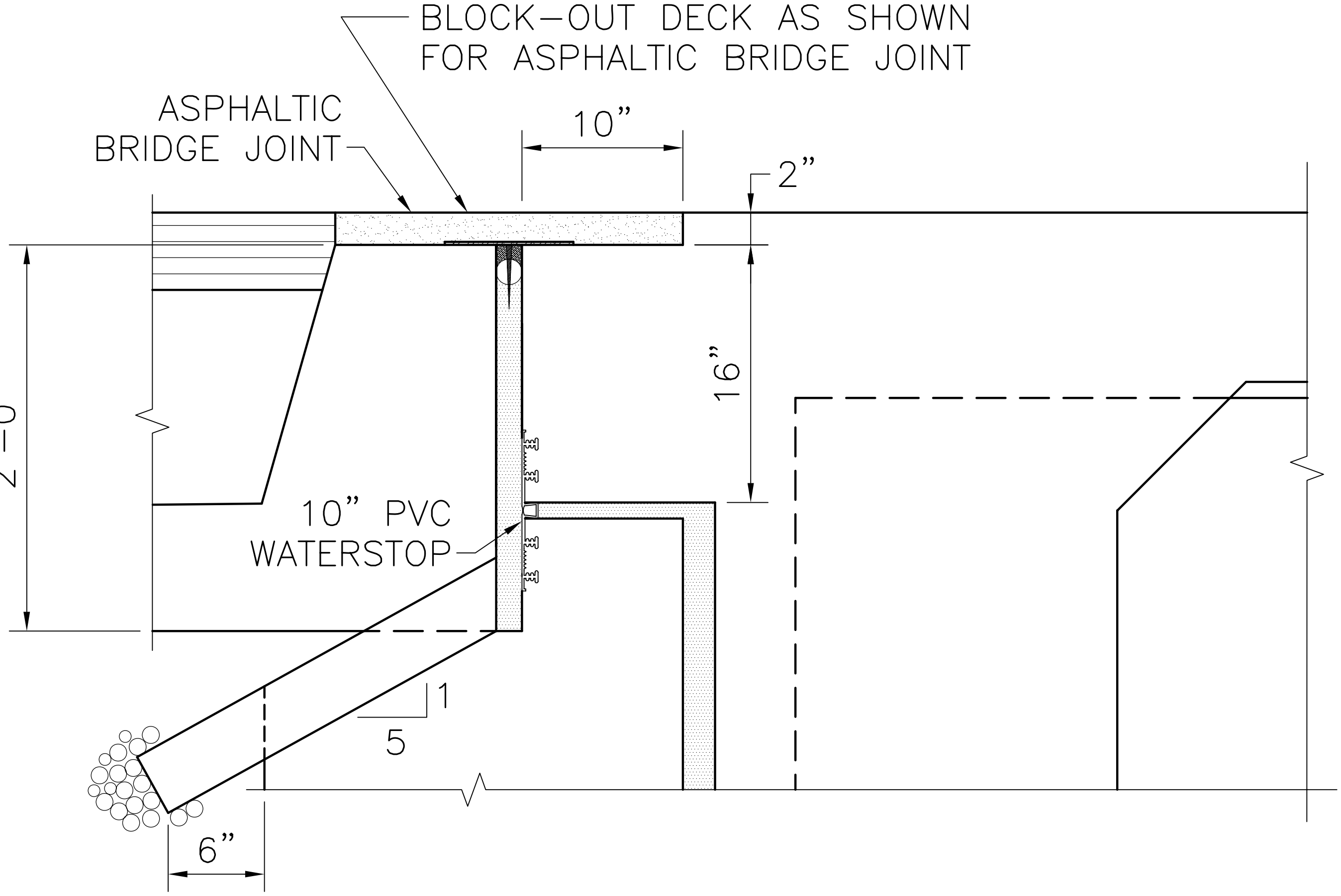
(See Dwg. No. 3.7.23 for Notes to be included on Construction Drawings)

DETAILS AT ABUTMENT – SIDEWALK SECTION

SCALE: 1" = 1'-0"

NOTE:
See Dwg. No. 3.7.21 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK SECTION WITH ASPHALTIC BRIDGE JOINT END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.20**



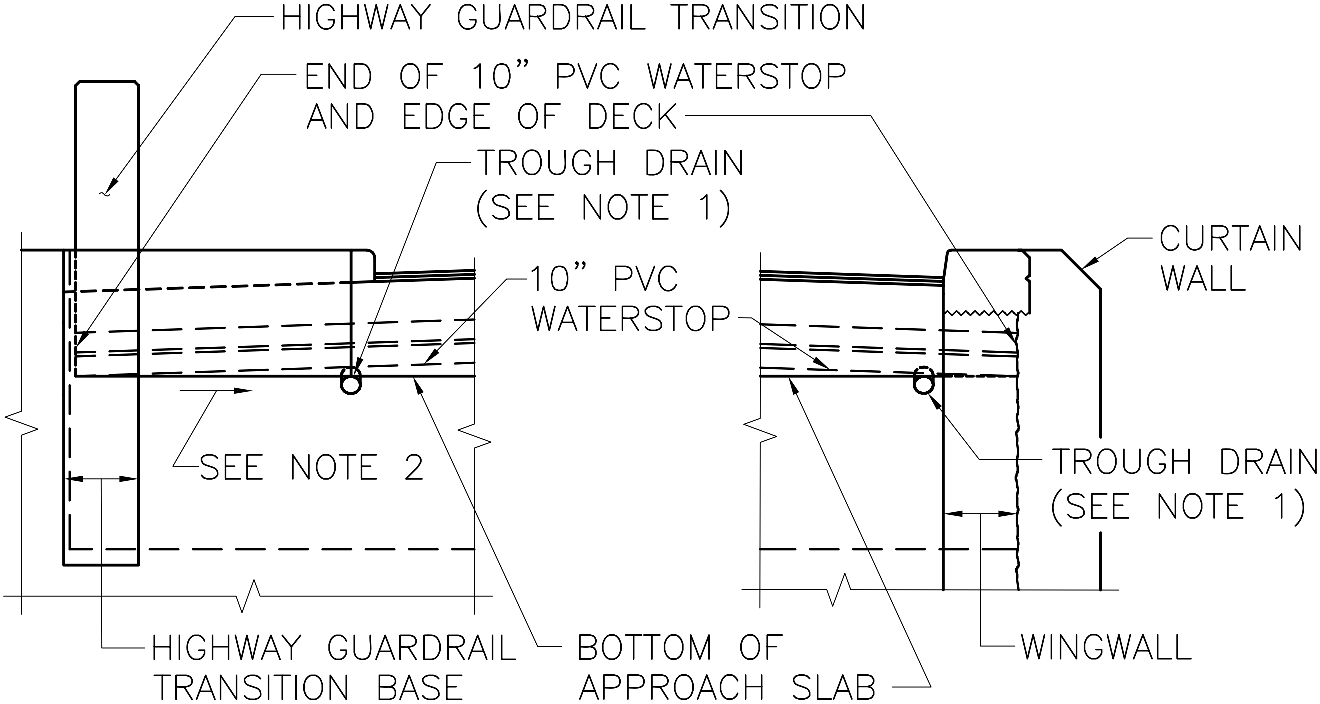
DETAILS AT ABUTMENT FOR EXPOSED CONCRETE DECKS

SCALE: 1" = 1'-0"

NOTES:

1. *Designer Notes listed here are for the details at abutment Dwg. No's 3.7.19 and 3.7.20.*
2. *This detail is to be used when the limits of the other abutment details are exceeded. When the limits of the Asphaltic Bridge Joint are exceeded (see Dwg. No. 10.1.2), use a strip seal and modify this detail accordingly. If the thermal movement range of a strip seal is exceeded, consult with the Bridge Engeener for an appropriate joint system.*
3. *This detail is to be used with Approach Slab Type III.*
4. *Bridges with HMA wearing surface require the use of deck drains.*
5. *If the bearing exceeds 16" in diameter, set this dimension equal to Bearing Dia./2 + 6". See Chapter 6 for additional modifications to this dimension required for the NEBT beams.*
6. *Design these bars for longitudinal seismic forces. Backwall reinforcement configuration shown is concptual. The Designer may modify the arrangement by adding additional hoops as required by the actual design.*
7. *This detail anticipates 1" of one-way thermal movement. The Designer may increase the closed cell foam thickness in ½" increments to accommodate larger thermal movements.*
8. *For bridges with exposed concrete decks, modify this detail as shown on Dwg. 3.7.21.*
9. *Modify the detail for the beam type used.*

MASS HIGHWAY BRIDGE MANUAL	EXPOSED CONCRETE DECK DETAILS & DESIGNER NOTES END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.21**



BRIDGES WITH SIDEWALK OR WITH SPLAYED WINGWALLS

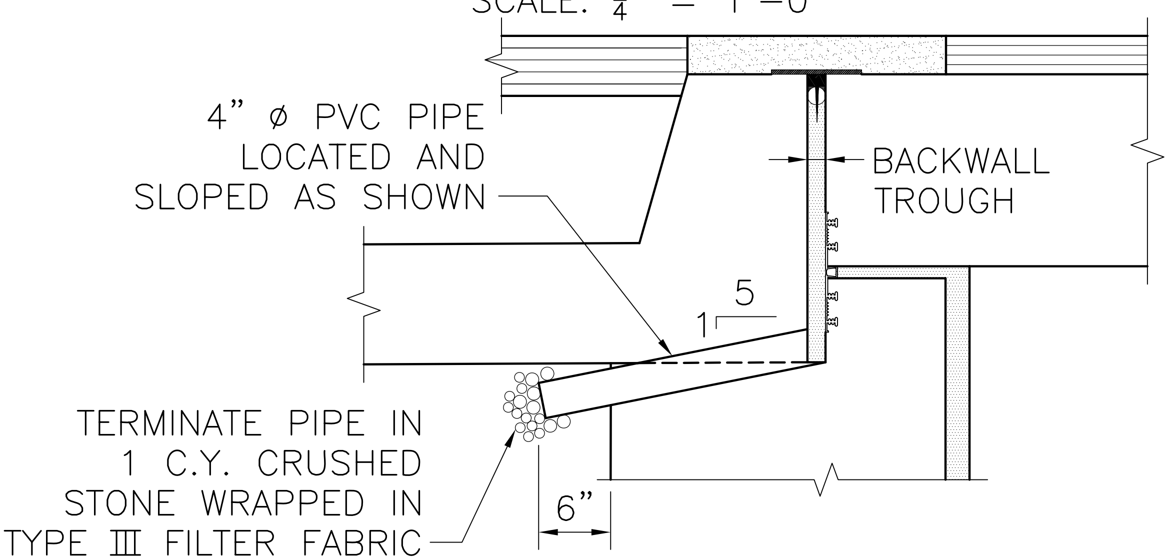
BRIDGES WITH SAFETY CURBS OR WITH U–WINGWALLS

NOTES:

1. PROVIDE BACKWALL TROUGH DRAINS AT LOW POINTS.
2. SLOPE BACKWALL TROUGH UNDER SIDEWALK 5% MIN. TOWARDS DRAIN.

END OF DECK ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"



TROUGH DRAIN DETAILS

SCALE: $\frac{3}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	END OF DECK ELEVATION TROUGH DRAIN DETAILS END OF DECK DETAILS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **3.7.22**

ROADWAY/SIDEWALK SECTION NOTES:

(Include these Notes with details shown on Dwg. No's. 3.7.19 and 3.7.20)

1. ALL REINFORCEMENT SHOWN IN THIS DETAIL SHALL BE COATED, EXCEPT FOR THE APPROACH SLAB REINFORCEMENT.

2. TOP OF BACKWALL SHALL BE TROWELED SMOOTH PARALLEL TO THE PROFILE GRADE.

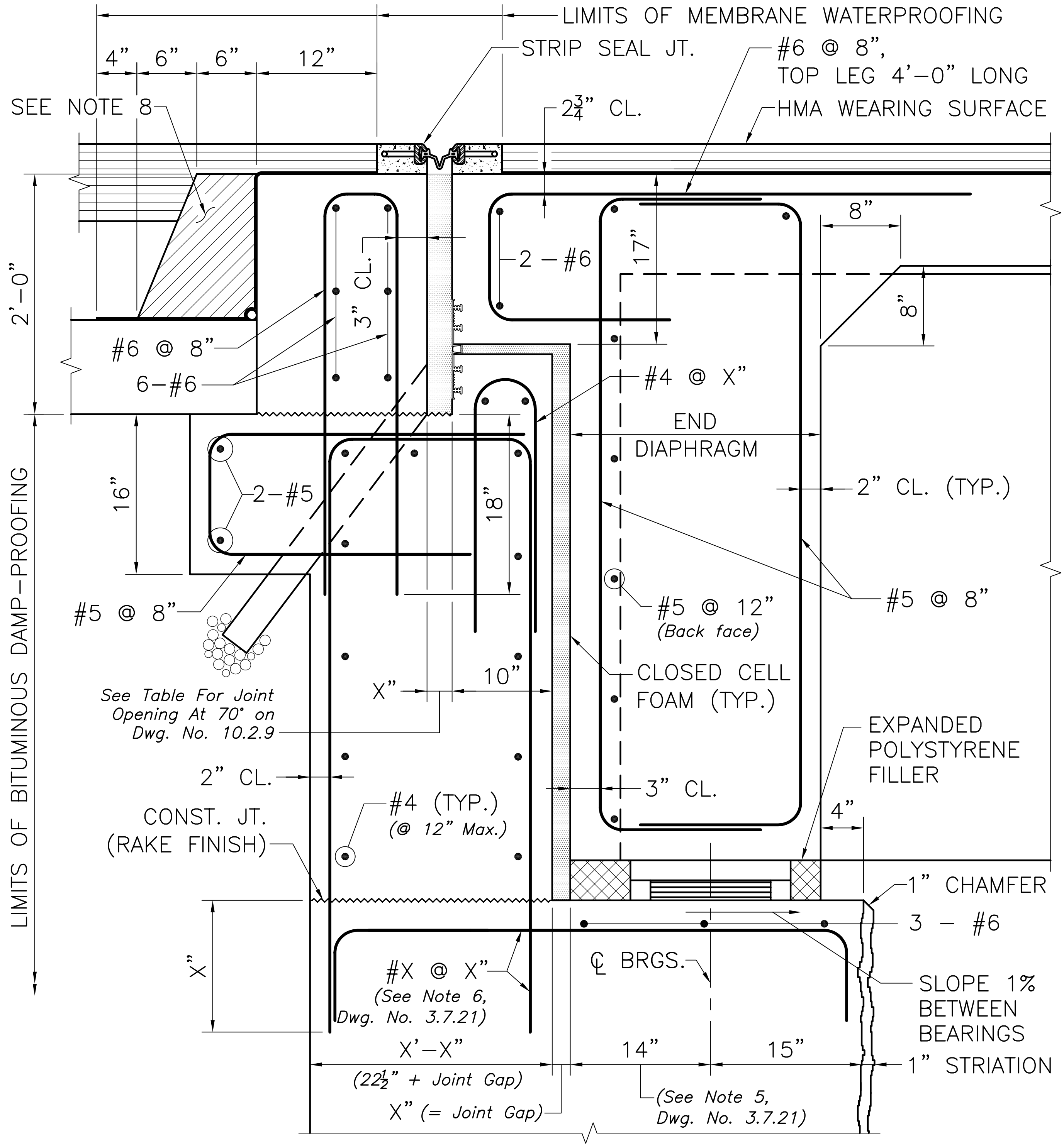
3. BACKWALL, KEEPER BLOCK AND CURTAIN WALL CONCRETE MUST BE PLACED AND SUFFICIENTLY CURED PRIOR TO PLACING THE END DIAPHRAGM CONCRETE.

4. THE END DIAPHRAGM CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE AND SHALL BE PLACED MONOLITHICALLY WITH THE DECK.

5. PRIOR TO PLACING THE END DIAPHRAGM CONCRETE, CLOSED CELL FOAM OF THE SPECIFIED THICKNESSES SHALL BE ATTACHED WITH ADHESIVE TO ALL SURFACES OF THE BACKWALL, KEEPER BLOCKS, AND CURTAIN WALLS AS SHOWN ON THE PLANS. EXPANDED POLYSTYRENE SHALL BE PLACED UNDER THE BEAM BOTTOM FLANGE AND THE BOTTOM OF THE END DIAPHRAGM SHALL BE FORMED AS SPECIFIED. THE CONTRACTOR SHALL INSURE THAT ALL ABUTMENT CONCRETE IS PROPERLY LINED. END DIAPHRAGM CONCRETE MUST NOT COME IN DIRECT CONTACT WITH THE ABUTMENT CONCRETE.

6. AFTER THE END DIAPHRAGM HAS CURED SUFFICIENTLY, PLACE THE APPROACH SLAB CONCRETE AND BACKWALL CONCRETE AT SIDEWALK. THE BACKWALL TROUGH WILL BE FORMED WITH CLOSED CELL FOAM AND CARE SHALL BE TAKEN TO INSURE THAT CONCRETE DOES NOT ENTER THE TROUGH DRAINS.

7. COVER THE BACKWALL TROUGH OPENING SECURELY TO KEEP DEBRIS OUT UNTIL READY TO INSTALL THE ASPHALTIC BRIDGE JOINT.



(See Dwg. No. 3.7.27 for Notes to be included on Construction Drawings)

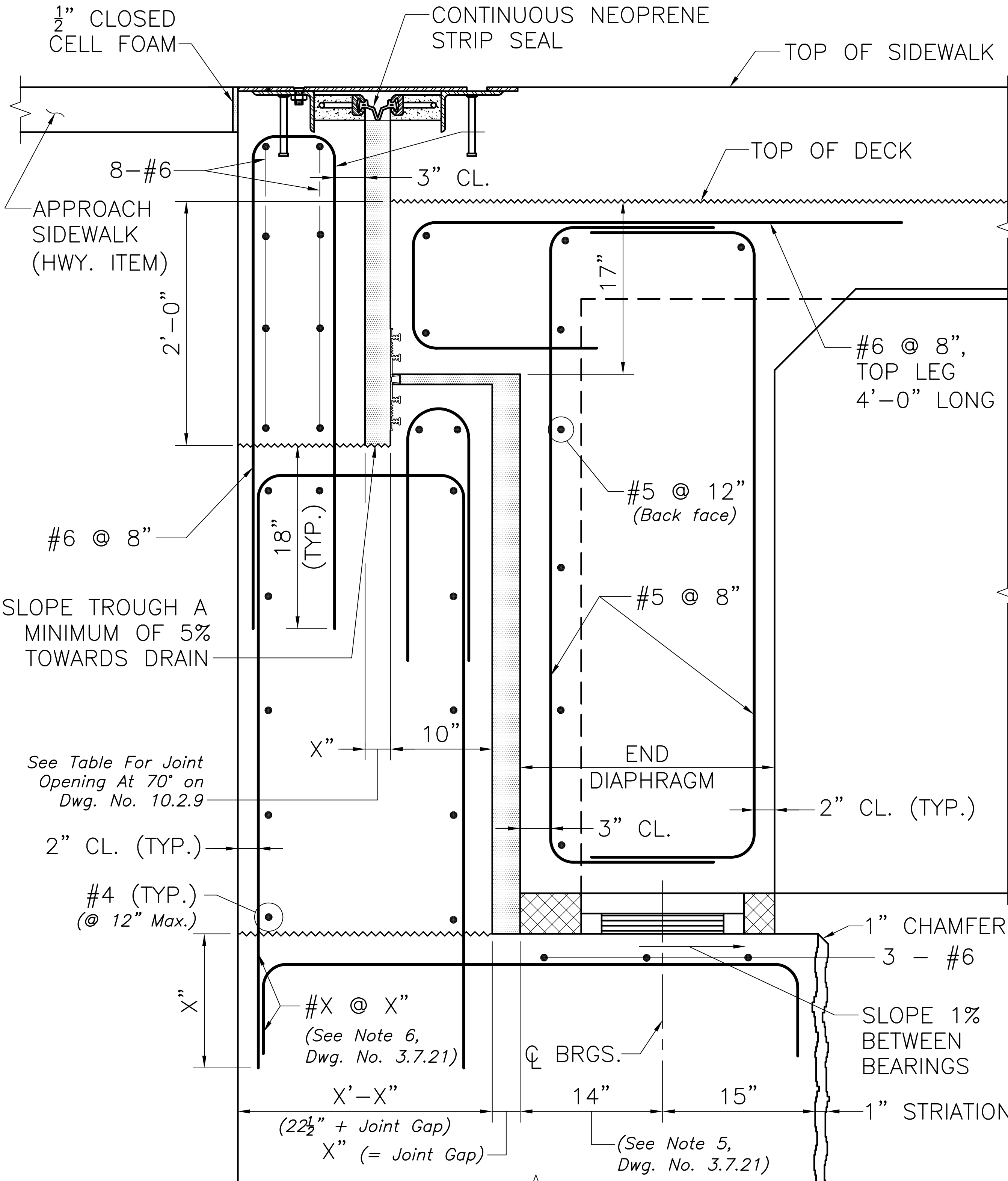
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'-0"

NOTES:

1. *This detail is to be used with approach slab Type I, modified as shown.*
2. *Bridges with HMA wearing surface require the use of deck drains.*
3. *For bridges with exposed concrete decks, modify this detail as shown on Dwg. No. 3.7.26.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION WITH STRIP SEAL JOINT END OF DECK DETAILS	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **3.7.24**



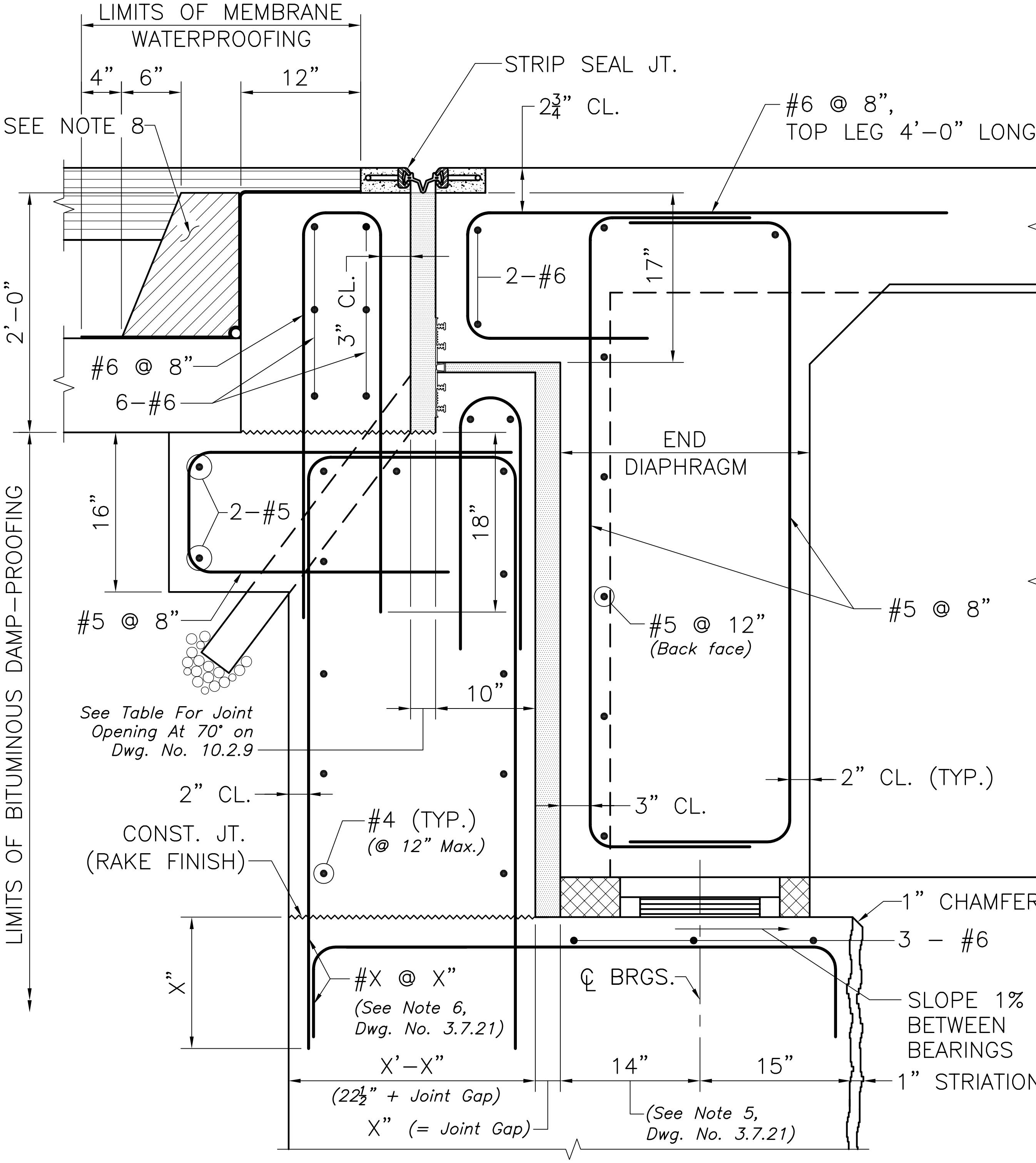
NOTES:

1. See Dwg. No. 3.7.27 for Notes to be included on Construction Drawings.
2. Refer to Dwg. No. 3.7.24 for dimensions and information not shown here .

DETAILS AT ABUTMENT–SIDWALK SECTION

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK SECTION WITH STRIP SEAL JOINT END OF DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **3.7.25**



NOTES:

1. *See Dwg. No. 3.7.27 for Notes to be included on Construction Drawings.*
2. *Refer to Dwg. No. 3.7.24 for dimensions and information not shown here.*
3. *This detail shall be used with Approach Slab Type I, modified as shown.*

DETAILS AT ABUTMENT – EXPOSED CONCRETE DECK

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	EXP. DECK RDWY. SECTION WITH STRIP SEAL JOINT END OF DECK DETAILS	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **3.7.26**

ROADWAY/SIDEWALK SECTION NOTES:

(Modify the Construction Notes on Dwg. No. 3.7.23 as shown below for strip seal joints)

1. *(No modifications)*

2. *(No modifications)*

3. *(Substitute the following)* BACKWALL BELOW CONSTRUCTION JOINT, KEEPER BLOCK AND CURTAIN WALL CONCRETE MUST BE PLACED AND SUFFICIENTLY CURED PRIOR TO PLACING THE END DIAPHRAGM CONCRETE.

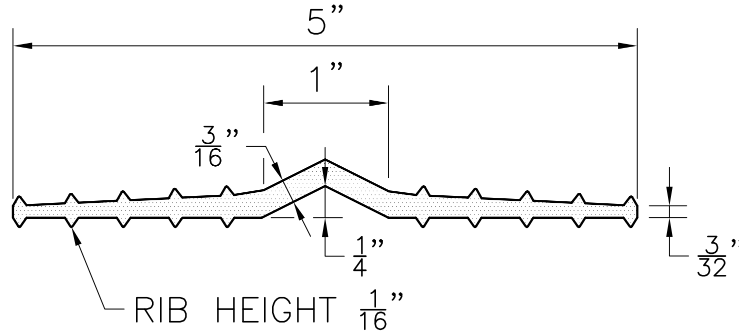
4. *(No modifications)*

5. *(No modifications)*

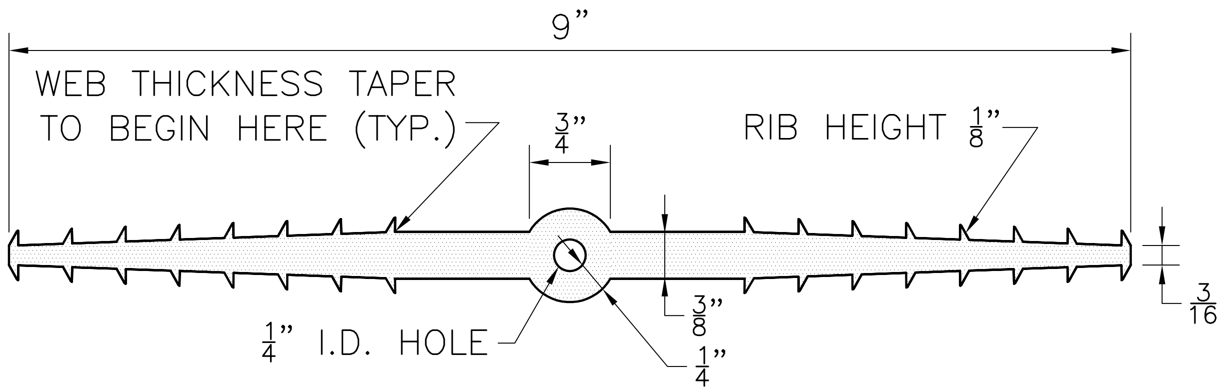
6. *(Substitute the following)* AFTER THE END DIAPHRAGM CONCRETE HAS CURED SUFFICIENTLY, PLACE THE APPROACH SLAB CONCRETE AND REMAINDER OF BACKWALL CONCRETE. THE BACKWALL TROUGH WILL BE FORMED WITH CLOSED CELL FOAM AND CARE SHALL BE TAKEN TO INSURE THAT CONCRETE DOES NOT ENTER THE TROUGH SUMP.

7. *(Substitute the following)* COVER THE BACKWALL TROUGH OPENING SECURELY TO KEEP DEBRIS OUT UNTIL READY TO INSTALL THE STRIP SEAL JOINT.

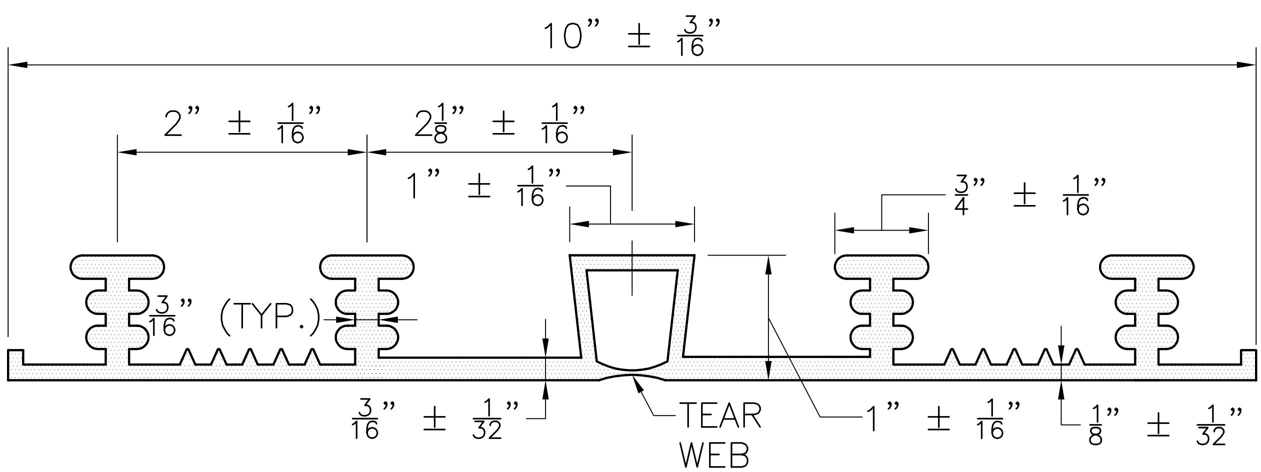
8. *(Add the following note)* PROTECTIVE COURSE TO BE HOT MIX ASPHALT DENSE BINDER COURSE FOR BRIDGES, PLACED IN 2" LAYERS AND COMPACTED WITH A MECHANICAL HAND–GUIDED TAMPER WITHIN 12 HOURS AFTER PLACING MEMBRANE WATERPROOFING.



5” WATERSTOP
NOT TO SCALE

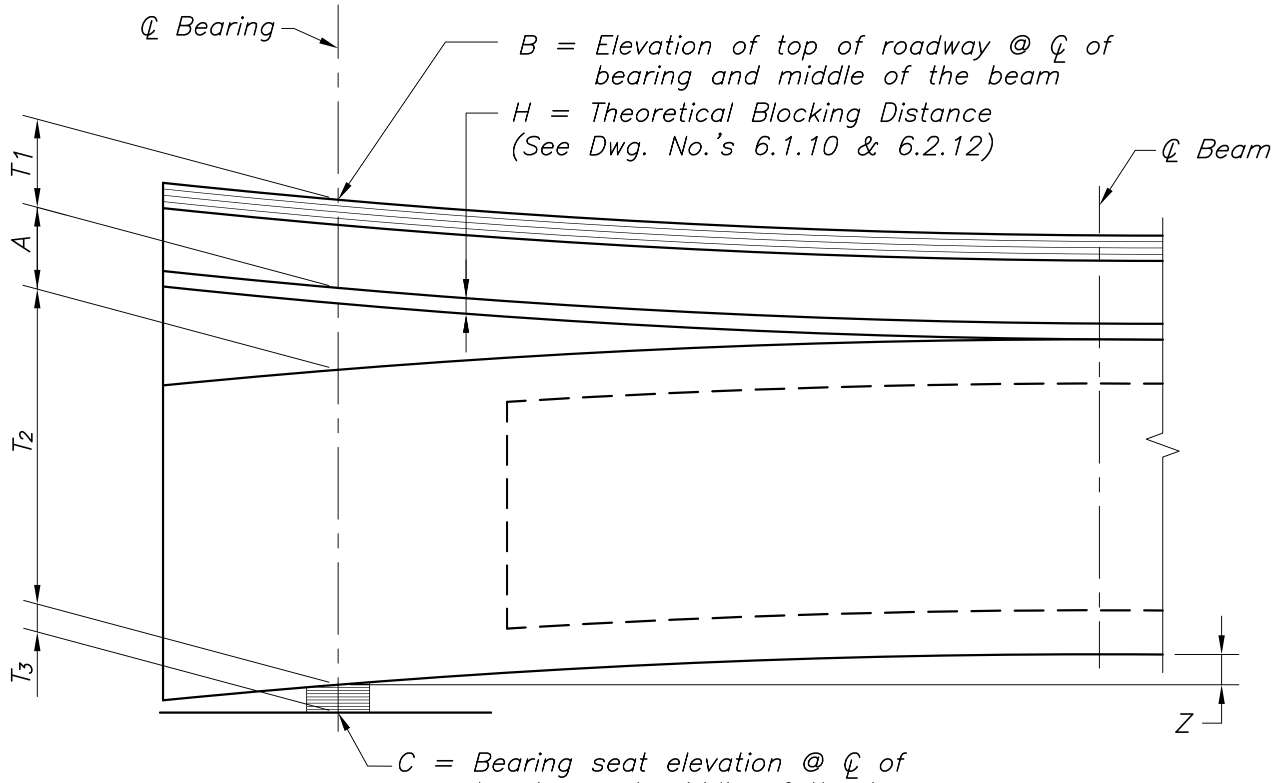


9” WATERSTOP
NOT TO SCALE



10” WATERSTOP
NOT TO SCALE

MASS HIGHWAY BRIDGE MANUAL	PLASTIC WATERSTOP DETAILS END OF DECK DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **3.7.28**



NOTES:

1. Bridge Seat Elevations shall be determined as follows:

$C = B - (T_1 + T_2 + T_3 + A)$, where:

T_1 = Wearing surface + slab thickness
T_2 = Depth of beam
T_3 = Height of bearing pad
A = Blocking distance @ centerline of bearing = H or $(H + Z - M)$, whichever is greater, where:

Z = Net upward camber at erection calculated using the PCI "at erection" multipliers for prestressing and selfweight, minus the unfactored elastic deflections from the weight of the slab, utilities, diaphragms, haunch, and superimposed dead load. Long term effects due to creep, shrinkage and live load shall be ignored for beam seat calculations.

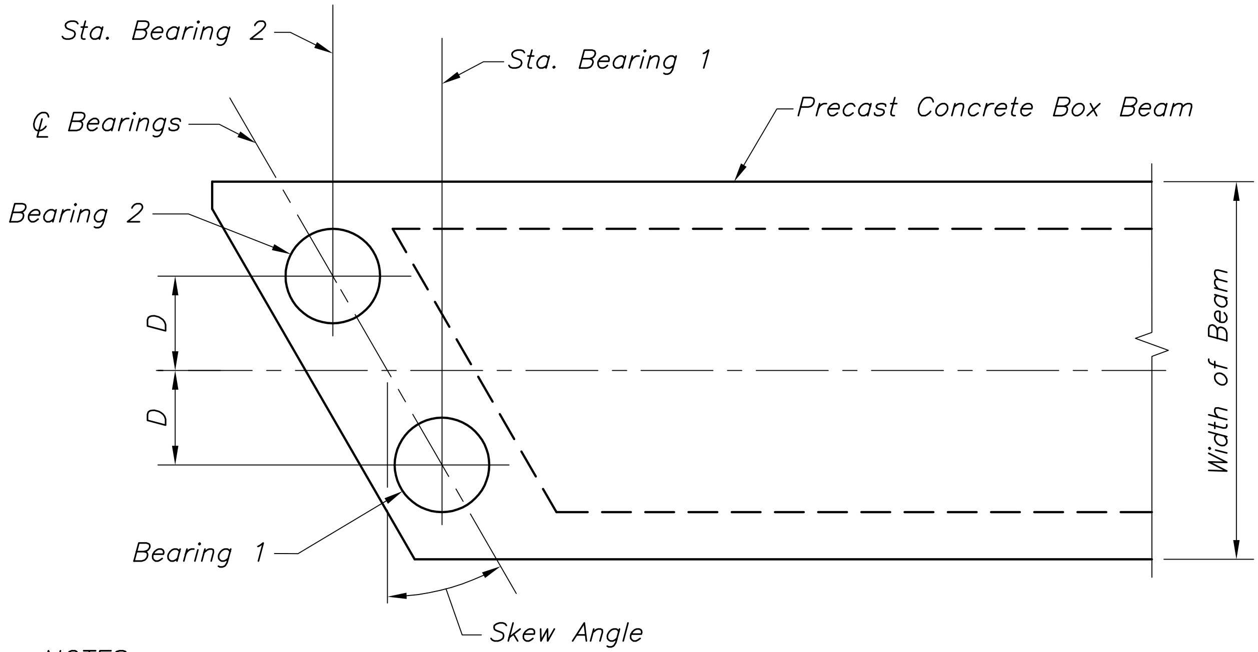
$M = B2 - (B1 + B3)/2$, where:

B1 = Final top of roadway elevation @ ℄ of Bearing @ Support No. 1
B2 = Final top of roadway elevation @ mid span of the beam
B3 = Final top of roadway elevation @ ℄ of Bearing @ Support No. 2

Note:
This method is limited to situations where the minimum haunch dimension occurs at either mid span or at the bearings. In cases where this is not so, (for example: the vertical curve starts or ends within the center lines of bearings) the designer shall use the other methods to determine the minimum haunch location along the length of the beam and adjust the beam seats accordingly so that the minimum haunch dimension is not violated at any point along the length of the beam.

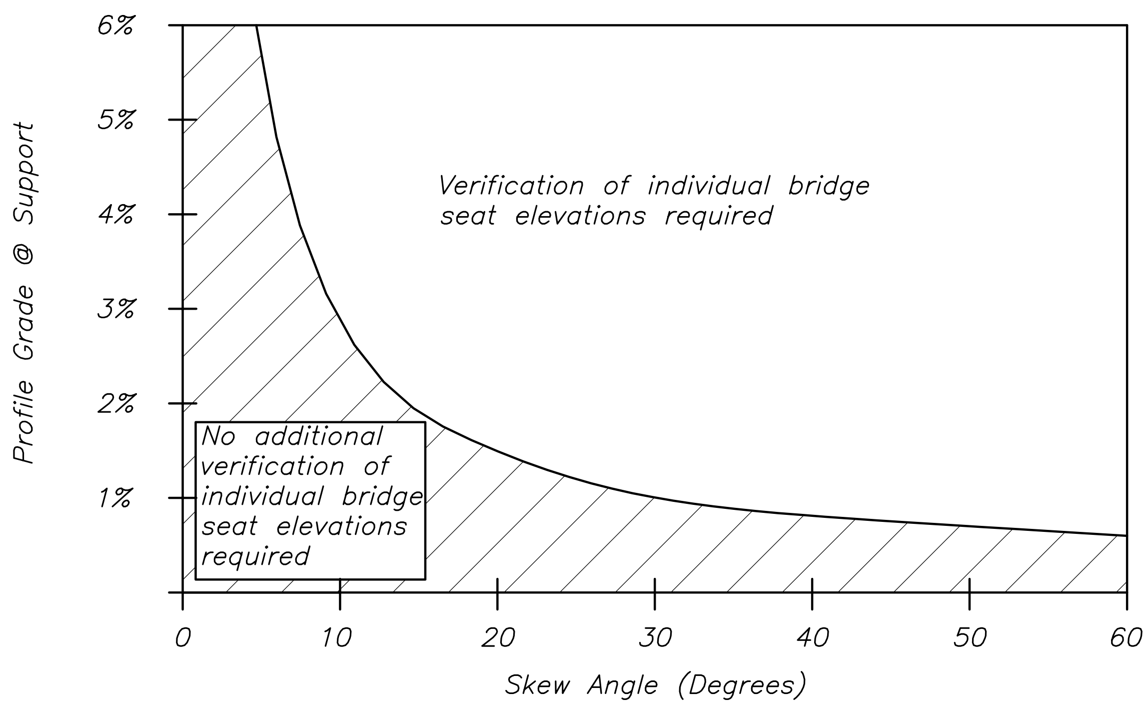
2. For spread precast concrete box beams, refer to Dwg. No. 3.8.2 for additional details.

MASS HIGHWAY BRIDGE MANUAL	BRIDGE SEAT ELEVATIONS PRECAST STRINGER BRIDGES	DATE OF ISSUE FEBRUARY 2007
	BRIDGE SEAT ELEVATIONS	DRAWING NUMBER **3.8.1**

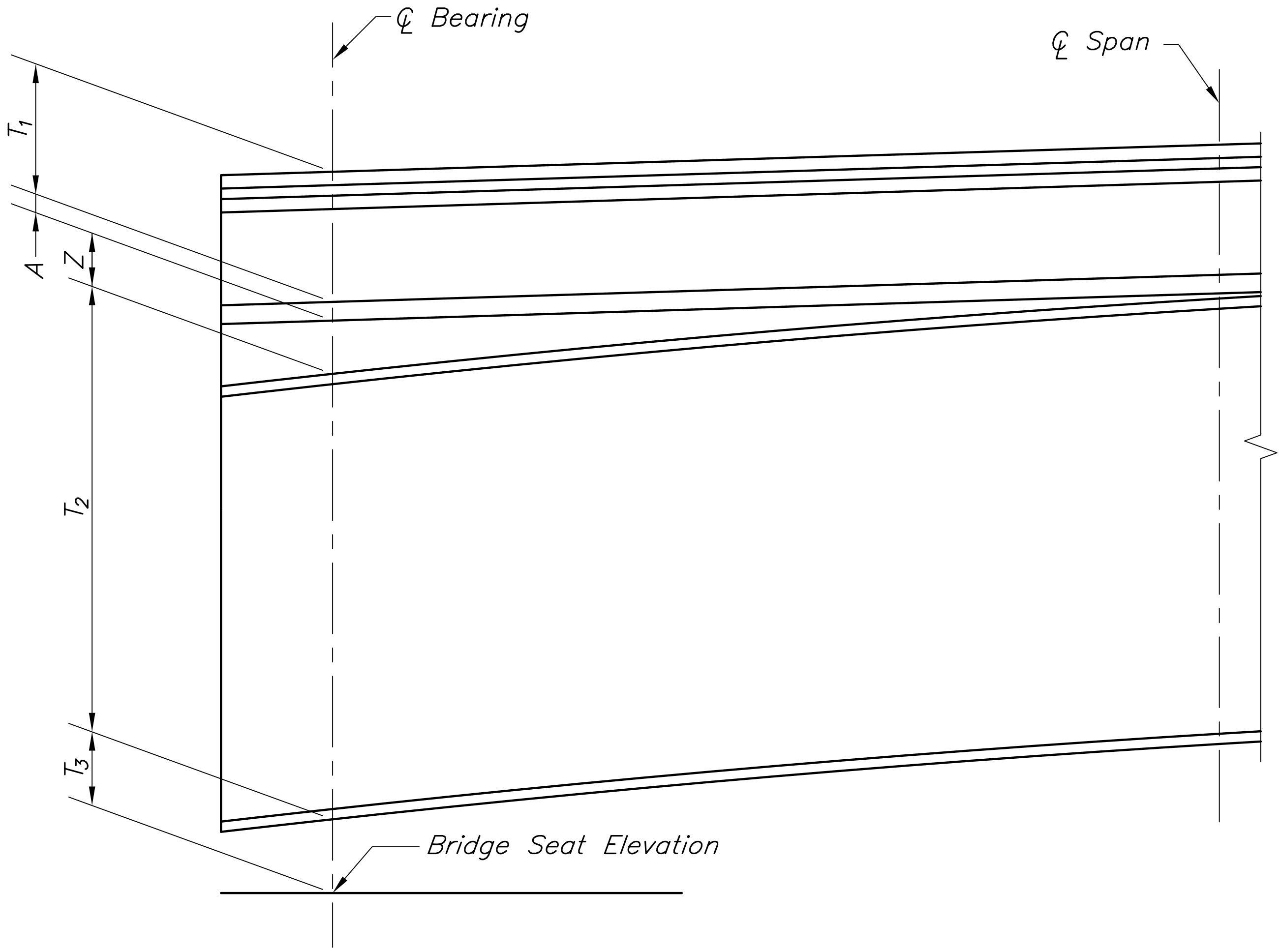


NOTES:

1. D = Width of Beam/4, rounded to the nearest $\frac{3}{8}$".
2. Because Spread Box Beam Bridges use two bearings, as the skew angle and profile grade increase, the longitudinal distance between bearing stations also increases. The chart below provides a guide for where individual bridge seat elevations would be required. Calculate bridge seat elevations as outlined on Dwg. No. 3.8.1 and provide seperate bridge seat elevations when the difference in elevation between the bearings is $\frac{1}{8}$" or greater. Do not use bearing pads of different thicknesses or specify shims or grout pads.



MASS HIGHWAY BRIDGE MANUAL	ADDITIONAL CONSIDERATIONS SPREAD BOX BEAM BRIDGES	DATE OF ISSUE	MAY 2005
	BRIDGE SEAT ELEVATIONS	DRAWING NUMBER	3.8.2



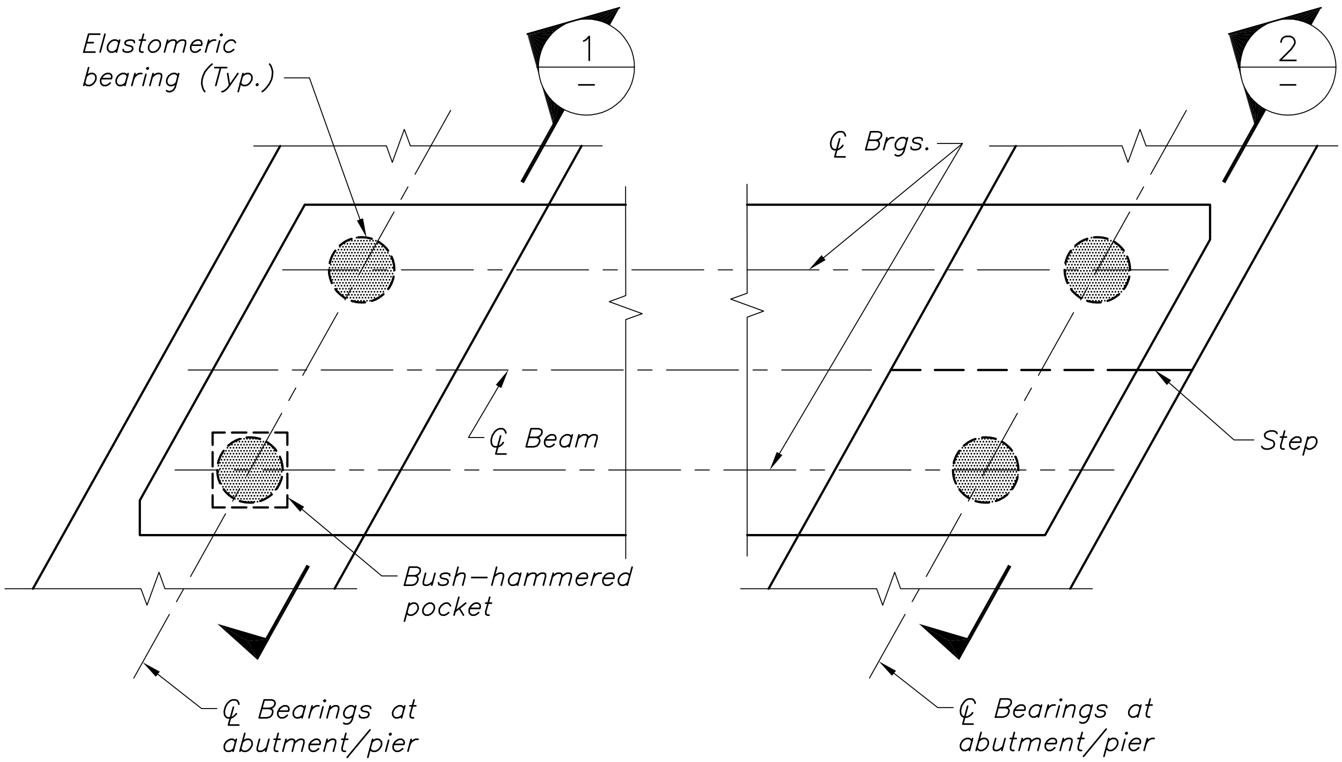
NOTES:

1. Bridge Seat Elevation is determined by the following:

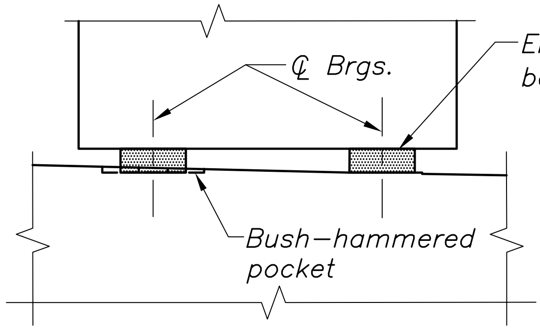
   Roadway Elev. − (T_1 + T_2 + T_3 + A + Z), where:

   T_1 = Wearing Surface + Slab Thickness
   T_2 = Depth of Stringer or Girder
   T_3 = Depth of Bearing
   A = Blocking Distance at maximum camber (See Dwg. No. 7.1.10)
   Z = Additional Camber (See Dwg. No. 5.6.1)

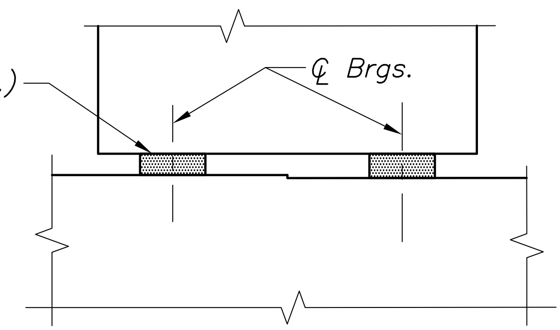
2. For a negative vertical curve, the middle ordinate of the curve should also be subtracted from the roadway elevation to get Bridge Seat Elevation.



PLAN



SECTION 1



SECTION 2

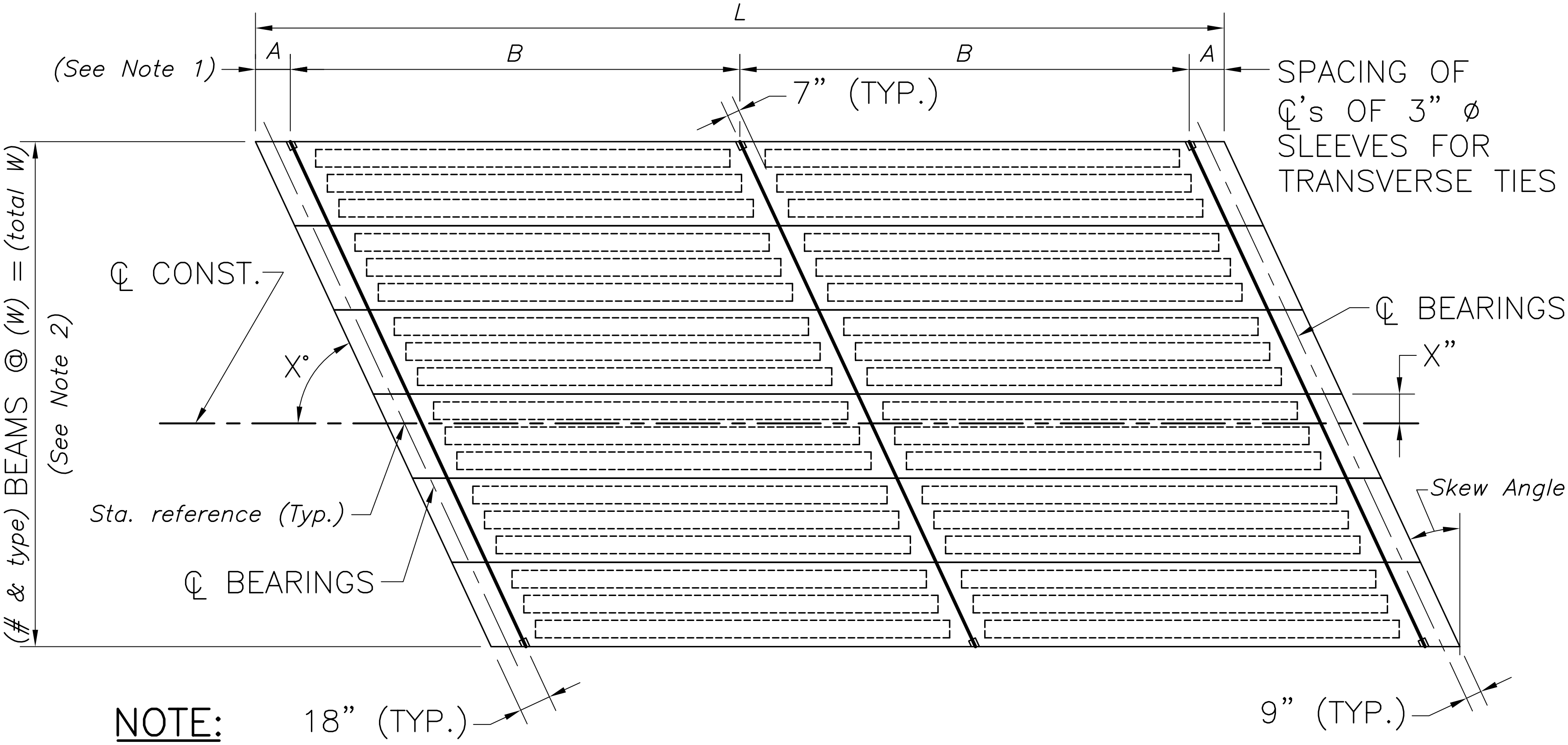
ADJUSTMENTS FOR UNEVEN BEAM SEAT ELEVATIONS FOR PRESTRESSED BEAM BRIDGES

NOT TO SCALE

NOTE:

The above adjustment details shall be used in case of uneven (non–parallel) bridge seat cross–slopes and/or longitudinal slopes between pairs of bearings, which may be a result of the bridge skew, profile grade, horizontal and/or vertical curvature, change of the cross–slope along the span length, etc. Use shallower slope and either bush–hammer bridge seat under one of the bearings or step the bridge seat if the change in elevation between bearings is greater than $\frac{3}{8}$", so that cross–slopes between bearings at both substructures and longitudinal slopes between pairs of bearings match.

MASS HIGHWAY BRIDGE MANUAL	ADJUSTMENTS FOR UNEVEN BEAM SEAT ELEVATIONS	DATE OF ISSUE MAY 2005
	BRIDGE SEAT ELEVATIONS	DRAWING NUMBER 3.8.4



NOTE:

SEE STANDARD SPECIFICATIONS FOR BEAMS ERECTION AND LAYOUT.

FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1'–0" Min.)

NOTES:

1. *A = 18"/cos(Skew Angle)*
   L = Span Length + A
   B = (L/2) − A
2. *Specify beam type (e.g. S48–21). Use only nominal beam widths when specifying beam width (W) and calculating total width (total W).*
3. *Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Show all internal voids and transverse ties and include North Arrow.*
4. *If torsional load in the fascia beams (due to sidewalk overhang or utilities) is excessive, consideration shall be given to increasing the number of lateral strands and/or post–tensioning, and adjusting transverse tie locations as necessary.*
5. *The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.*

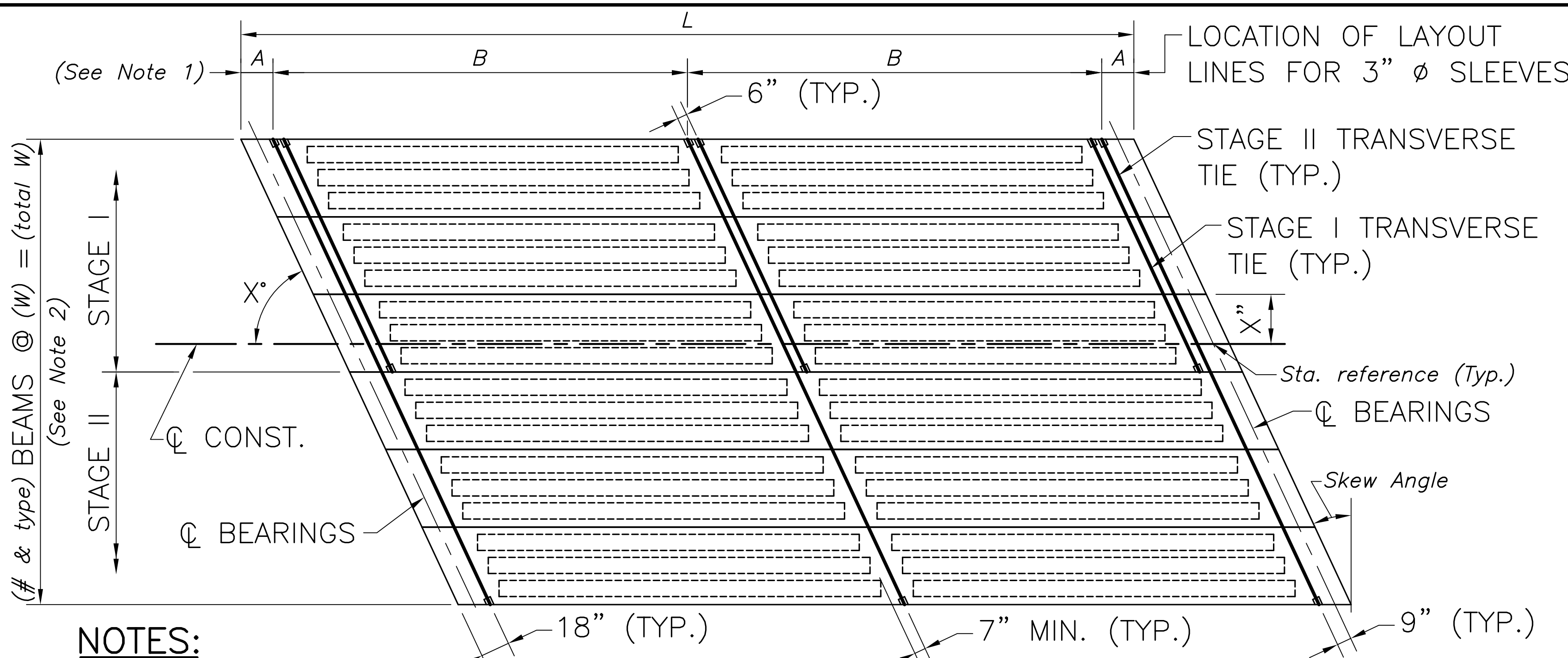
MASS HIGHWAY BRIDGE MANUAL

FRAMING PLAN

PRECAST CONCRETE DECK BEAMS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **4.1.1**



NOTES:

1. SEE STANDARD SPECIFICATIONS FOR BEAMS ERECTION AND LAYOUT.

2. STAGE I: AFTER ERECTING STAGE I BEAMS, INSTALL AND TENSION TRANSVERSE TIES IN STAGE I SLEEVES.

3. STAGE II: AFTER ERECTING STAGE II BEAMS, INSTALL AND TENSION TRANSVERSE TIES IN STAGE II SLEEVES FULL WITDTH OF BRIDGE.

FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1"–0" Min.)

NOTES:

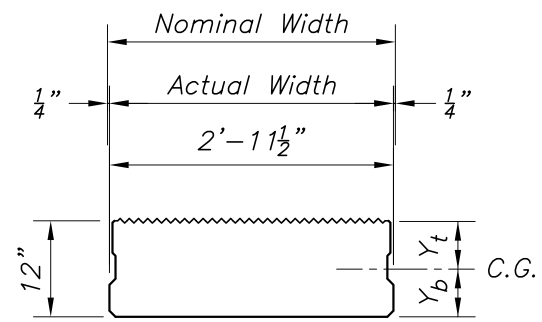
1. *A = 18"/cos(Skew Angle)*
   L = Span Length + A
   B = (L/2) − A
2. *Specify beam type (e.g. S48–21). Use only nominal beam widths when specifying beam width (W) and calculating total width (total W).*
3. *Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Show all internal voids and transverse ties and include North Arrow.*
4. *If torsional load in the fascia beams (due to sidewalk overhang or utilities) is excessive, consideration shall be given to increasing the number of lateral strands and/or post–tensioning, and adjusting transverse tie locations as necessary.*
5. *The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.*

MASS HIGHWAY BRIDGE MANUAL

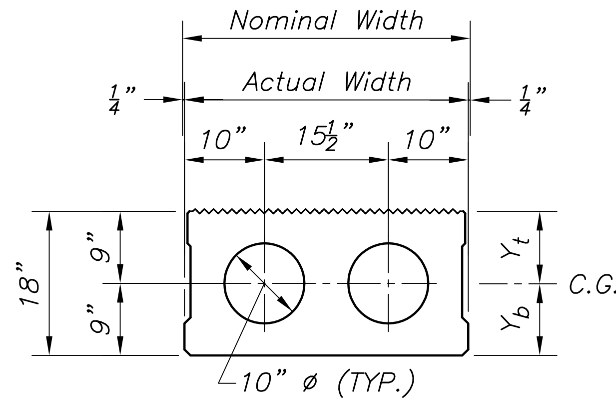
FRAMING PLAN
STAGE CONSTRUCTION
PRECAST CONCRETE DECK BEAM

DATE OF ISSUE
MAY 2005

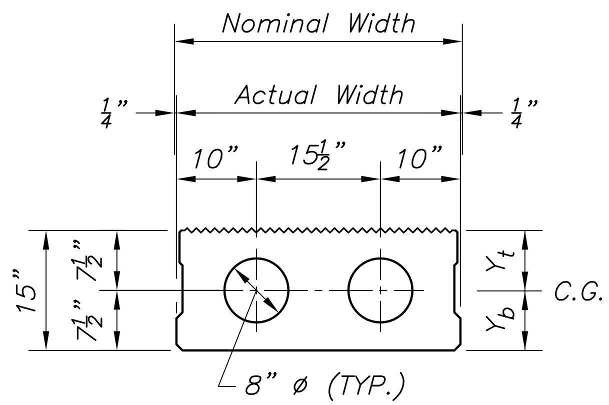
DRAWING NUMBER
4.1.2



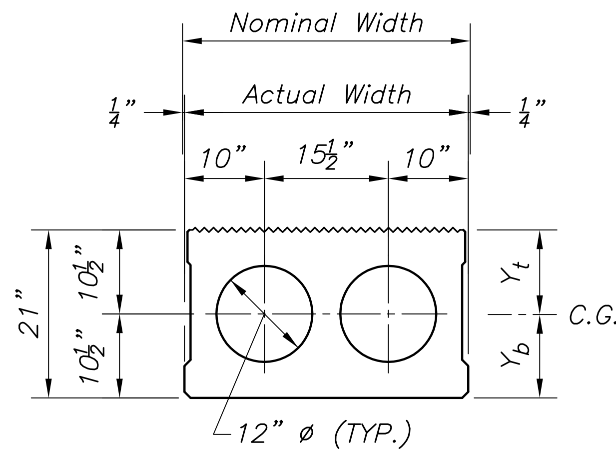
S36-12



S36-18



S36-15



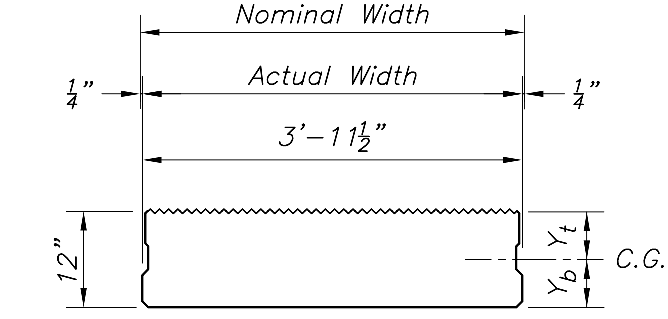
S36-21

BEAM PROPERTIES

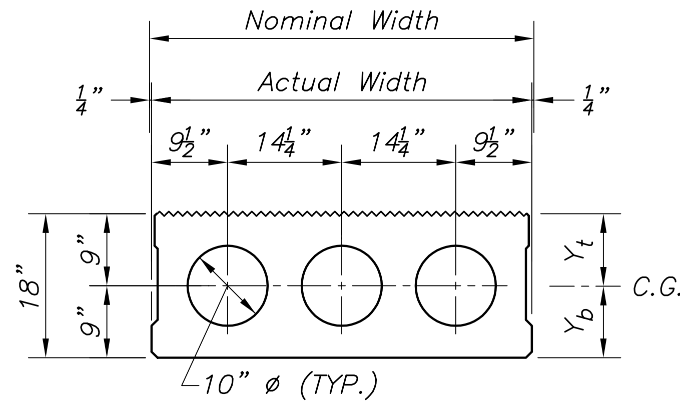
BEAM TYPE	WIDTH (in)		DEPTH (in)	AREA (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
	Nom.	Act.									
S36–12	36.0	35.5	12	417	5033	5.98	6.02	842	836	434	30
S36–15	36.0	35.5	15	419	9419	7.47	7.53	1261	1251	436	40
S36–18	36.0	35.5	18	464	15963	8.96	9.04	1782	1766	483	46
S36–21	36.0	35.5	21	497	24827	10.45	10.55	2376	2353	518	54

NOTES:

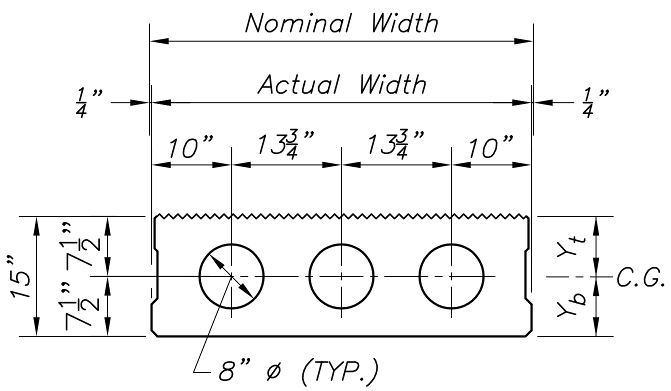
1. Above drawing is not to scale.
2. See Dwg. No. 4.1.8 for shear key details.
3. Maximum Span lengths are approximate and are based on the following assumptions:
   $f'c = 6500$ psi
   $f'ci = 4500$ psi
   $f'c = 4000$ psi for 5" Composite Deck
   Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   HS25 Truck loading.
4. Weight of beams does not include the weight of the solid sections located at the transverse ties. Include the weight of the solid sections for design.



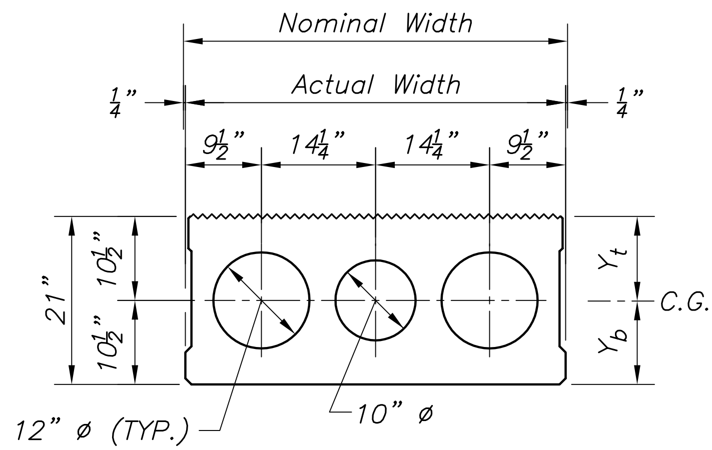
S48–12



S48–18



S48–15



S48–21

BEAM PROPERTIES

BEAM TYPE	WIDTH (in)		DEPTH (in)	AREA (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
	Nom.	Act.									
S48–12	48.0	47.5	12	561	6761	5.98	6.02	1131	1123	584	34
S48–15	48.0	47.5	15	548	12593	7.47	7.53	1686	1672	571	39
S48–18	48.0	47.5	18	601	21303	8.97	9.03	2375	2359	626	47
S48–21	48.0	47.5	21	670	33597	10.47	10.53	3209	3191	698	58

NOTES:

1. Above drawing is not to scale.
2. See Dwg. No. 4.1.8 for shear key details.
3. Maximum Span lengths are approximate and are based on the following assumptions:
   f'c = 6500 psi
   f'ci = 4500 psi
   f'c = 4000 psi for 5" Composite Deck
   Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   HS25 Truck loading.
4. Weight of beams does not include the weight of the solid sections located at the transverse ties. Include the weight of the solid sections for design.

MASS HIGHWAY BRIDGE MANUAL

STANDARD 48" WIDE BEAMS

PRECAST CONCRETE DECK BEAMS

DATE OF ISSUE
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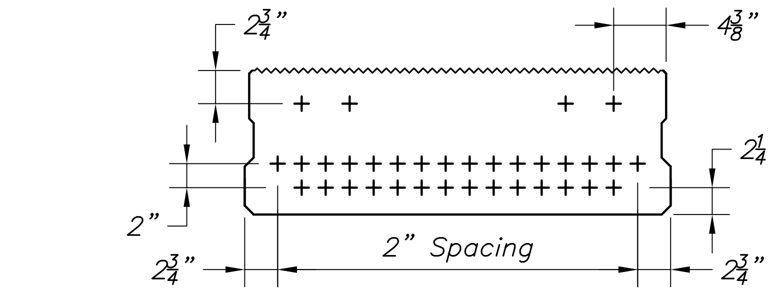
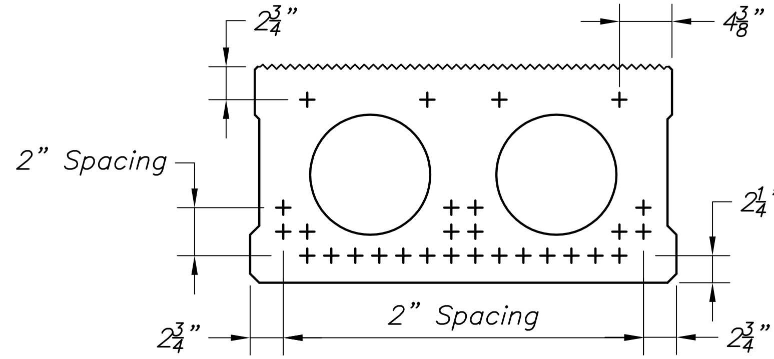
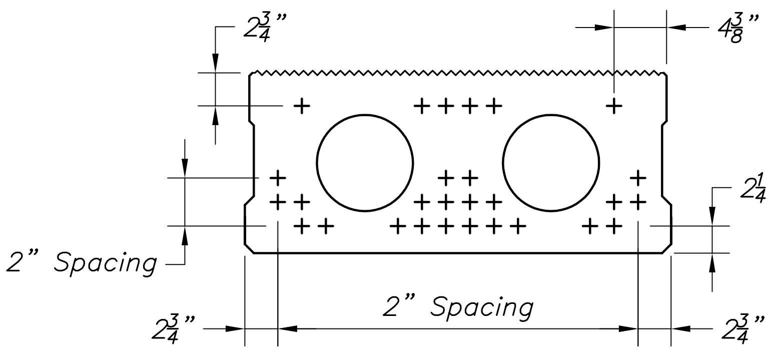


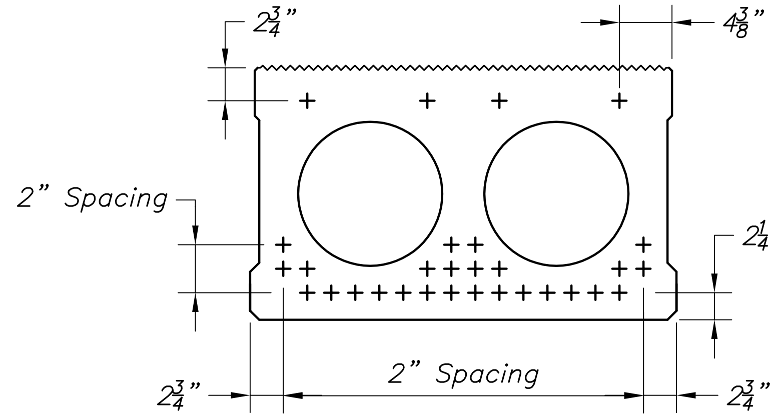
S36–12



S36–18



S36–15



S36–21

STRAND LOCATION

NOT TO SCALE

NOTES:

1. The standard strand pattern shown above depicts the maximum number of strands possible that can be located in a given beam while still meeting applicable fabrication clearances. For most beam designs, strands shall be placed in as many locations within the pattern as required. If a particular beam design requires the placement of strands outside this pattern, the Designer shall be responsible for verifying the beam's constructibility and its conformance to AASHTO requirements.
2. + Denotes straight strands.
3. ⊕ Denotes debonded strands (none shown above). No more than 25% of the total number of strands may be debonded. The spacing between debonded strands must be at least 4" apart, vertically or horizontally. Do not debond the outermost strands of each layer.
4. The Designer shall verify that the strands will not interfere with the transverse tie and the chuck hardware.
5. If required by design, the top row of strands may consist of a maximum of 4 fully stressed strands. Otherwise, use a minimum of 2 strands pretensioned to 2 Kips each.

MASS HIGHWAY
BRIDGE MANUAL

STANDARD STRAND LOCATION
36" WIDE BEAMS
PRECAST CONCRETE DECK BEAMS

DATE OF ISSUE
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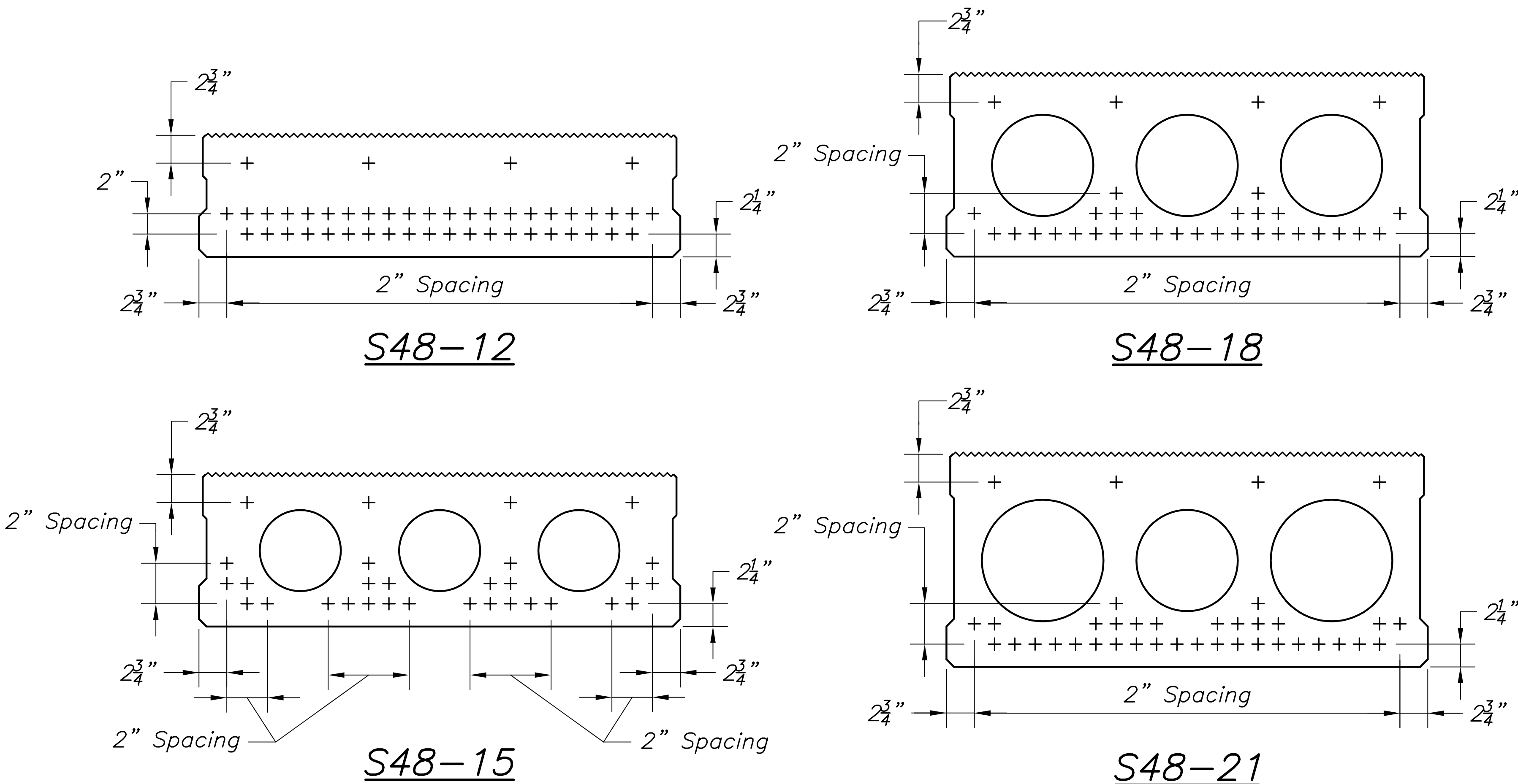
DRAWING NUMBER
4.1.5



STRAND LOCATION

NOT TO SCALE

NOTES:

1. The standard strand pattern shown above depicts the maximum number of strands possible that can be located in a given beam while still meeting applicable fabrication clearances. For most beam designs, strands shall be placed in as many locations within the pattern as required. If a particular beam design requires the placement of strands outside this pattern, the Designer shall be responsible for verifying the beam's constructibility and its conformance to AASHTO requirements.
2. + Denotes straight strands.
3. ⊕ Denotes debonded strands (none shown above). No more than 25% of the total number of strands may be debonded. The spacing between debonded strands must be at least 4" apart, vertically or horizontally. Do not debond the outermost strands of each layer.
4. The Designer shall verify that the strands will not interfere with the transverse tie and the chuck hardware.
5. If required by design, the top row of strands may consist of a maximum of 4 fully stressed strands. Otherwise, use a minimum of 2 strands pretensioned to 2 Kips each.

MASS HIGHWAY BRIDGE MANUAL	STANDARD STRAND LOCATION 48" WIDE BEAMS PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.6**

PRESTRESS NOTES:

1. ALL PRETENSIONING ELEMENTS SHALL BE 0.6" Ø, UNCOATED, SEVEN–WIRE, LOW RELAXATION STEEL STRANDS AND SHALL CONFORM TO AASHTO M 203.

2. THE MINIMUM ULTIMATE TENSILE STRENGTH OF THE PRETENSIONING STRANDS SHALL BE 270 KSI.

3. THE INITIAL TENSION PER 0.6" Ø STRAND SHALL BE 44 KIPS.

4. THE MINIMUM 28 DAY COMPRESSIVE STRENGTH SHALL BE 6500 PSI. *(See Note)*

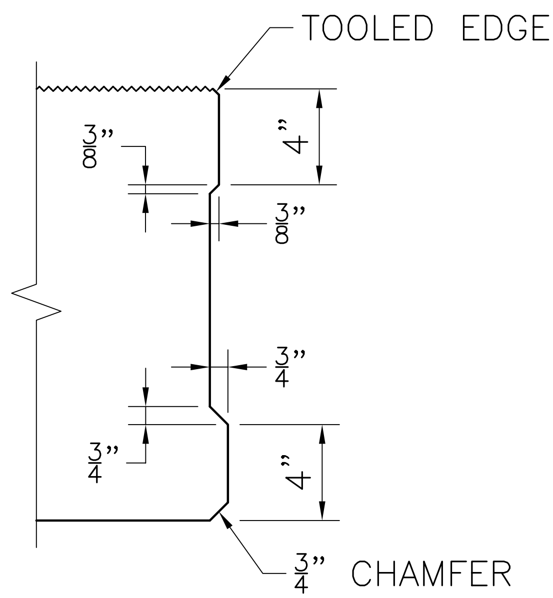
5. NO PRESTRESS SHALL BE TRANSFERRED TO THE CONCRETE UNTIL IT HAS ATTAINED A COMPRESSIVE STRENGTH, AS SHOWN BY CYLINDER TEST, OF AT LEAST 4000 PSI. *(See Note)*

6. THE TOP OF ALL BEAMS SHALL BE GIVEN A RAKE FINISH ($\frac{1}{4}$" AMPLITUDE) ACROSS THE WIDTH (PERPENDICULAR TO THE BEAM'S AXIS).

7. THE FABRICATOR IS FULLY RESPONSIBLE FOR THE DESIGN OF THE LIFTING DEVICES WHICH SHALL BE ADEQUATE FOR THE SAFETY FACTORS REQUIRED BY THE ERECTION PROCEDURE.

NOTE:

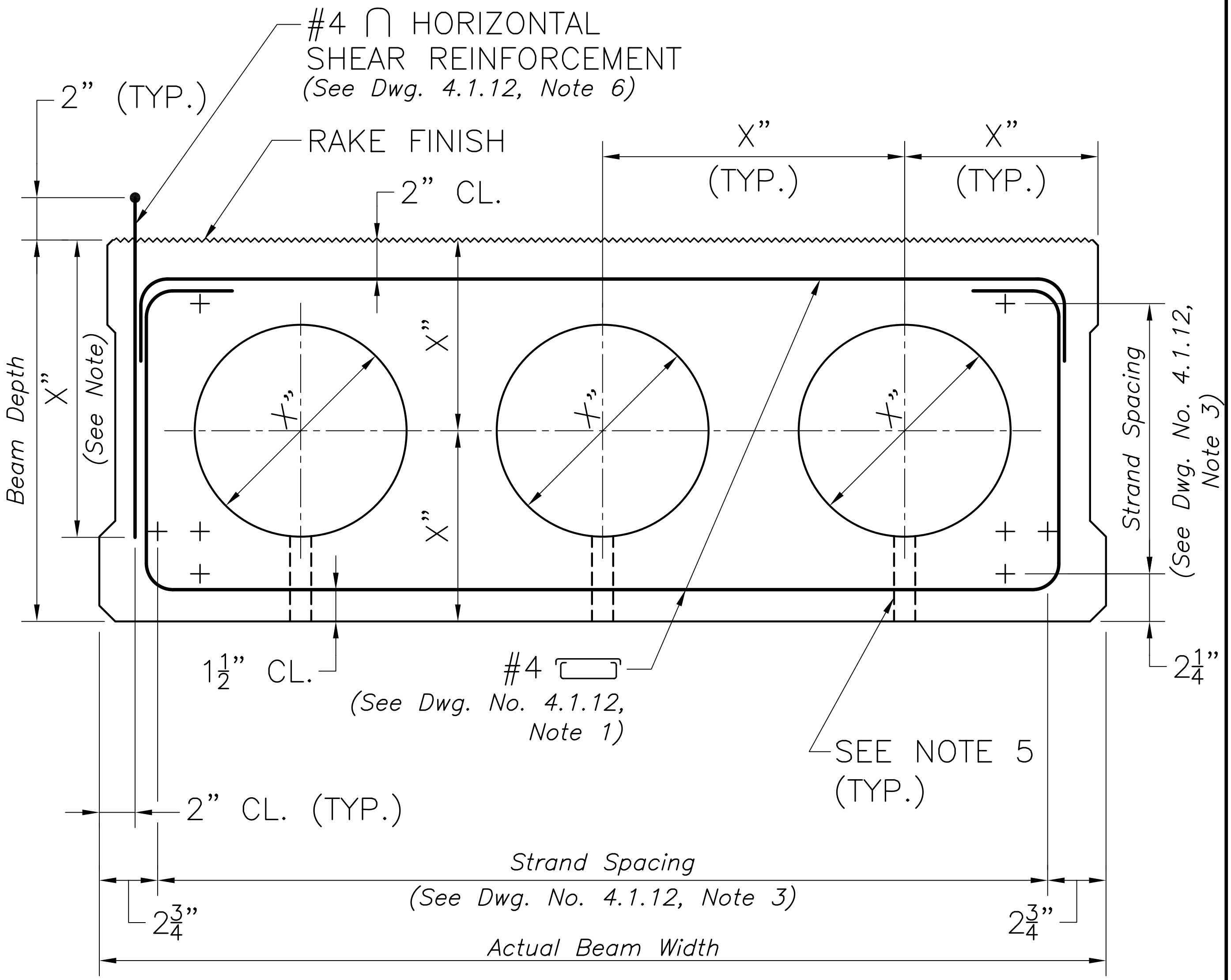
The Designer may increase the 28 day compressive strength of the concrete and/or the compressive strength at transfer if justified and feasible. See the prestressed concrete section of Part I of the Bridge Manual.



SHEAR KEY DETAIL

SCALE: 1½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SHEAR KEY DETAILS	DATE OF ISSUE MAY 2005
	PRECAST CONCRETE DECK BEAMS	DRAWING NUMBER **4.1.8**



NOTES:

1. + DENOTES STRAIGHT STRANDS.
2. ⊕ DENOTES DEBONDED STRANDS. *(None Shown Above)*
3. SEE SHEAR KEY DETAIL ON SHEET (*Provide Reference*).
4. SEE END OF BEAM PLAN FOR STIRRUP SPACING.
5. 1" ø DRAIN, PLACED AT BOTH ENDS OF EACH VOID.

MIDSPAN SECTION

SCALE: 1½" = 1'–0"

NOTE:
Specify 10" for 12" deep beams, 12" for 15" deep beams, and 14" for 18" and 21" deep beams.

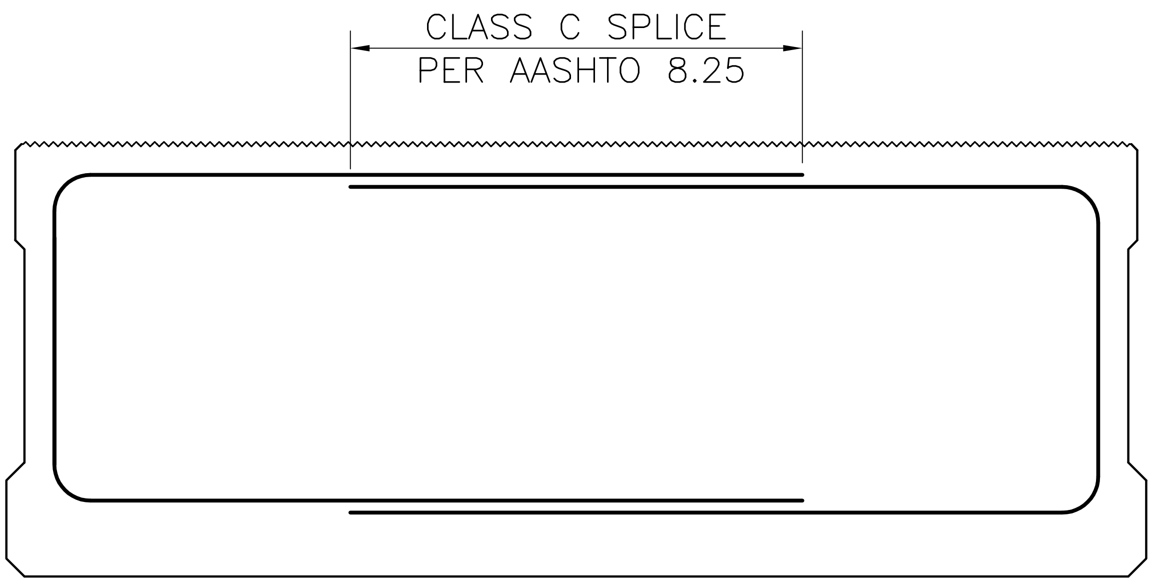
MASS HIGHWAY BRIDGE MANUAL

TYPICAL MIDSPAN SECTION

PRECAST CONCRETE DECK BEAMS

DATE OF ISSUE: FEBRUARY 2007

DRAWING NUMBER: 4.1.9



NOTES:

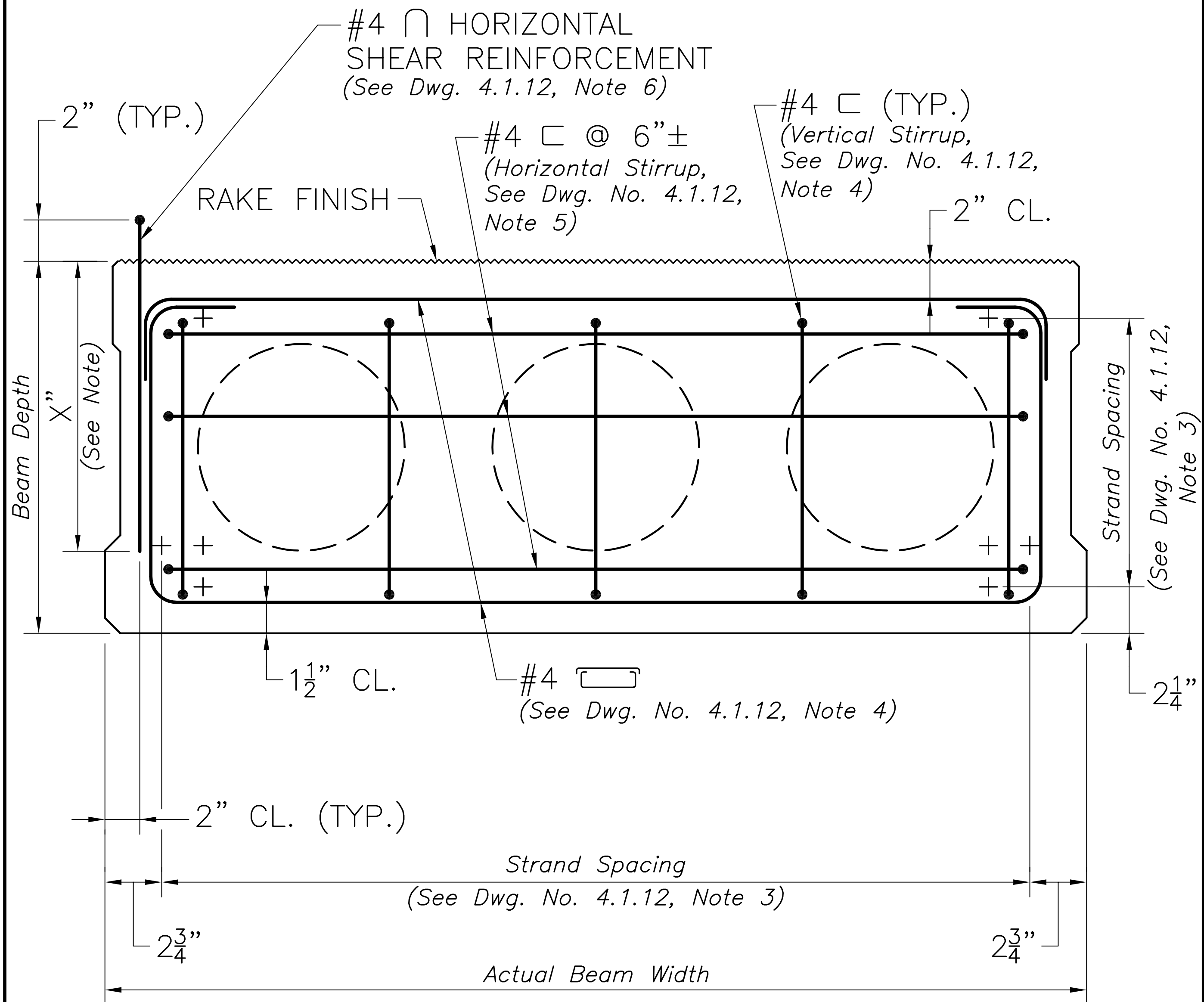
1. CONTRACTOR MAY SUBMIT ABOVE STIRRUP PATTERN TO THE ENGINEER FOR APPROVAL PROVIDED THAT THE ABOVE CRITERIA IS MET.
2. MAINTAIN ALL CLEARANCES AS SHOWN ON THE PLANS.

ALTERNATE STIRRUP PATTERN

SCALE: $1\frac{1}{2}$" = 1'–0"

For S36–12 and S48–12 (12" deep) beams use this alternate stirrup pattern exclusively.

MASS HIGHWAY BRIDGE MANUAL	ALTERNATE STIRRUP PATTERN PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.10**



NOTES:

1. + DENOTES STRAIGHT STRANDS.
2. ⊕ DENOTES DEBONDED STRANDS. *(None Shown Above)*
3. SEE SHEAR KEY DETAIL ON SHEET (*Provide Reference*).
4. SEE END OF BEAM PLAN FOR STIRRUP SPACING.

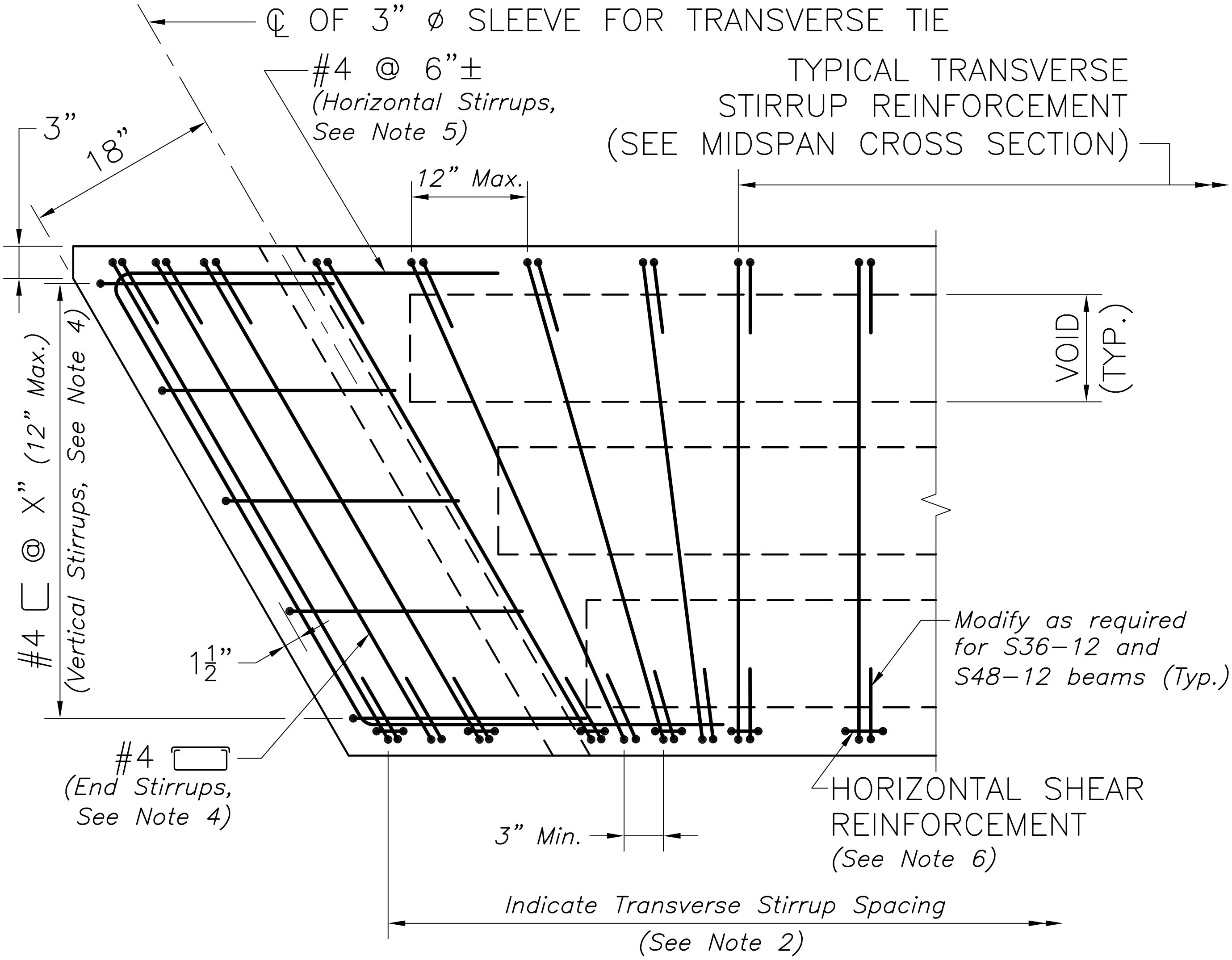
END OF BEAM SECTION

SCALE: 1½" = 1'–0"

NOTE:

Specify 10" for 12" deep beams, 12" for 15" deep beams, and 14" for 18" and 21" deep beams.

MASS HIGHWAY BRIDGE MANUAL	TYPICAL END OF BEAM SECTION PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.11**



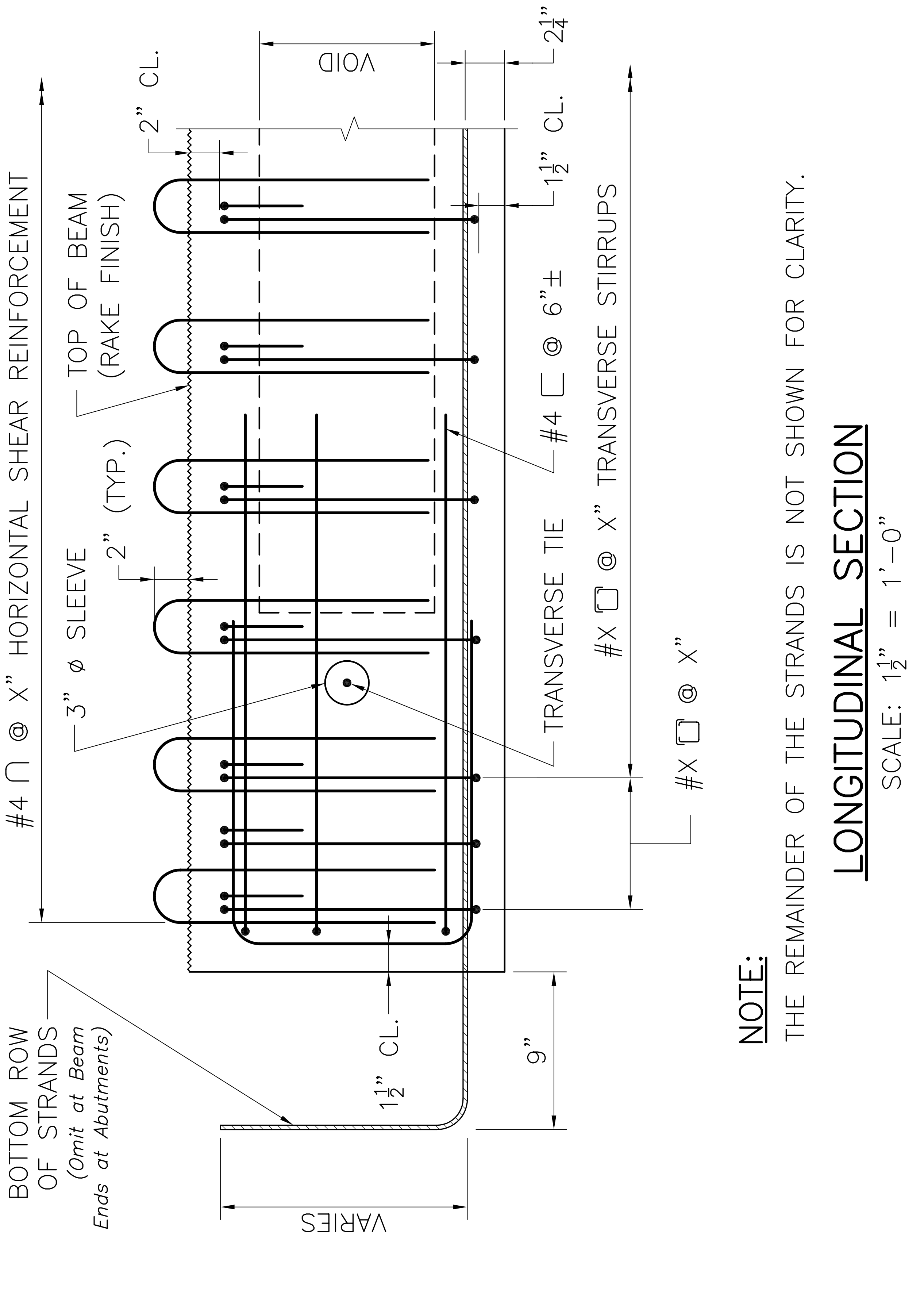
END OF BEAM PLAN

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. See the prestressed section of Part I of the Bridge Manual for the design of the transverse stirrups. Spacing shall not exceed 12".
2. The extent of the beam shown in the Plan of Beam should be long enough to indicate typical transverse stirrup spacing throughout the beam.
3. The actual number and location of the prestressing strands shall be designed and shall conform to the spacings shown in Dwg. No.'s 4.1.6 and 4.1.7.
4. See the prestressed section of Part I of the Bridge Manual for the design of the end transverse stirrups and vertical stirrups. The horizontal leg lengths of the vertical stirrups are equal to the depth of the beam and shall be dimensioned on the plan view.
5. Horizontal stirrups shall be embedded a minimum distance equal to the depth of the beam or 12" into the web of the voided section, whichever is longer. Length of embedment shall be noted on the plan view.
6. Horizontal shear reinforcement shall be designed in accordance with AASHTO and shall be spaced at a multiple of the transverse stirrups.
7. Properly note and show the location and spacing of any dowels which extend into slabs, sidewalks, curb, or barriers on the cross section and plan views of the beams.

MASS HIGHWAY BRIDGE MANUAL	TYPICAL END OF BEAM PLAN PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.12**

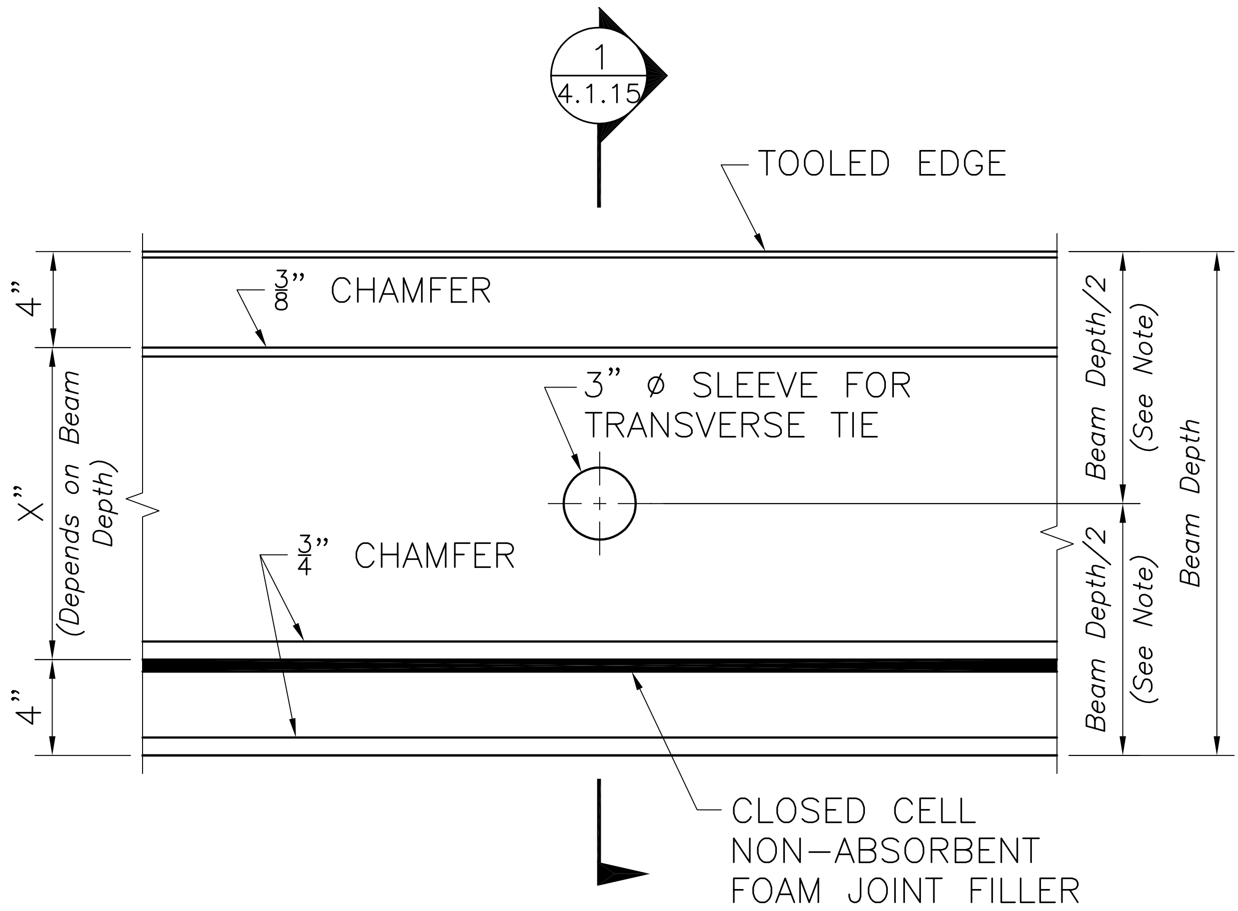


NOTE:
THE REMAINDER OF THE STRANDS IS NOT SHOWN FOR CLARITY.

LONGITUDINAL SECTION

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	LONGITUDINAL SECTION PRECAST CONCRETE DECK BEAM	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.13**



TYPICAL BEAM ELEVATION AT TRANSVERSE TIE LOCATIONS

SCALE: $1\frac{1}{2}$" = 1'–0"

NOTE:

Transverse ties are located at the midspan and at both ends of the deck beams.

MASS HIGHWAY
BRIDGE MANUAL

TYPICAL LONGITUDINAL JOINT ELEVATION

PRECAST CONCRETE DECK BEAMS

DATE OF ISSUE
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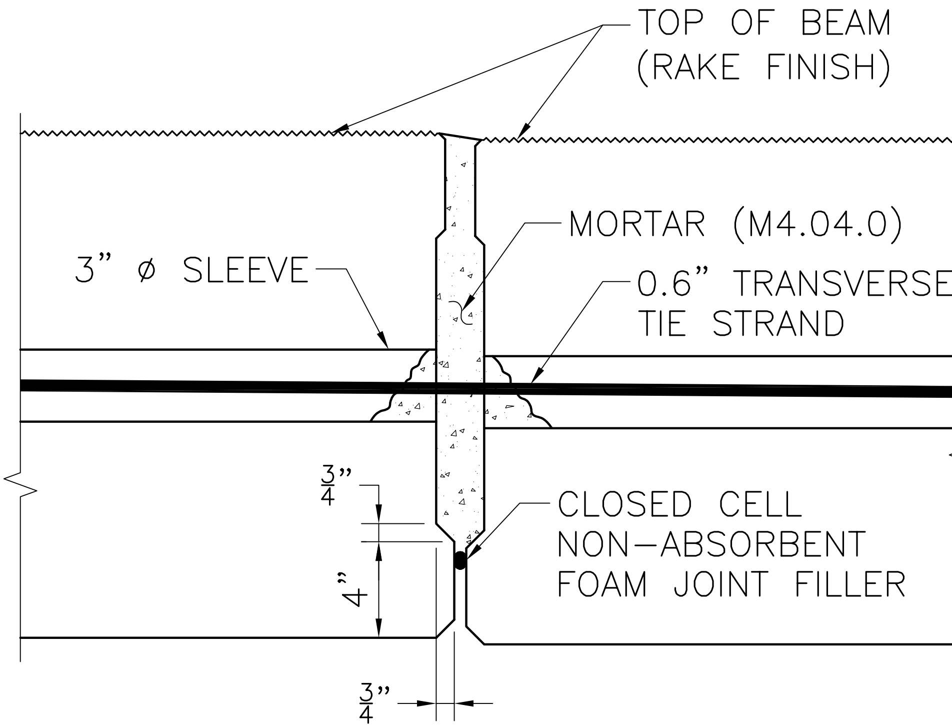
4.1.14



SECTION 1

SCALE: $1\frac{1}{2}$" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	TYPICAL LONGITUDINAL JOINT SECTION PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.15**

CONSTRUCTION SEQUENCE NOTES:

1. AFTER ALL BEAMS HAVE BEEN ERECTED, TENSION EACH TRANSVERSE TIE TO 5 KIPS.

2. FILL ALL KEYWAYS WITH MORTAR (M4.04.0). IF THE KEYWAYS ARE NOT FILLED WITHIN FIVE (5) DAYS AFTER THE BEAMS ARE ERECTED, THE CONTRACTOR SHALL COVER AND PROTECT THE KEYWAYS FROM WEATHER AND DEBRIS UNTIL THEY ARE FILLED.

3. AFTER THE MORTAR HAS CURED (24 HOURS MINIMUM), TENSION EACH TRANSVERSE TIE TO 44 KIPS.

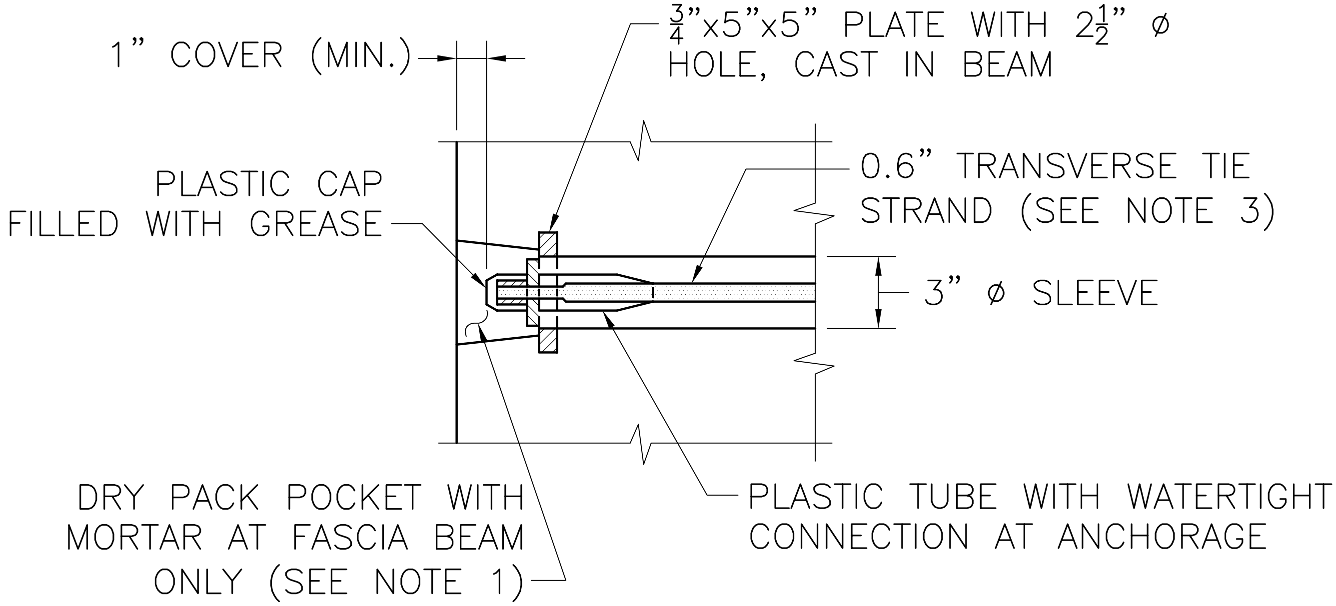
4. CONCRETE FOR DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE AND SHALL BE PLACED AFTER THE TRANSVERSE TIES HAVE BEEN FULLY TENSIONED.

5. NO TRAFFIC OR HEAVY EQUIPMENT WILL BE PERMITTED ON THE BRIDGE UNTIL ALL TRANSVERSE TIES HAVE BEEN PROPERLY TENSIONED AND THE DECK HAS BEEN CAST AND CURED PER THE STANDARD SPECIFICATIONS.

NOTE:

Include the Notes from Dwg. No. 4.1.21 on projects with Stage Construction.

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION SEQUENCE NOTES PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.16**



NOTES:

1. MORTAR FOR EXTERIOR POCKETS SHALL CONFORM TO M4.02.15 AND SHALL BE THE SAME COLOR AND TEXTURE AS THE BEAM CONCRETE.

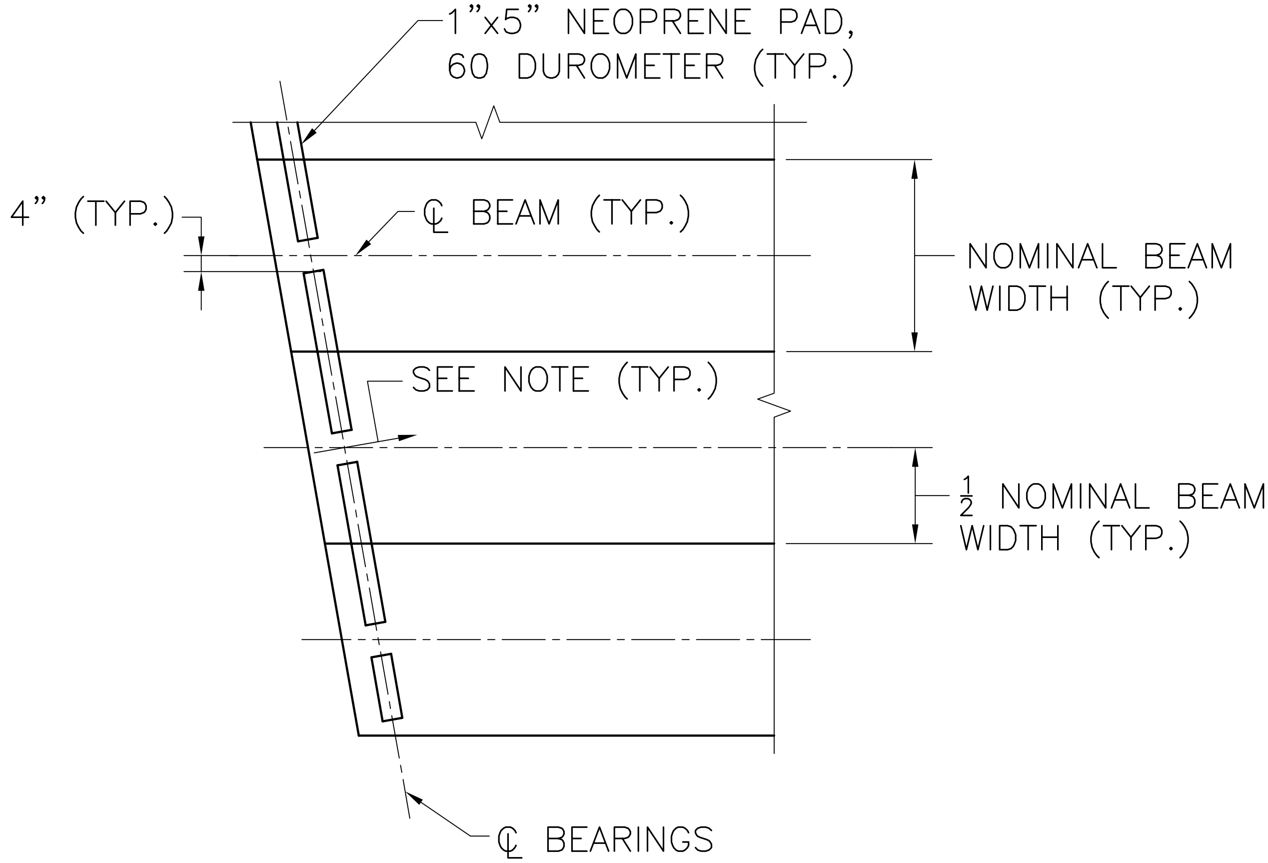
2. OTHER ANCHORAGE SYSTEMS MAY BE SUBSTITUTED WITH THE APPROVAL OF THE ENGINEER. ALTERNATE ANCHORAGE SYSTEMS SHALL BE WATERTIGHT AND CORROSION PROOF.

3. TRANSVERSE TIES SHALL BE COVERED BY A SEAMLESS POLYPROPYLENE SHEATH (WITH CORROSION INHIBITING GREASE BETWEEN THE STRAND AND SHEATH) FOR THE FULL LENGTH OF THE STRAND, EXCEPT AT THE ANCHORAGE LOCATION.

TRANSVERSE TIE ANCHORAGE

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	TRANSVERSE TIE ANCHORAGE PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.17**



NOTE:

PROVIDE $\frac{1}{8}$"/FT. SLOPE BETWEEN BEARINGS.

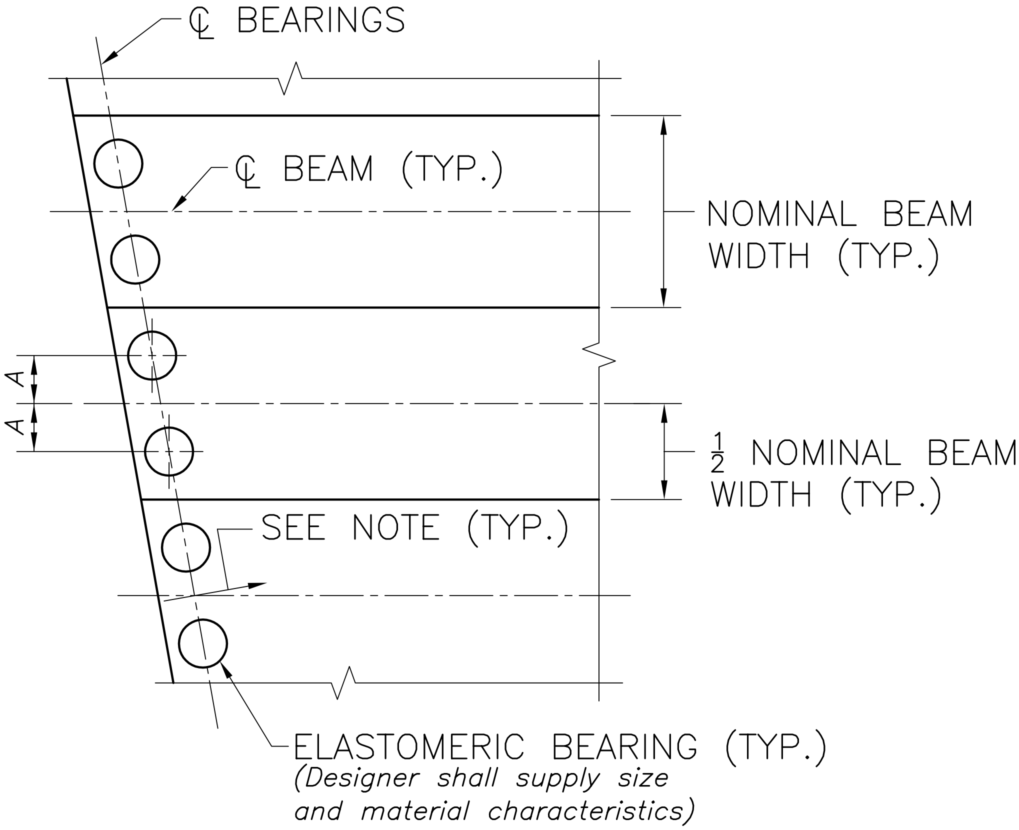
LAYOUT OF BEARINGS

SCALE: $\frac{1}{4}$" = 1'–0"

NOTE:

See Dwg. No. 4.1.19 for spans greater than 50'.

MASS HIGHWAY BRIDGE MANUAL	LAYOUT OF BEARINGS SPANS ⩽ 50' PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.18**



NOTE:

PROVIDE $\frac{1}{8}$"/FT. SLOPE BETWEEN BEARINGS.

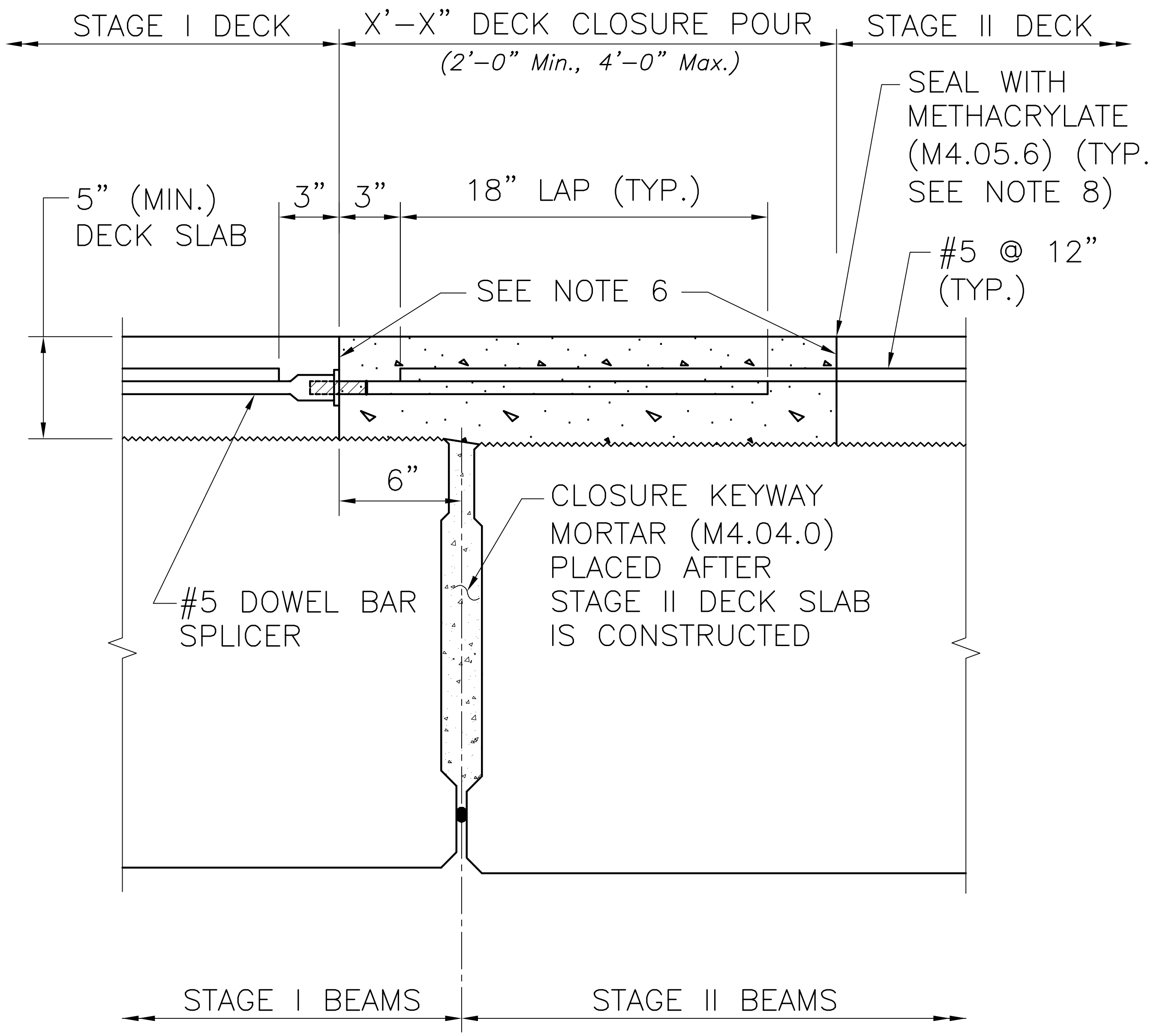
LAYOUT OF BEARINGS *(SPANS > 50')*

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *A = (Nominal Width of Beam)/4*
2. *See Dwg. No. 4.1.18 for spans less or equal to 50'.*

MASS HIGHWAY BRIDGE MANUAL	LAYOUT OF BEARINGS SPANS > 50' PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **4.1.19**



NOTES:

(See Dwg. No. 4.1.21 for Notes to be included on the Construction Drawings)

STAGE CONSTRUCTION DETAIL

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	STAGE CONSTRUCTION DETAIL PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.1.20**

STAGE CONSTRUCTION NOTES:

1. AFTER ALL STAGE II BEAMS HAVE BEEN ERECTED, TENSION EACH STAGE II TRANSVERSE TIE TO 5 KIPS.

2. FILL ALL KEYWAYS BETWEEN STAGE II BEAMS WITH MORTAR (M4.04.0). IF THE KEYWAYS ARE NOT FILLED WITHIN FIVE (5) DAYS AFTER THE BEAMS HAVE BEEN ERECTED, THE CONTRACTOR SHALL COVER AND PROTECT THE KEYWAYS FROM WEATHER AND DEBRIS UNTIL THEY ARE FILLED.

3. AFTER THE MORTAR HAS CURED (24 HOURS MINIMUM), TENSION EACH TRANSVERSE TIE TO 44 KIPS.

4. CONCRETE FOR STAGE II DECK SLAB SHALL BE PLACED AFTER THE STAGE II TRANSVERSE TIES HAVE BEEN FULLY TENSIONED. DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

5. FILL CLOSURE KEYWAY BETWEEN STAGE I AND STAGE II BEAMS WITH MORTAR (M4.04.0).

6. VERTICAL SURFACES OF PREVIOUSLY CAST DECK SLAB CONCRETE SHALL BE PRE–WETTED FOR 24 HOURS IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS.

7. IMMEDIATELY PLACE AND CURE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE CLOSURE POUR.

8. AFTER END OF CURING PERIOD TOP OF DECK STAGE CONSTRUCTION JOINT SHALL BE SEALED IN ACCORDANCE WITH REQUIREMENTS FOR METHACRYLATE CRACK SEALING OF SECTION 901.73 OF STANDARD SPECIFICATIONS.

LOCATION	LEFT EDGE OF DECK SLAB	PROFILE GRADE LINE	CROWN LINE	RIGHT EDGE OF DECK SLAB
℄ BRGS. @ ABUT.				
MIDSPAN				
℄ BRGS. @ ABUT.				

NOTES:

1. THIS TABLE INDICATES THE THEORETICAL THICKNESS OF THE DECK SLAB IN INCHES BASED UPON ASSUMED BEAM CAMBERS AT ERECTION.

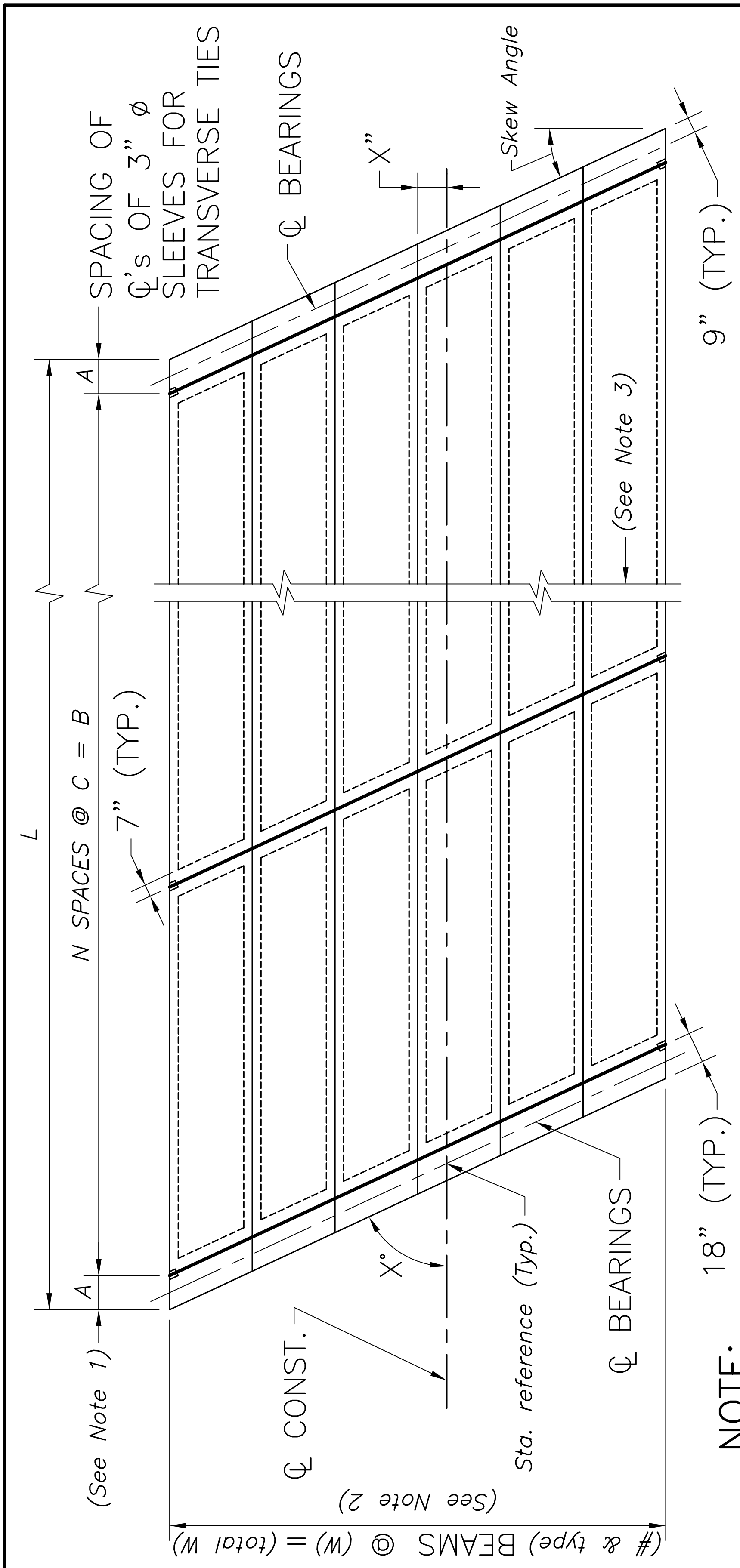
2. TABLE IS PROVIDED TO ASSIST IN ESTIMATING THE REQUIRED CONCRETE VOLUME.

3. THE ACTUAL DECK THICKNESSES WILL BE AS REQUIRED TO MEET THE PROFILE GRADES.

THEORETICAL DECK SLAB THICKNESS TABLE

NOTES:

1. *Expand the table where required to include all spans.*
2. *Crown line dimensions need only be provided when they differ from the profile grade line.*



NOTE:
SEE STANDARD SPECIFICATIONS FOR BEAM ERECTION AND LAYOUT.

FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1'-0" Min.)

NOTES:

1. A = 18"/cos(Skew Angle)
   L = Span Length + A
   B = L − 2A
   C = B/N, where N = number of internal voids. (See Dwg. No. 4.2.13 for the required number of transverse ties.)
2. Specify beam type (e.g. B36-24). Use only nominal beam widths when specifying beam width (W) and calculating total width (total W).
3. Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Show all internal voids and transverse ties and include North Arrow.
4. The beams shall be consecutively numbered from South to North for bridges oriented generally East-West and from West to East for bridges oriented generally North-South. Spans shall be consecutively numbered from West to East for bridges generally oriented East-West and from South to North for bridges generally oriented North-South.

MASS HIGHWAY BRIDGE MANUAL

FRAMING PLAN

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
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DRAWING NUMBER
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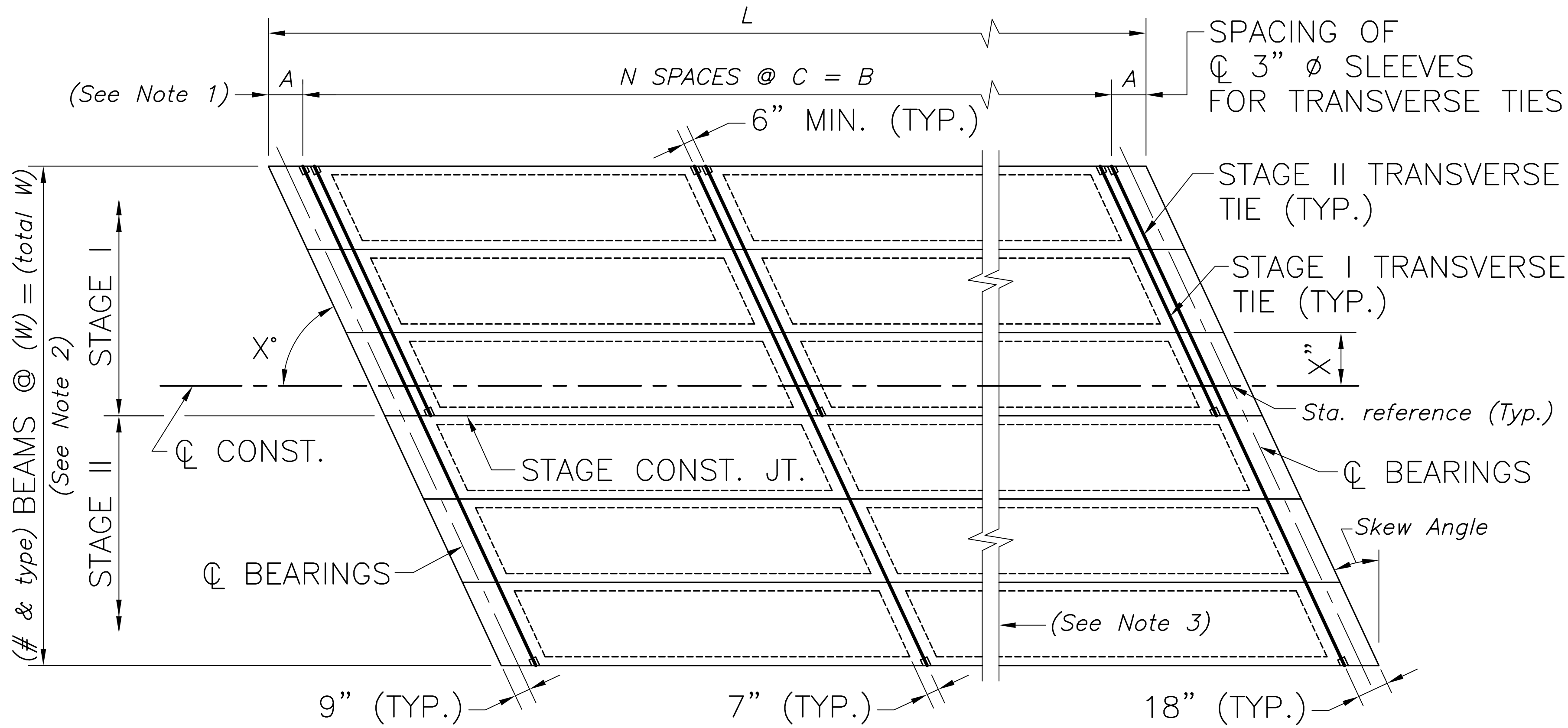


NOTE:

SEE STANDARD SPECIFICATIONS FOR BEAM ERECTION AND LAYOUT.

FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1'–0" Min.)

NOTES:

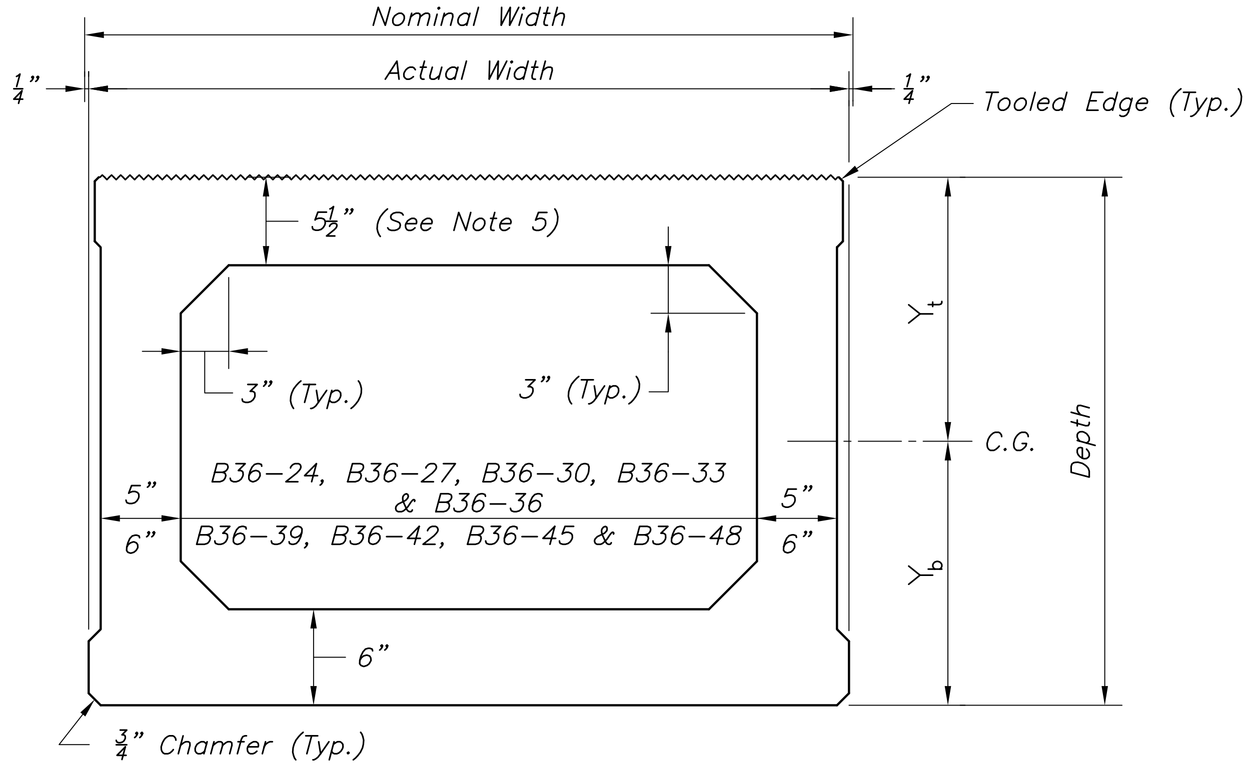
1. *A = 18"/cos(Skew Angle)*
   L = Span Length + A
   B = L − 2A
   C = B/N, where N = number of internal voids. (See Dwg. No. 4.2.13 for the required number of transverse ties.)
2. *Specify beam type (e.g. B48–24). Use only nominal beam widths when specifying beam width (W) and calculating total width (total W).*
3. *Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Show all internal voids and transverse ties and include North Arrow.*
4. *The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.*

MASS HIGHWAY
BRIDGE MANUAL

FRAMING PLAN
STAGE CONSTRUCTION
PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.2.2



BEAM PROPERTIES

BEAM TYPE	WIDTH (in.)		DEPTH (in)	AREA (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
	Nom.	Act.									
B36-24	36.0	35.5	24	543	36609	11.82	12.18	3097	3006	566	64
B36-27	36.0	35.5	27	573	50267	13.29	13.71	3782	3666	597	71
B36-30	36.0	35.5	30	603	66503	14.77	15.23	4503	4367	628	78
B36-33	36.0	35.5	33	633	85453	16.24	16.76	5262	5099	659	84
B36-36	36.0	35.5	36	663	107251	17.72	18.28	6053	5867	691	92
B36-39	36.0	35.5	39	748	135514	19.24	19.76	7043	6858	779	99
B36-42	36.0	35.5	42	784	164680	20.73	21.27	7944	7742	817	107
B36-45	36.0	35.5	45	820	197374	22.21	22.79	8887	8661	854	113
B36-48	36.0	35.5	48	856	233759	23.70	24.30	9863	9620	892	117

NOTES:

1. Above drawing is not to scale.
2. See Dwg. No. 4.2.8 for shear key details.
3. Maximum Span lengths are approximate and are based on the following assumptions:
   $f'c = 6500$ psi
   $f'ci = 4500$ psi
   $f'c = 4000$ psi for 5" Composite Deck
   Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   HS25 Truck loading.
4. Weights of beams do not include the weight of the solid sections located at the transverse ties. Include the weight of the solid sections for design.
5. Thickness of top flange may have to be increased in order to develop sidewalk/safety curb barrier reinforcement (see Dwg. No. 4.3.2). The Designer will have to calculate and use the modified beam properties in such cases.

MASS HIGHWAY
BRIDGE MANUAL

STANDARD 36" WIDE BEAMS

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
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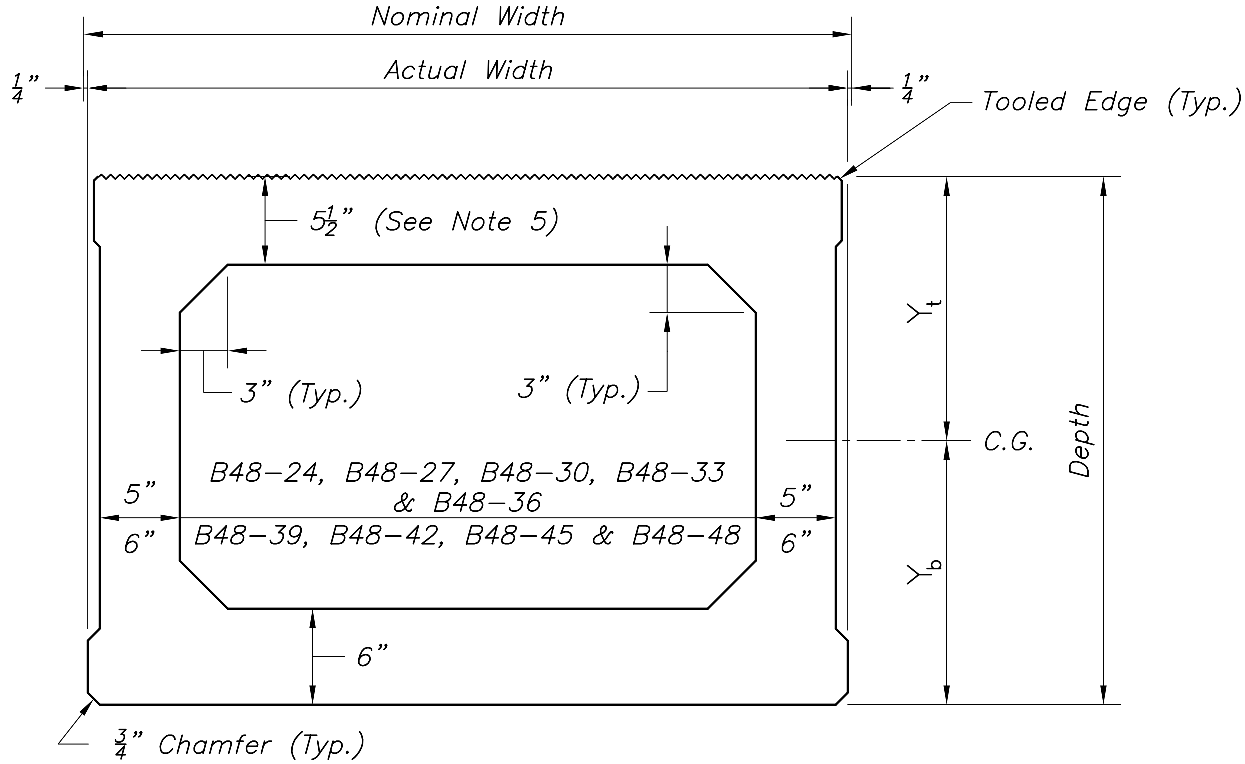
DRAWING NUMBER
4.2.3



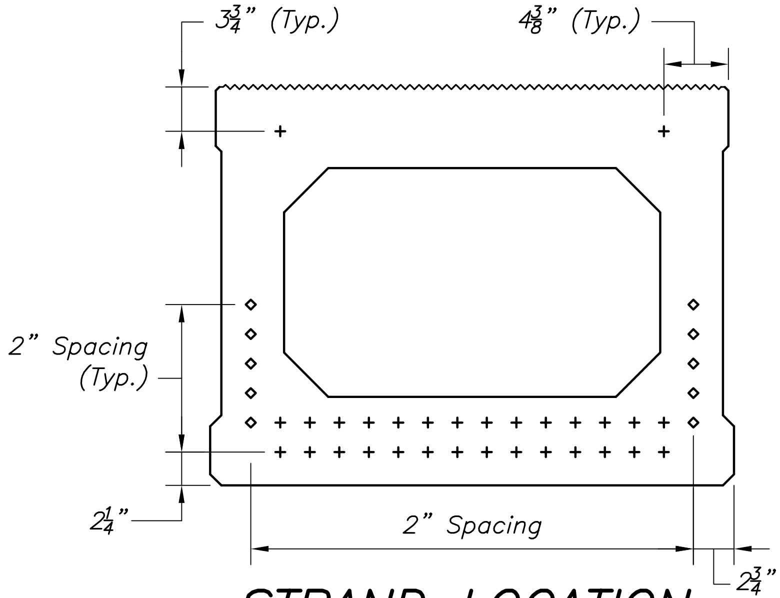
BEAM PROPERTIES

BEAM TYPE	WIDTH (in.) Nom.	WIDTH (in.) Act.	DEPTH (in)	Area (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
B48–24	48	47.5	24	681	48461	11.80	12.20	4107	3972	709	64
B48–27	48	47.5	27	711	66201	13.27	13.73	4989	4822	741	70
B48–30	48	47.5	30	741	87139	14.73	15.27	5916	5707	772	79
B48–33	48	47.5	33	771	111410	16.20	16.80	6877	6632	803	85
B48–36	48	47.5	36	801	139151	17.68	18.32	7871	7596	834	92
B48–39	48	47.5	39	886	173980	19.19	19.81	9066	8782	923	103
B48–42	48	47.5	42	922	210330	20.67	21.33	10176	9861	960	111
B48–45	48	47.5	45	958	250828	22.15	22.85	11324	10977	998	115
B48–48	48	47.5	48	994	295638	23.63	24.37	12511	12131	1035	122

NOTES:

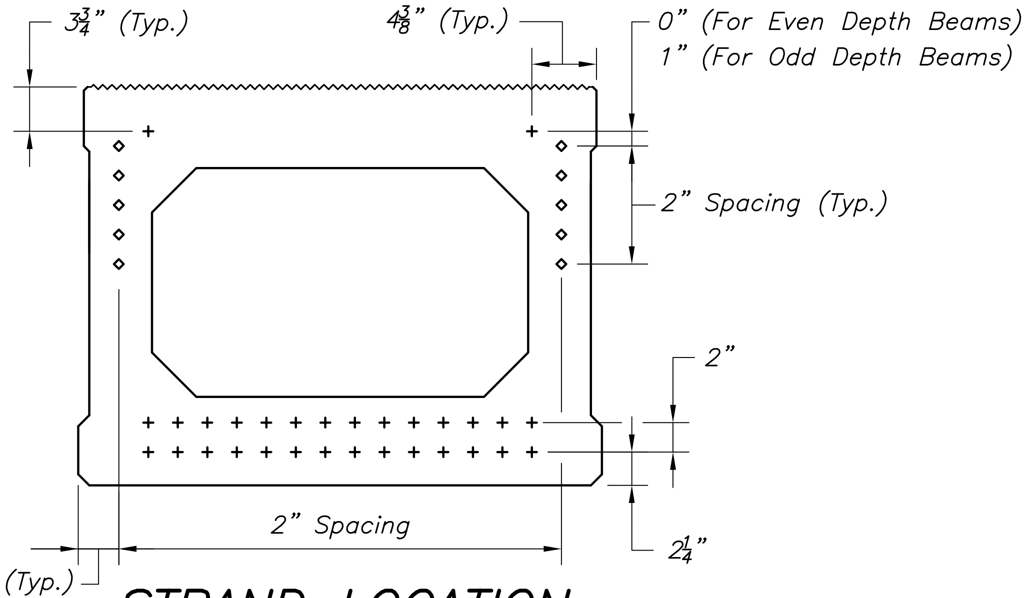
1. Above drawing is not to scale.
2. See Dwg. No. 4.2.8 for shear key details.
3. Maximum Span lengths are approximate and are based on the following assumptions:
   - f'c = 6500 psi
   - f'ci = 4500 psi
   - f'c = 4000 psi for 5" Composite Deck
   - Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   - HS25 Truck loading.
4. Weights of beams do not include the weight of the solid sections located at the transverse ties. Include the weight of the solid sections for design.
5. Thickness of top flange may have to be increased in order to develop sidewalk/safety curb barrier reinforcement (see Dwg. No. 4.3.2). The Designer will have to calculate and use the modified beam properties in such cases.

MASS HIGHWAY BRIDGE MANUAL	STANDARD 48" WIDE BEAMS	DATE OF ISSUE MAY 2005
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER 4.2.4



STRAND LOCATION AT MIDSPAN

NOT TO SCALE

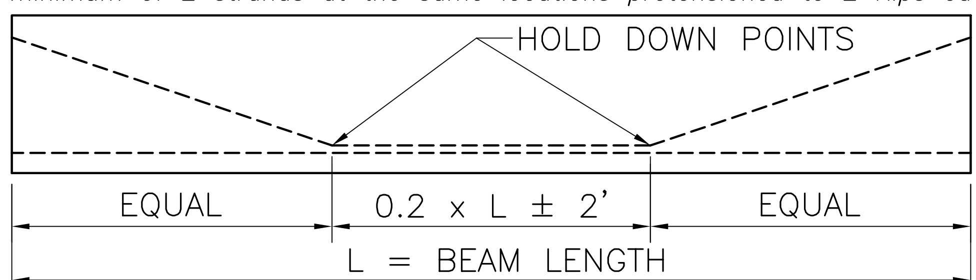


STRAND LOCATION AT END OF BEAM

NOT TO SCALE

NOTES:

1. + Denotes straight strands.
2. ⋄ Denotes draped strands.
3. ⊕ Denotes debonded strands (none shown above). No more than 25% of the total number of strands shall be debonded. Debonded strands shall be at least 4" apart, vertically and horizontally. Do not debond the outermost strands of each layer.
4. Design must accommodate hold down location tolerance shown.
5. If required by design, a maximum of 2 fully stressed strands may be provided in the top flange at the specified locations. Otherwise, provide a minimum of 2 strands at the same locations pretensioned to 2 Kips each.



HOLD DOWN POINTS FOR DRAPED STRANDS

NOT TO SCALE

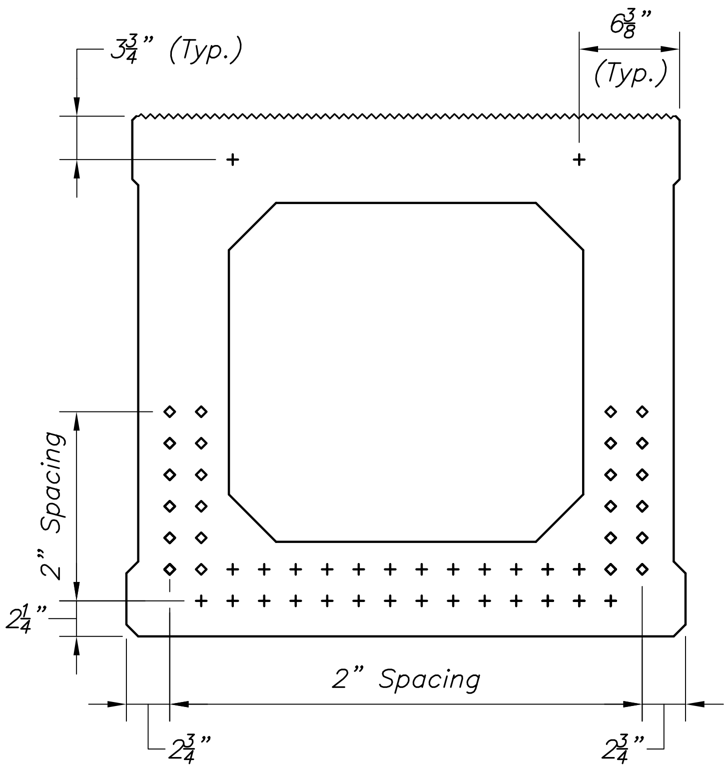
MASS HIGHWAY BRIDGE MANUAL

STANDARD STRAND LOCATION 24" THRU 36" DEEP BEAMS

PRECAST CONCRETE BOX BEAMS

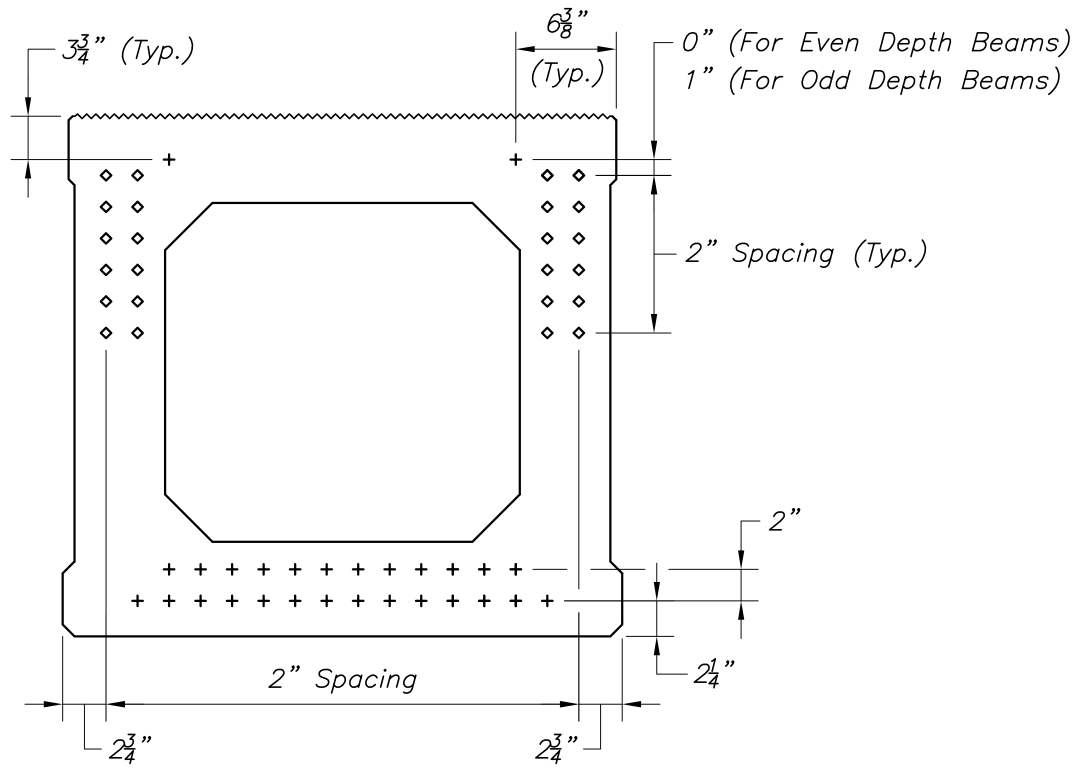
DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.2.5



STRAND LOCATION AT MIDSPAN

NOT TO SCALE



STRAND LOCATION AT END OF BEAM

NOT TO SCALE

NOTES:

1. + Denotes straight strands.
2. ◇ Denotes draped strands. When using two columns of draped strands in each web, an even number of strands shall be used.
3. ⊕ Denotes debonded strands (none shown above). No more than 25% of the total number of strands shall be debonded. Debonded strands shall be at least 4" apart, vertically and horizontally. Do not debond the outermost strands of each layer.
4. For location of hold down points see Dwg. No. 4.2.5. Design must accommodate hold down location tolerance shown on Dwg. No. 4.2.5.
5. If required by design, a maximum of 2 fully stressed strands may be provided in the top flange at the specified locations. Otherwise, provide a minimum of 2 strands at the same locations pretensioned to 2 Kips each.

MASS HIGHWAY BRIDGE MANUAL

STANDARD STRAND LOCATION 39" THRU 48" DEEP BEAMS

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.2.6

PRESTRESS NOTES:

1. ALL PRETENSIONING ELEMENTS SHALL BE 0.6" ⌀, UNCOATED, SEVEN–WIRE, LOW RELAXATION STEEL STRANDS AND SHALL CONFORM TO AASHTO M 203.

2. THE MINIMUM ULTIMATE TENSILE STRENGTH OF THE PRETENSIONING STRANDS SHALL BE 270 KSI.

3. THE INITIAL TENSION PER 0.6" ⌀ STRAND SHALL BE 44 KIPS.

4. THE MINIMUM 28 DAY COMPRESSIVE STRENGTH SHALL BE 6500 PSI. *(See Note)*

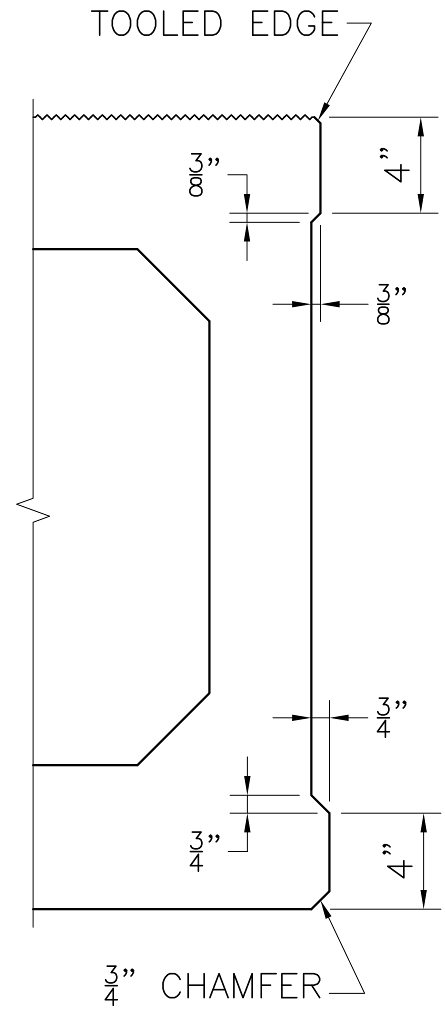
5. NO PRESTRESS SHALL BE TRANSFERRED TO THE CONCRETE UNTIL IT HAS ATTAINED A COMPRESSIVE STRENGTH, AS SHOWN BY CYLINDER TEST, OF AT LEAST 4000 PSI. *(See Note)*

6. THE TOP OF ALL BEAMS SHALL BE GIVEN A RAKE FINISH ($\frac{1}{4}$" AMPLITUDE) ACROSS THE WIDTH (PERPENDICULAR TO THE BEAM'S AXIS).

7. THE FABRICATOR IS FULLY RESPONSIBLE FOR THE DESIGN OF THE LIFTING DEVICES, WHICH SHALL BE ADEQUATE FOR THE SAFETY FACTORS REQUIRED BY THE ERECTION PROCEDURE.

NOTE:

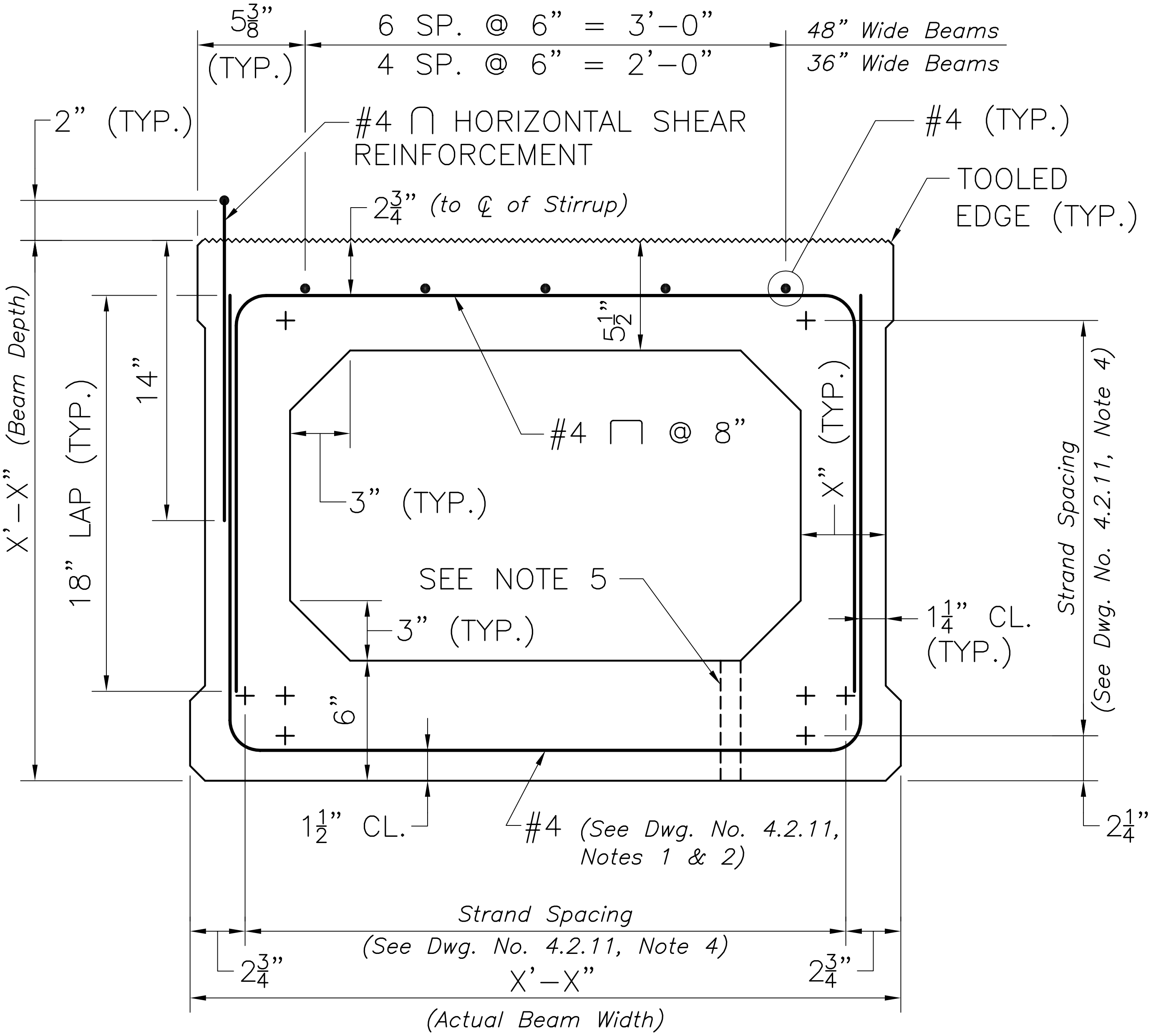
The Designer may increase the 28 day compressive strength of the concrete and/or the compressive strength at transfer if justified and feasible. See the prestressed concrete section of Part I of the Bridge Manual.



SHEAR KEY DETAIL

SCALE: 1½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SHEAR KEY DETAIL	DATE OF ISSUE MAY 2005
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER **4.2.8**



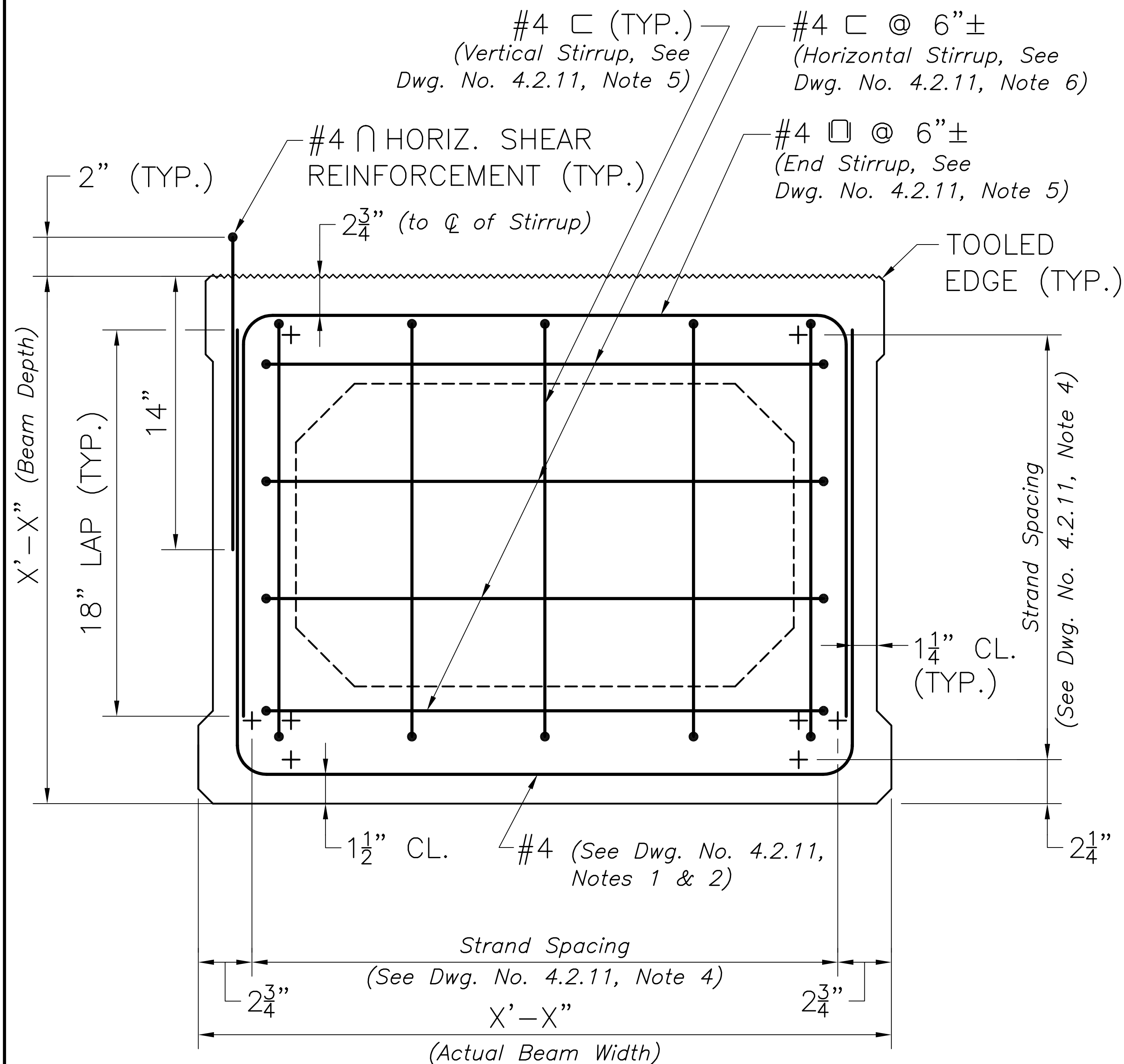
NOTES:

1. + DENOTES STRAIGHT STRANDS.
2. ◇ DENOTES DRAPED STRANDS. *(None Shown Above)*
3. ⊕ DENOTES DEBONDED STRANDS. *(None Shown Above)*
4. SEE SHEAR KEY DETAIL ON SHEET (*Provide Reference*).
5. 1" ø DRAIN PLACED AT BOTH ENDS OF EACH VOID.
6. SEE END OF BEAM PLAN FOR STIRRUP SPACING.

MIDSPAN SECTION

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

MASS HIGHWAY BRIDGE MANUAL	TYPICAL MIDSPAN SECTION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.9**



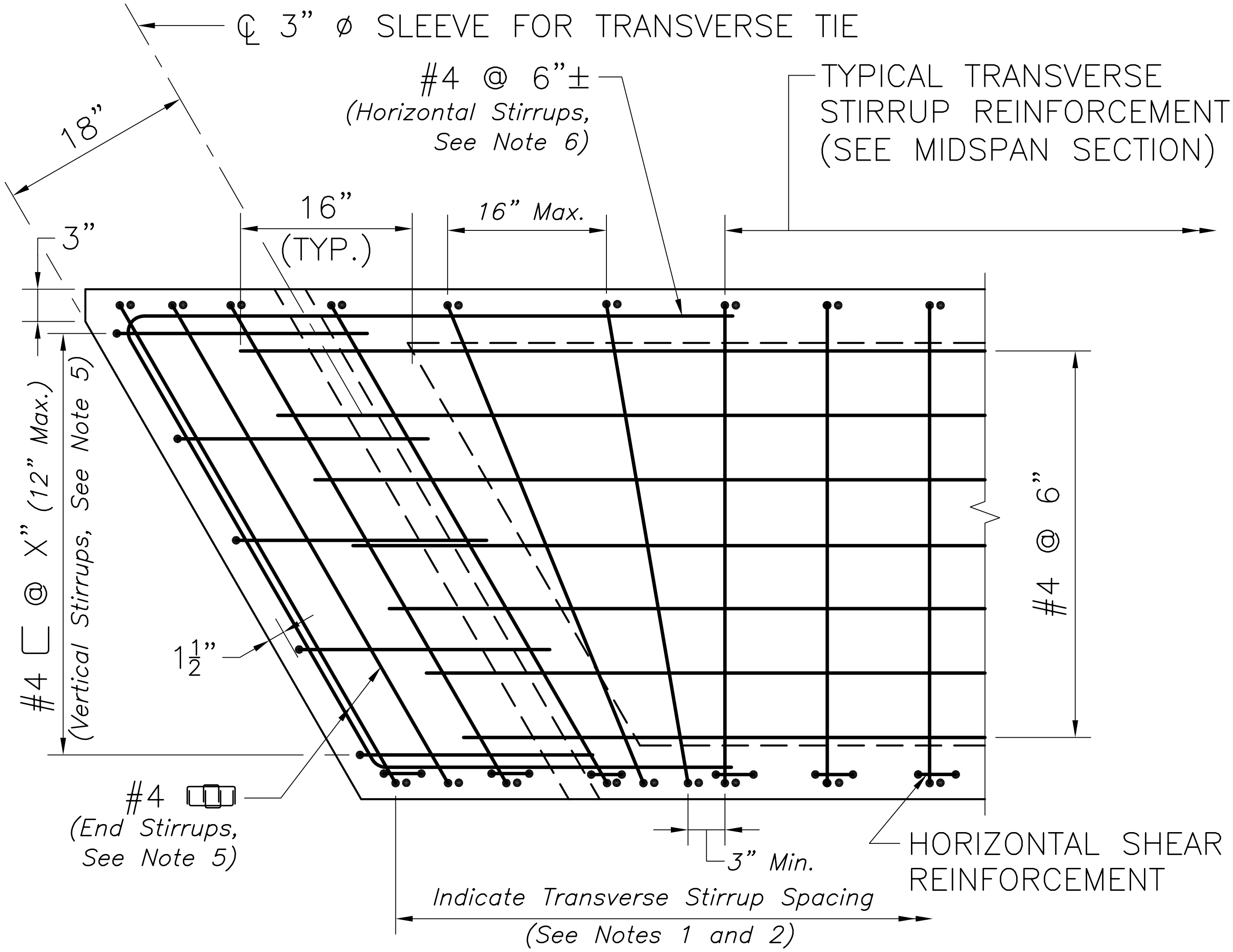
NOTES:

1. + DENOTES STRAIGHT STRANDS.
2. ◇ DENOTES DRAPED STRANDS. *(None Shown Above)*
3. ⊕ DENOTES DEBONDED STRANDS. *(None Shown Above)*
4. SEE SHEAR KEY DETAIL ON SHEET (*Provide Reference*).

END OF BEAM SECTION

SCALE: 1½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	TYPICAL END OF BEAM SECTION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.10**



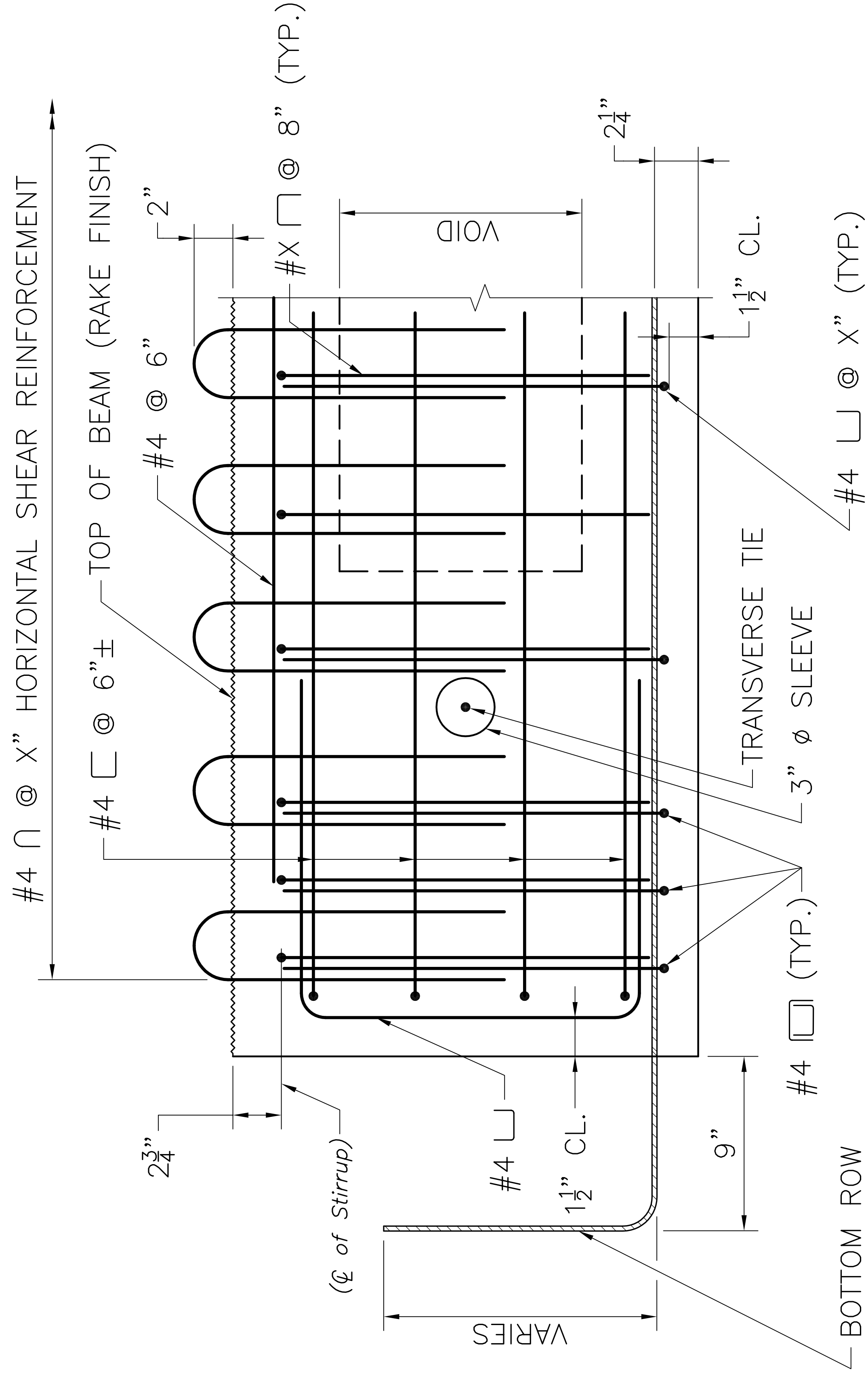
END OF BEAM PLAN

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *See the prestressed section of Part I of the Bridge Manual for the design of the transverse stirrups.*
2. *Bottom transverse stirrups shall be placed at a multiple of the top transverse stirrups spacing with a maximum spacing of 16".*
3. *The extent of the beam shown in the End of Beam Plan should be long enough to indicate typical transverse stirrup spacing throughout the beam.*
4. *The actual number and location of the prestressing strands shall be designed and shall conform to Dwg. No.'s 4.2.5 and 4.2.6.*
5. *See the prestressed section of Part I of the Bridge Manual for the design of the end transverse stirrups and vertical stirrups. The horizontal leg lengths of the vertical stirrups shall equal the depth of the beam and shall be dimensioned on the plan view.*
6. *Horizontal stirrups shall be embedded a minimum distance equal to the depth of the beam or 12" into the web of the voided section, whichever is longer. Length of embedment shall be noted on the plan view.*
7. *Horizontal shear reinforcement shall be designed in accordance with AASHTO and shall be spaced at a multiple of the transverse stirrups.*
8. *Properly note or show the location and spacing of any dowels which extend into sidewalks, curb, or barriers on the cross section and plan views of the beams.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL END OF BEAM PLAN PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.11**



NOTE:

THE REMAINDER OF THE STRANDS IS NOT SHOWN FOR CLARITY.

LONGITUDINAL SECTION

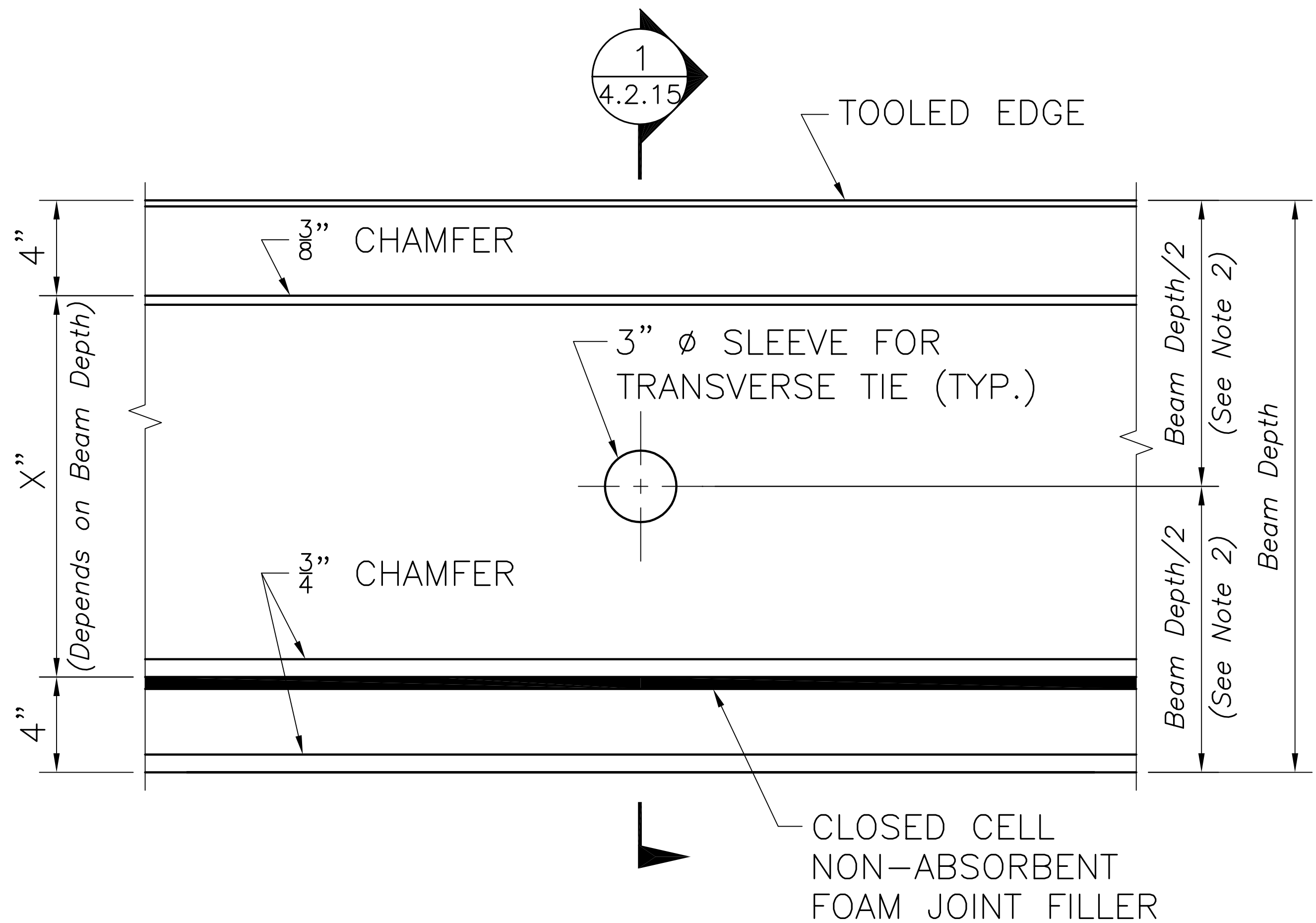
SCALE: 1½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	LONGITUDINAL SECTION PRECAST CONCETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.12**

SPAN LENGTH	TIE LOCATIONS		
	Ends	$\frac{1}{4}$ Points	Midspan
⩽ 50'	X		X
> 50'	X	X	X

TRANSVERSE TIE LOCATIONS

NOTE:
If torsional load in the fascia beams (due to sidewalk, overhang or utilities) is excessive, consideration shall be given to increasing the number of transverse ties and/or the post-tensioning force. Adjust the transverse tie locations as necessary.



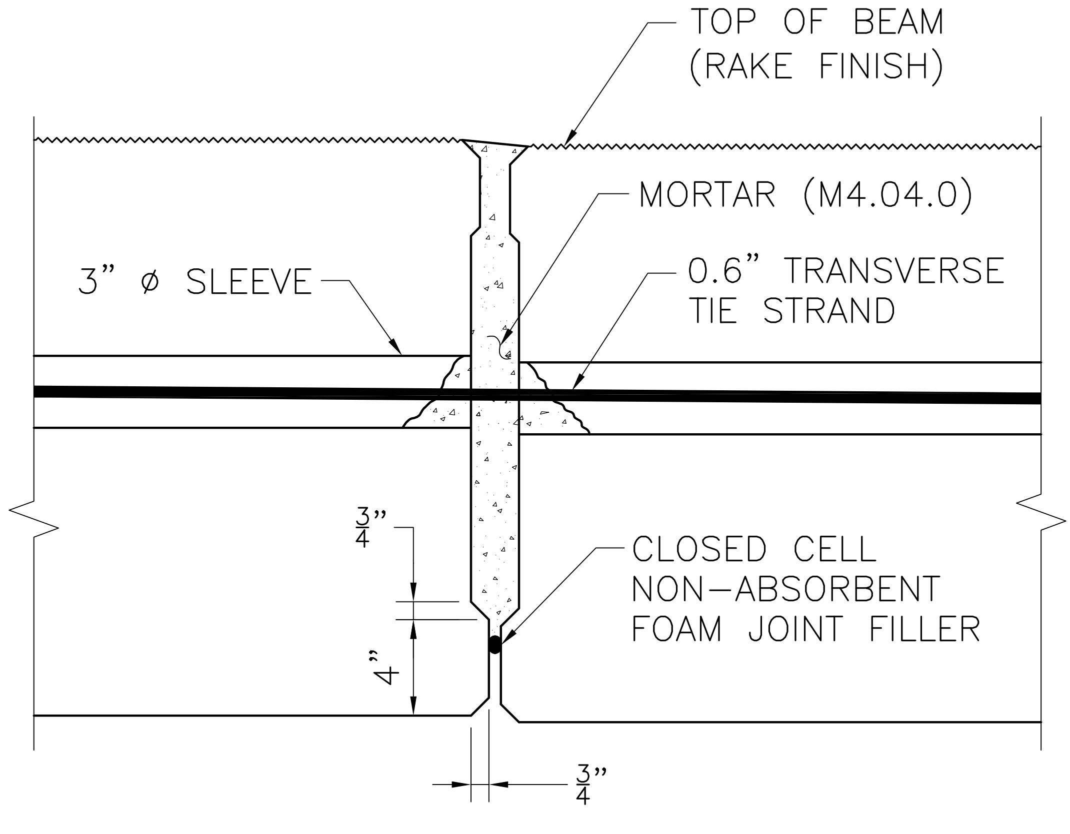
TYPICAL BEAM ELEVATION AT TRANSVERSE TIE LOCATIONS

SCALE: $1\frac{1}{2}$" = 1'-0"

NOTES:

1. *See Dwg. No. 4.2.13 for the locations of the transverse ties and for the bottom strand requirements.*
2. *The vertical position of the transverse tie strands must be coordinated with the locations of the prestressing strands and adjusted as necessary to avoid interference.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL LONGITUDINAL JOINT ELEVATION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.14**



SECTION 1

SCALE: $1\frac{1}{2}$" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL

TYPICAL LONGITUDINAL JOINT SECTION

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.2.15

CONSTRUCTION SEQUENCE NOTES:

1. AFTER ALL BEAMS HAVE BEEN ERECTED, TENSION EACH TRANSVERSE TIE TO 5 KIPS.

2. FILL ALL KEYWAYS WITH MORTAR (M4.04.0). IF THE KEYWAYS ARE NOT FILLED WITHIN FIVE (5) DAYS AFTER THE BEAMS ARE ERECTED, THE CONTRACTOR SHALL COVER AND PROTECT THE KEYWAYS FROM WEATHER AND DEBRIS UNTIL THEY ARE FILLED.

3. AFTER THE MORTAR HAS CURED (24 HOURS MINIMUM), TENSION EACH TRANSVERSE TIE TO 44 KIPS.

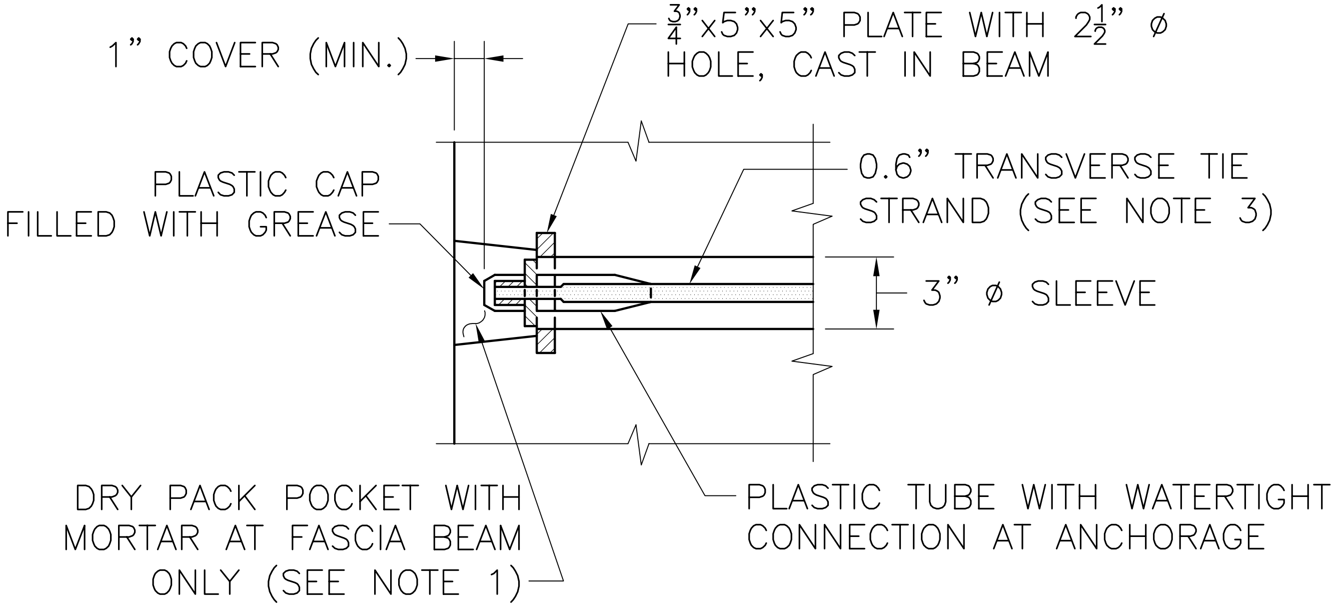
4. CONCRETE FOR DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE AND SHALL BE PLACED AFTER THE TRANSVERSE TIES HAVE BEEN FULLY TENSIONED.

5. NO TRAFFIC OR HEAVY EQUIPMENT WILL BE PERMITTED ON THE BRIDGE UNTIL ALL TRANSVERSE TIES HAVE BEEN PROPERLY TENSIONED AND THE DECK HAS BEEN CAST AND CURED PER THE STANDARD SPECIFICATIONS.

NOTE:

Include the Notes from Dwg. No. 4.1.21 on projects with Stage Construction.

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION SEQUENCE NOTES PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.16**



NOTES:

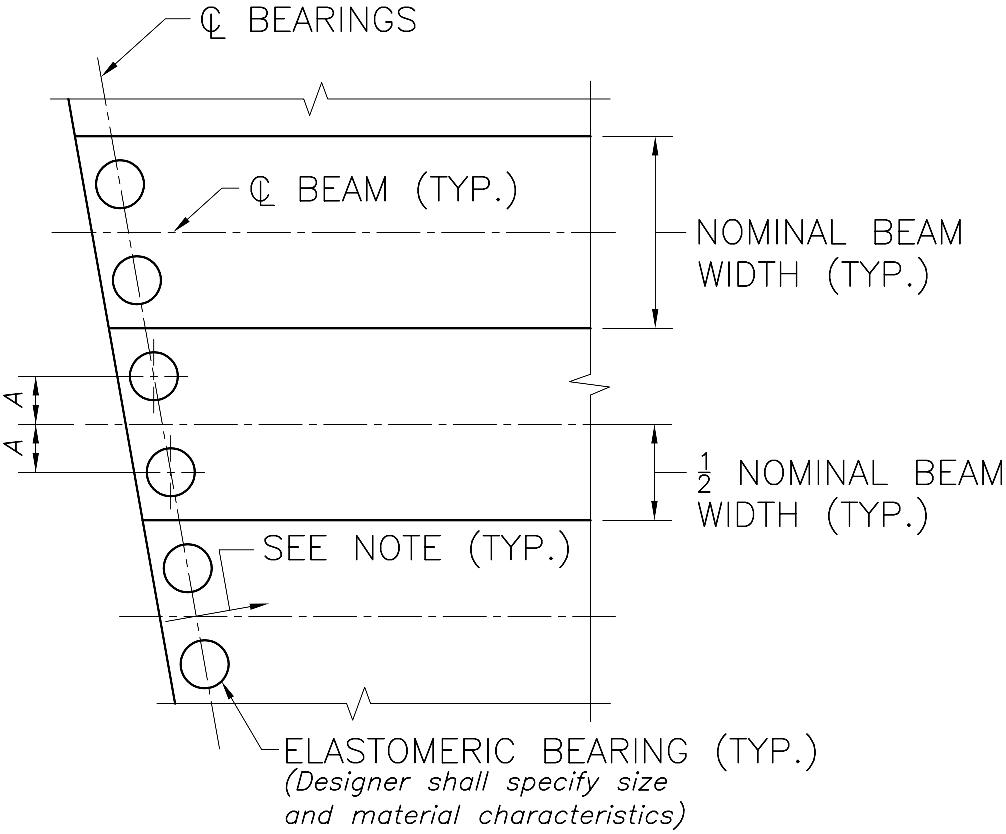
1. MORTAR FOR EXTERIOR POCKETS SHALL CONFORM TO M4.02.15 AND SHALL BE THE SAME COLOR AND TEXTURE AS THE BEAM CONCRETE.

2. OTHER ANCHORAGE SYSTEMS MAY BE SUBSTITUTED WITH THE APPROVAL OF THE ENGINEER. ALTERNATE ANCHORAGE SYSTEMS SHALL BE WATERTIGHT AND CORROSION PROOF.

3. TRANSVERSE TIES SHALL BE COVERED BY A SEAMLESS POLYPROPYLENE SHEATH (WITH CORROSION INHIBITING GREASE BETWEEN THE STRAND AND SHEATH) FOR THE FULL LENGTH OF THE STRAND, EXCEPT AT THE ANCHORAGE LOCATION.

TRANSVERSE TIE ANCHORAGE

SCALE: $1\frac{1}{2}$" = 1'–0"



NOTE:

PROVIDE $\frac{1}{8}$"/FT. SLOPE BETWEEN BEARINGS.

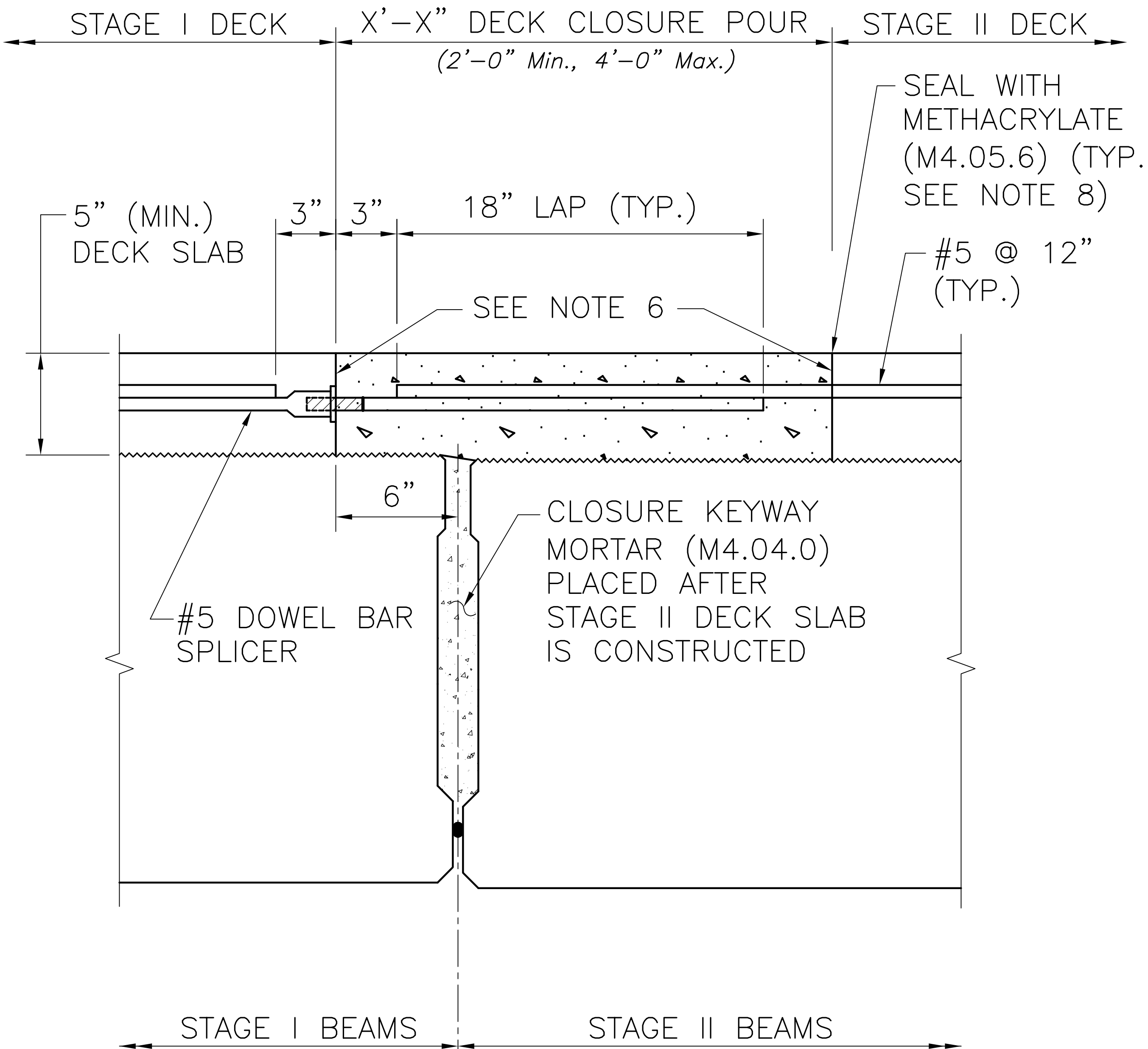
LAYOUT OF BEARINGS

SCALE: $\frac{1}{4}$" = 1'–0"

NOTE:

A = (Nominal Width of Beam)/4

MASS HIGHWAY BRIDGE MANUAL	TYPICAL LAYOUT OF BEARINGS PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.18**



NOTES:

(See Dwg. No. 4.2.20 for Notes to be included on the Construction Drawings)

STAGE CONSTRUCTION DETAIL

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	STAGE CONSTRUCTION DETAIL PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.19**

STAGE CONSTRUCTION NOTES:

1. AFTER ALL STAGE II BEAMS HAVE BEEN ERECTED, TENSION EACH STAGE II TRANSVERSE TIE TO 5 KIPS.

2. FILL ALL KEYWAYS BETWEEN STAGE II BEAMS WITH MORTAR (M4.04.0). IF THE KEYWAYS ARE NOT FILLED WITHIN FIVE (5) DAYS AFTER THE BEAMS HAVE BEEN ERECTED, THE CONTRACTOR SHALL COVER AND PROTECT THE KEYWAYS FROM WEATHER AND DEBRIS UNTIL THEY ARE FILLED.

3. AFTER THE MORTAR HAS CURED (24 HOURS MINIMUM), TENSION EACH TRANSVERSE TIE TO 44 KIPS.

4. CONCRETE FOR STAGE II DECK SLAB SHALL BE PLACED AFTER THE STAGE II TRANSVERSE TIES HAVE BEEN FULLY TENSIONED. DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

5. FILL CLOSURE KEYWAY BETWEEN STAGE I AND STAGE II BEAMS WITH MORTAR (M4.04.0).

6. VERTICAL SURFACES OF PREVIOUSLY CAST DECK SLAB CONCRETE SHALL BE PRE–WETTED FOR 24 HOURS IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS.

7. IMMEDIATELY PLACE AND CURE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE CLOSURE POUR.

8. AFTER END OF CURING PERIOD TOP OF DECK STAGE CONSTRUCTION JOINT SHALL BE SEALED IN ACCORDANCE WITH REQUIREMENTS FOR METHACRYLATE CRACK SEALING OF SECTION 901.73 OF STANDARD SPECIFICATIONS.

LOCATION	LEFT EDGE OF DECK SLAB	PROFILE GRADE LINE	CROWN LINE	RIGHT EDGE OF DECK SLAB
℄ BRGS. @ ABUT.				
MIDSPAN				
℄ BRGS. @ ABUT.				

NOTES:

1. THIS TABLE INDICATES THE THEORETICAL THICKNESS OF THE DECK SLAB IN INCHES BASED UPON ASSUMED BEAM CAMBERS AT ERECTION.

2. TABLE IS PROVIDED TO ASSIST IN ESTIMATING THE REQUIRED CONCRETE VOLUME.

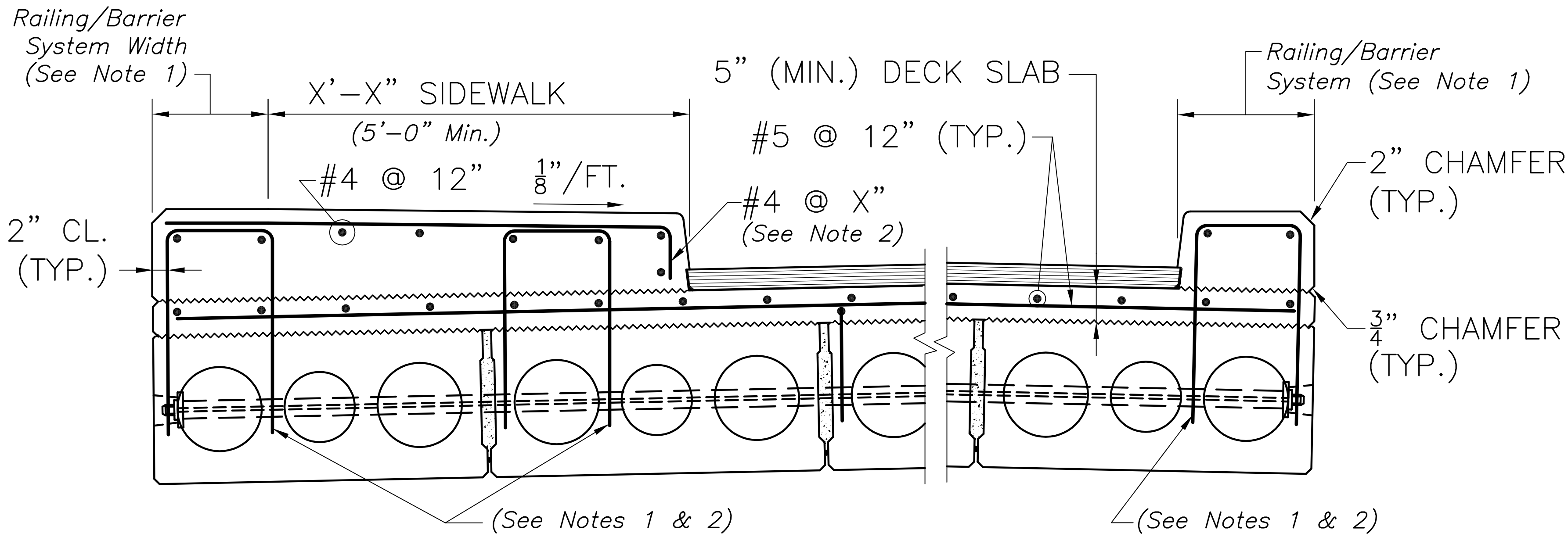
3. THE ACTUAL DECK THICKNESSES WILL BE AS REQUIRED TO MEET THE PROFILE GRADES.

THEORETICAL DECK SLAB THICKNESS TABLE

NOTES:

1. *Expand the table where required to include all spans.*
2. *Crown line dimensions need only be provided when they differ from the profile grade line.*

MASS HIGHWAY BRIDGE MANUAL	THEORETICAL DECK SLAB THICKNESS TABLE PRECAST CONCRETE DECK BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.2.21**



NOTES:

1. DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

2. SIDEWALK AND SAFETY CURB CONCRETE SHALL BE 5000 PSI, $\frac{3}{4}$ IN, 685 HP CEMENT CONCRETE.

SIDEWALK SECTION

SCALE: $\frac{1}{2}$" = 1'–0"

SAFETY CURB SECTION

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *See Chapter 9, Railing/Barrier System for sidewalk and safety curb dimensions, reinforcement and embedment lengths not shown. Modify the sections in Chapter 9 to show the beam arrangement and details shown above. Safety curb for S3–TL4 rail shown (width shall not be less than 19$\frac{1}{2}$" for S3–TL4 rail). Actual safety curb width depends on railling/barrier system chosen.*
2. *Spacing of sidewalk and safety curb dowels and transverse sidewalk and safety curb reinforcement shall be in multiples of the deck beam stirrup reinforcement.*
3. *Sidewalk slab may overhang the exterior beam by a maximum of 3" without altering the reinforcement shown. For overhangs greater than 3" use the details shown on Dwg. No.'s 4.3.5 and 9.3.5 and 9.3.6. Safety curb cannot overhang beam.*
4. *Provide paraffin joints in the sidewalk and safety curb.*

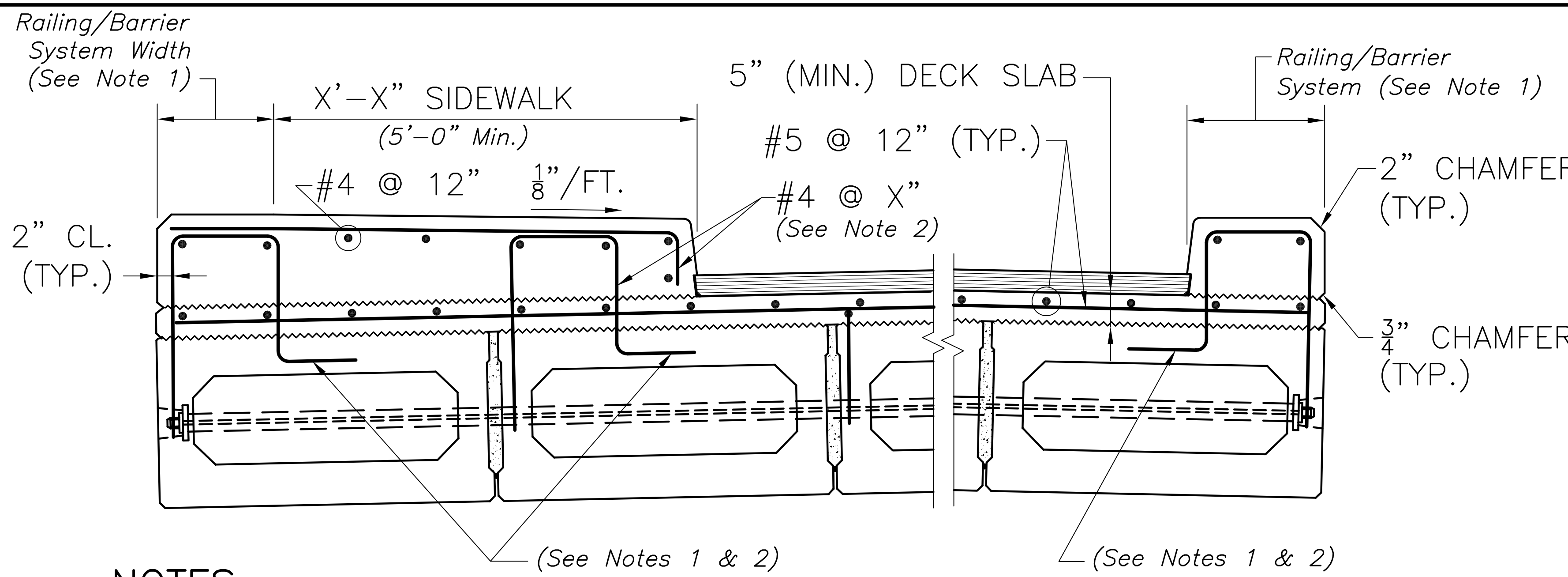
MASS HIGHWAY BRIDGE MANUAL

SIDEWALK & SAFETY CURB DETAILS FOR DECK BEAMS

SIDEWALK AND SAFETY CURB DETAILS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **4.3.1**



NOTES:

1. DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

2. SIDEWALK AND SAFETY CURB CONCRETE SHALL BE 5000 PSI, $\frac{3}{4}$ IN, 685 HP CEMENT CONCRETE.

SIDEWALK SECTION

SCALE: $\frac{1}{2}$" = 1'–0"

SAFETY CURB SECTION

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *See Chapter 9, Railing/Barrier System for sidewalk and safety curb dimensions, reinforcement and embedment lengths not shown. Modify the sections in Chapter 9 to show the beam arrangement and details shown above. Safety curb for S3–TL4 rail shown (width shall not be less than 19$\frac{1}{2}$" for S3–TL4 rail). Actual safety curb width depends on railing/barrier system chosen.*
2. *Spacing of sidewalk and safety curb dowels and transverse sidewalk and safety curb reinforcement shall be in multiples of the box beam stirrup reinforcement.*
3. *Sidewalk slab may overhang the exterior beam by a maximum of 3" without altering the reinforcement shown. For overhangs greater than 3" use the details shown on Dwg. No.'s 4.3.6 and 9.3.5 and 9.3.6. Safety curb cannot overhang beam.*
4. *Provide paraffin joints in the sidewalk and safety curb.*

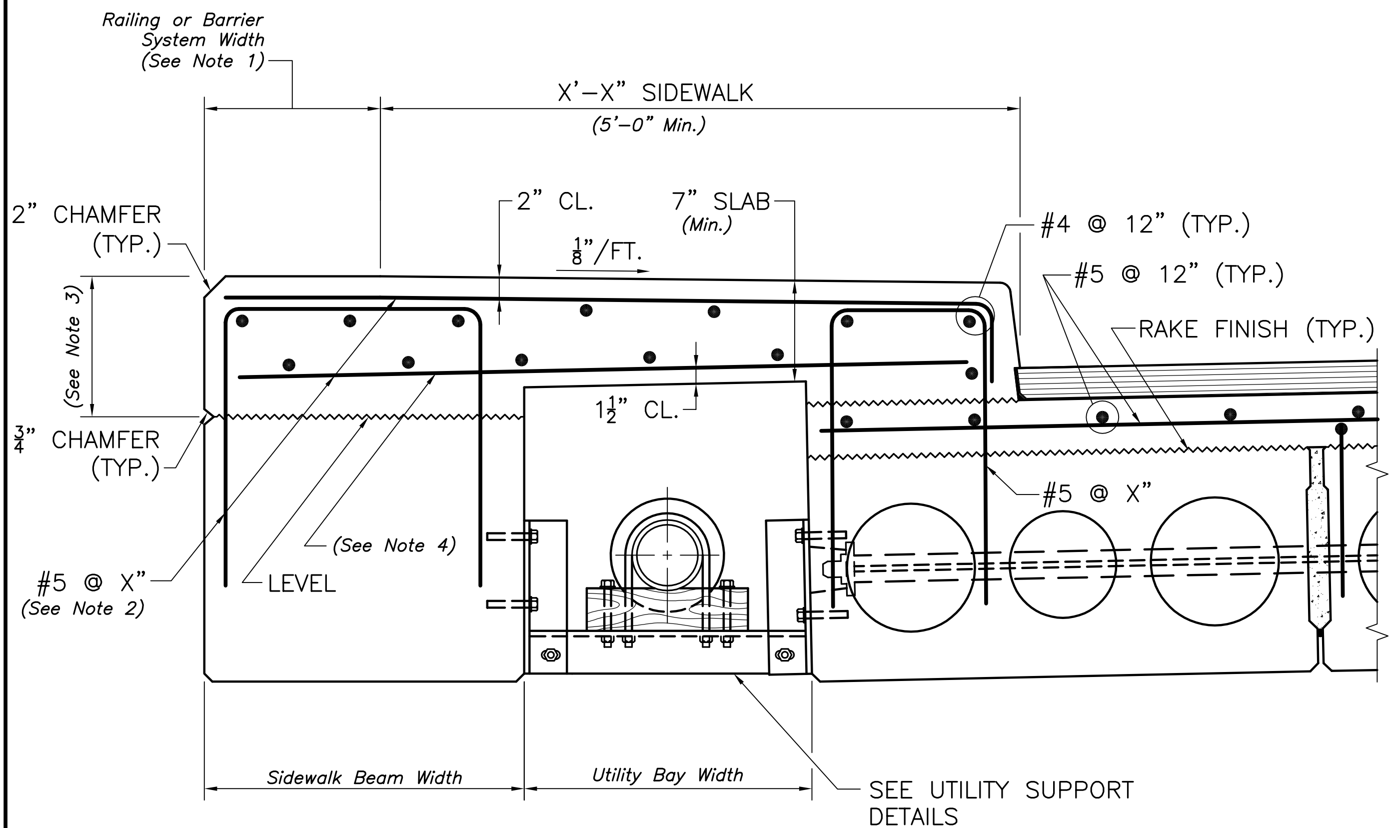
MASS HIGHWAY
BRIDGE MANUAL

SIDEWALK & SAFETY CURB DETAILS FOR BOX BEAMS

SIDEWALK AND SAFETY CURB DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.3.2



NOTES:

1. DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.
2. SIDEWALK AND SAFETY CURB CONCRETE SHALL BE 5000 PSI, $\frac{3}{4}$ IN, 685 HP CEMENT CONCRETE.

(18" DEEP AND 21" DEEP DECK BEAMS ONLY)

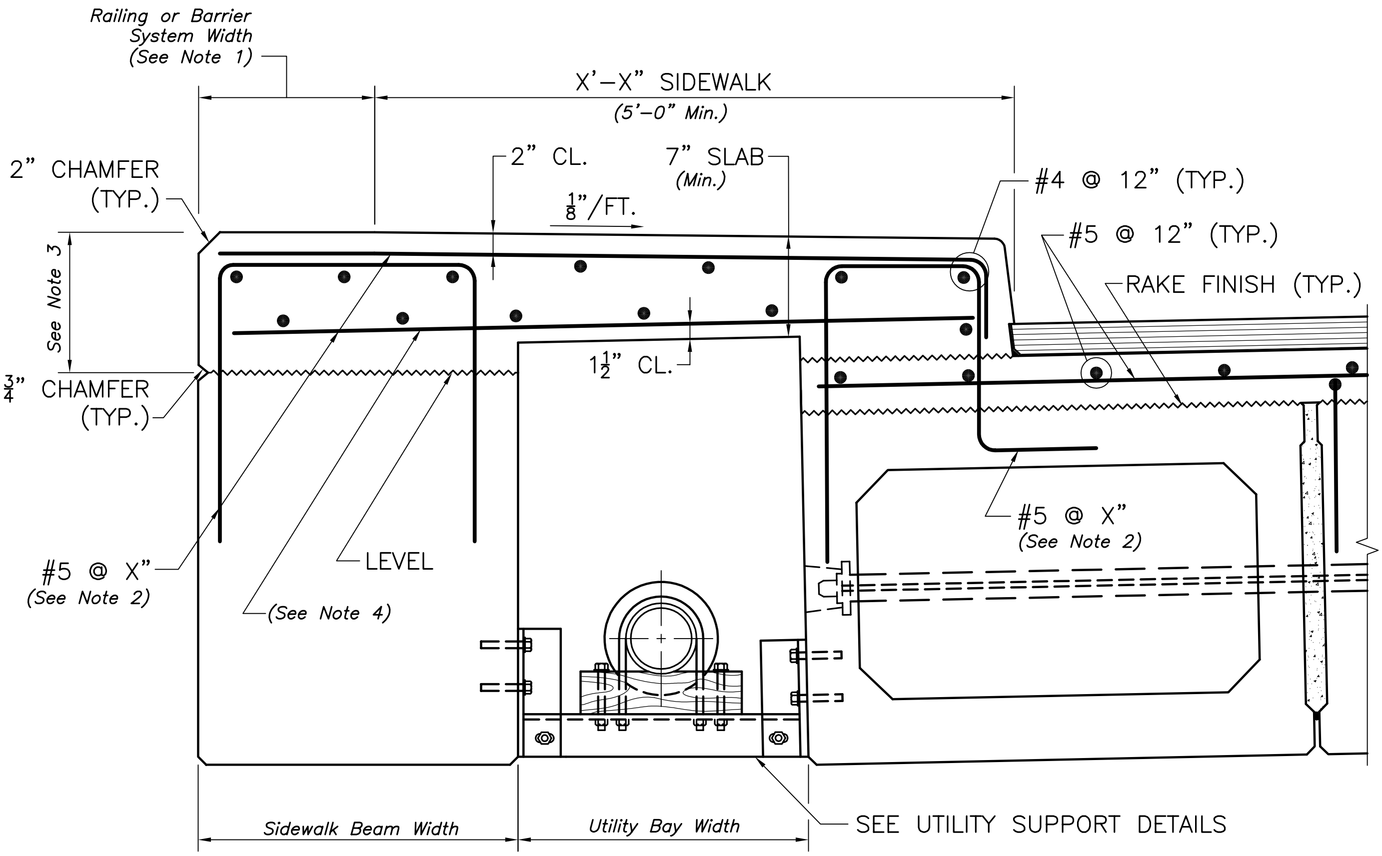
SIDEWALK SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Dimensions vary depending on railing or barrier used. Modify the sections in Chapter 9 to show the beam arrangement and details shown above.*
2. *Spacing of the sidewalk reinforcement shall be designed and it shall be spaced in multiples of beam stirrups.*
3. *Depth of slab over sidewalk beam must be sufficient to embed the bolts or develop the reinforcing of the railing or barrier system.*
4. *The development length of the slab reinforcement shall be labeled on both sides of the utility bay (15" Min.)*
5. *Do not provide paraffin joints in sidewalk.*
6. *For bridges with 12" and 15" deep beams, large utilities, and/or other restrictive features, use exterior utility supports shown on Dwg. No. 4.3.5.*

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK DETAIL W/UTILITY BAY FOR DECK BEAMS SIDEWALK AND SAFETY CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.3.3**



NOTES:

1. DECK SLAB SHALL BE 4000 PSI, 3/4 IN, 585 HP CEMENT CONCRETE.
2. SIDEWALK AND SAFETY CURB CONCRETE SHALL BE 5000 PSI, 3/4 IN, 685 HP CEMENT CONCRETE.

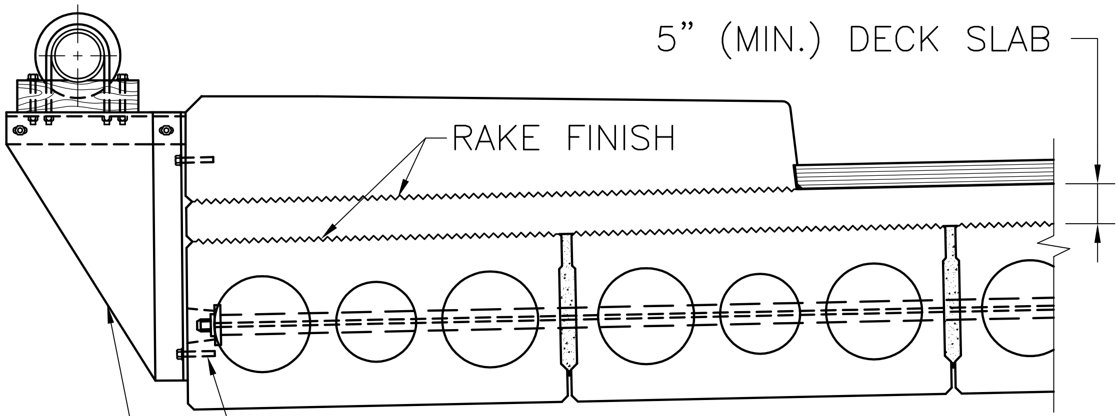
SIDEWALK SECTION

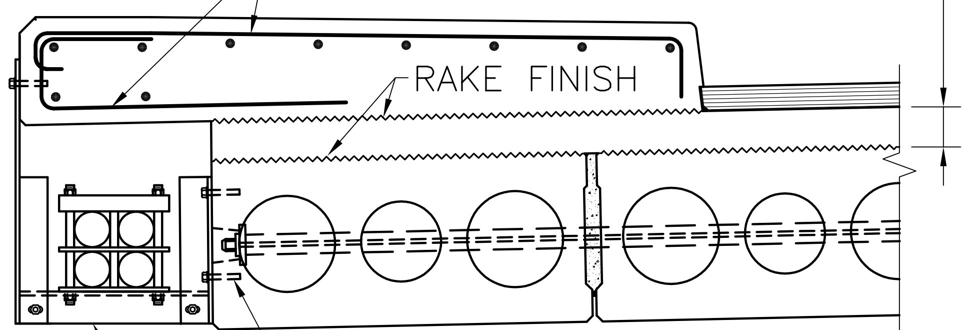
SCALE: 1" = 1'–0"

NOTES:

1. *Dimensions vary depending on railing or barrier system used. Modify the sections in Chapter 9 to show the beam arrangement and details shown above.*
2. *Spacing of the sidewalk reinforcement shall be designed and it shall be spaced in multiples of beam stirrups and top of beam slab reinforcement.*
3. *Depth of slab over sidewalk beam must be sufficient to embed the bolts or develop the reinforcing of the railing or barrier system.*
4. *The development length of the slab reinforcement shall be labeled on both sides of the utility bay (15" Min.)*
5. *Do not provide paraffin joints in sidewalk.*
6. *For bridges with large utilities and shallow beams, this detail may not be practical, in which case use exterior utility supports shown on Dwg. No. 4.3.6.*

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK DETAIL W/UTILITY BAY FOR BOX BEAMS SIDEWALK AND SAFETY CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.3.4**



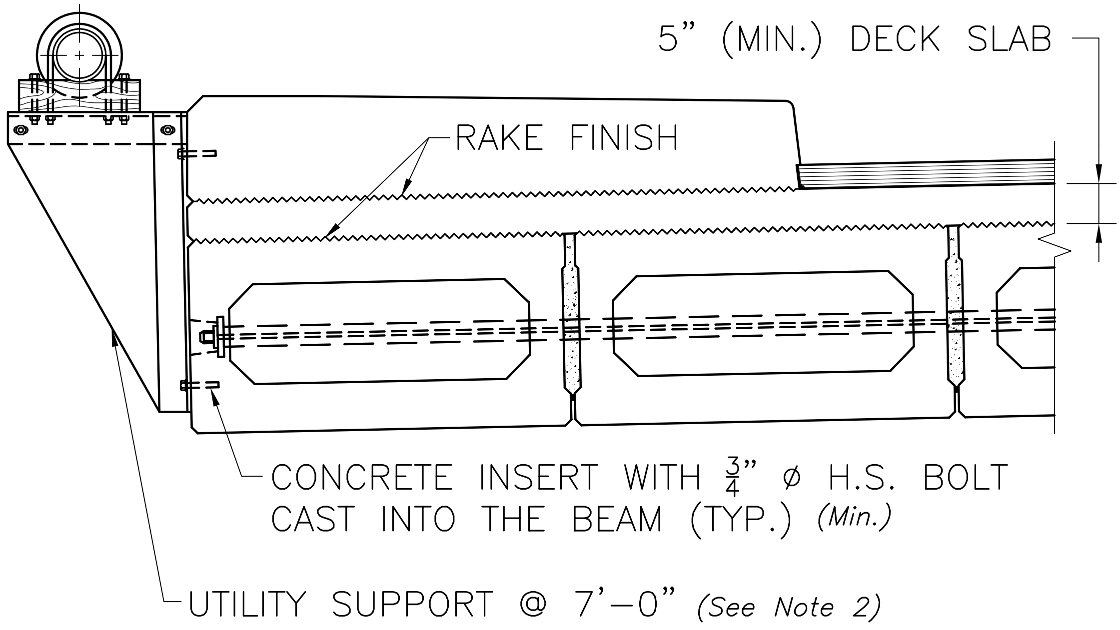


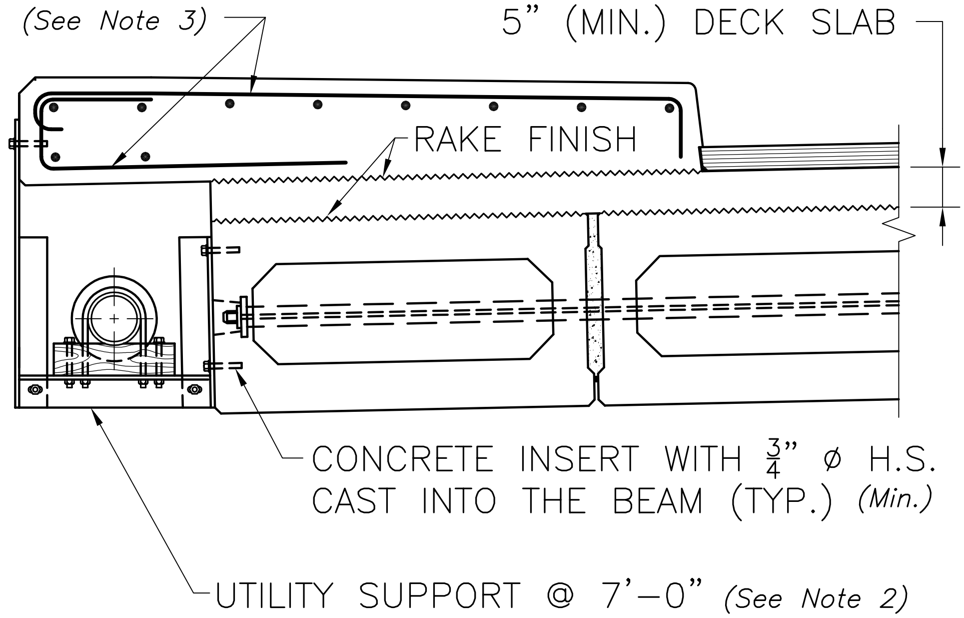
EXTERIOR UTILITY SUPPORTS FOR DECK BEAMS

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Incorporate the above details with the sidewalk details shown on Dwg. No. 4.3.1.*
2. *The Designer shall be responsible for the design of the utility supports and shall check the adequacy of the bolts and inserts. Inserts shall be spaced so that they do not interfere with strands or internal voids. The details of the utility support shall be shown on the Construction Drawings.*
3. *For reinforcement, see Chapter 9, Railing/Barrier Systems, overhanging sidewalk details.*



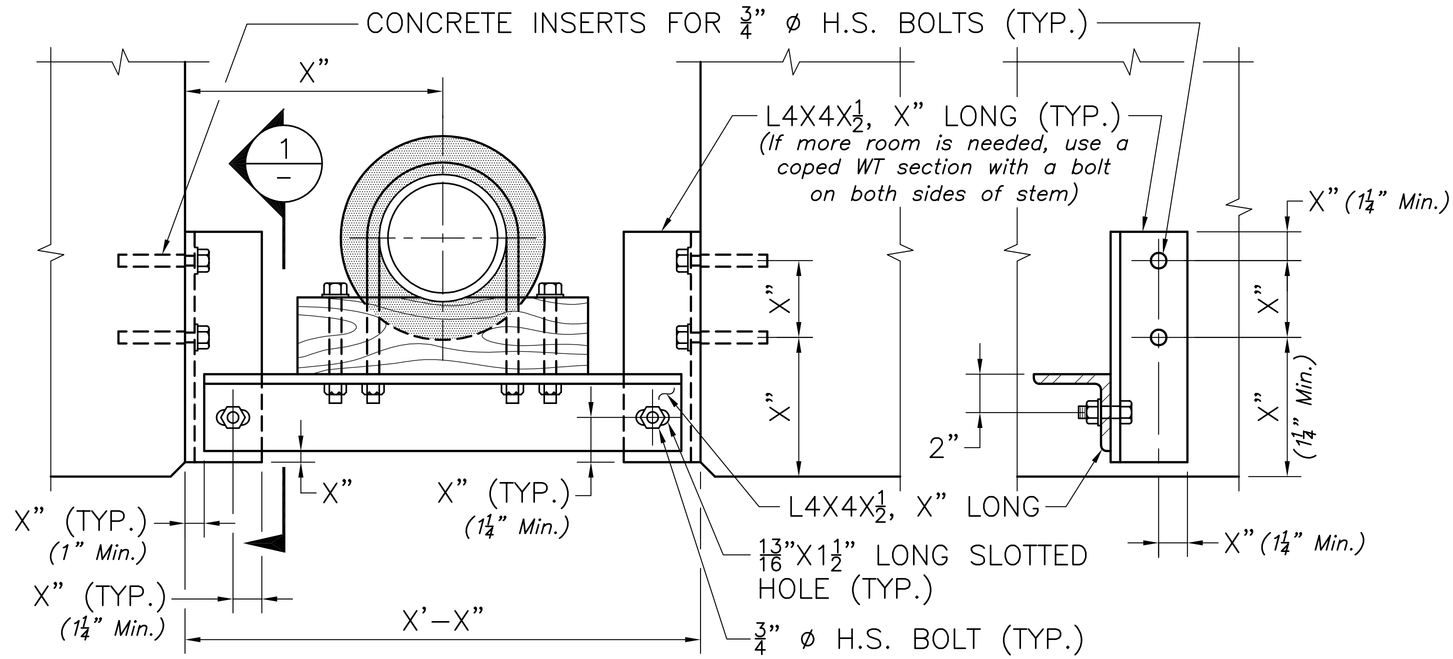


EXTERIOR UTILITY SUPPORTS FOR BOX BEAMS

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *Incorporate the above details with the sidewalk details shown on Dwg. No. 4.3.2.*
2. *The Designer shall be responsible for the design of the utility supports and shall check the adequacy of the bolts and inserts. Inserts shall be spaced so that they do not interfere with strands or internal voids. The details of the utility support shall be shown on the Construction Drawings.*
3. *For reinforcement, see Chapter 9, Railing/Barrier Systems, overhanging sidewalk details.*



ELEVATION

SECTION 1

NOTES:

1. ALL STRUCTURAL STEEL SHALL CONFORM TO AASHTO M 270 GRADE 36.
2. ALL STRUCTURAL STEEL AND FASTENERS SHALL BE GALVANIZED IN ACCORDANCE WITH AASHTO M 111 AND M 232.
3. INSERTS FOR $\frac{3}{4}$" ø BOLTS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THEY SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 1.1 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 4.1 KIPS IN 3000 PSI CONCRETE.

UTILITY SUPPORT DETAILS

SCALE: $1\frac{1}{2}$" = 1'–0"

NOTES:

1. *The limits of the utility support detailed above are: Maximum total utility weight is 250 plf; Maximum utility bay width is 4'–0"; Maximum support spacing is 10'–0". If any of these limits is exceeded, the Designer shall size the members accordingly.*
2. *Position the bolts such that they meet the standard edge distances and construction requirements and that the inserts do not interfere with strands and reinforcing bars.*

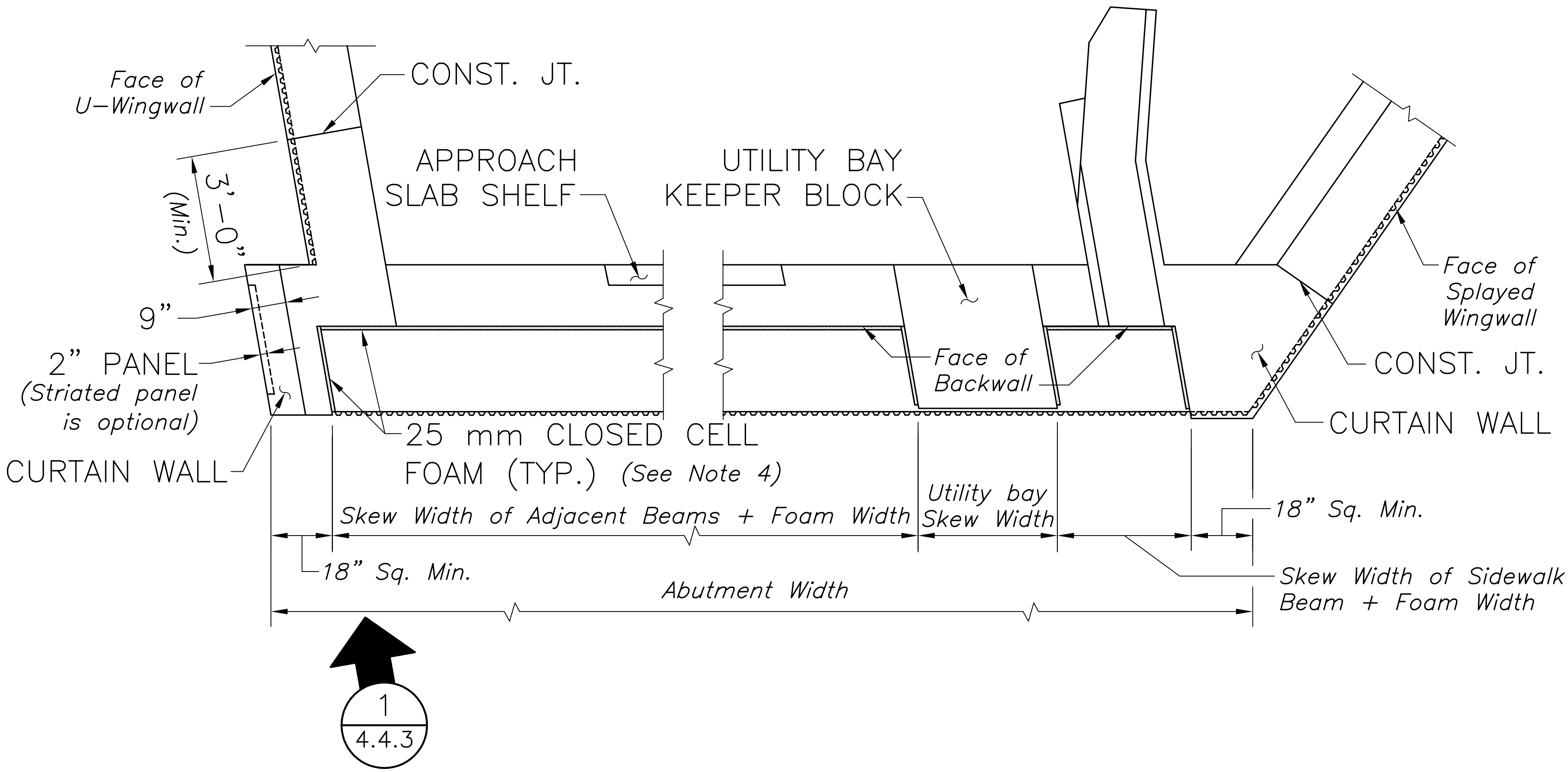
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL UTILITY SUPPORT DETAILS

SIDEWALK AND SAFETY CURB DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.3.7



BRIDGE WITHOUT UTILITY BAY
BRIDGE WITH U–WINGWALLS

BRIDGE WITH UTILITY BAY
BRIDGE WITH SPLAYED WINGWALLS

ABUTMENT PLAN

SCALE: ($\frac{1}{4}$" = 1'–0" Min.)

NOTES:

1. Utility bay details may be used with either U–wingwalls or splayed wingwalls.
2. Remainder of abutment has been omitted for clarity.
3. Abutment Plan shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant dimensions, angles, survey information and North Arrow.
4. The thickness of the closed cell foam may be increased as necessary to accommodate thermal expansion.

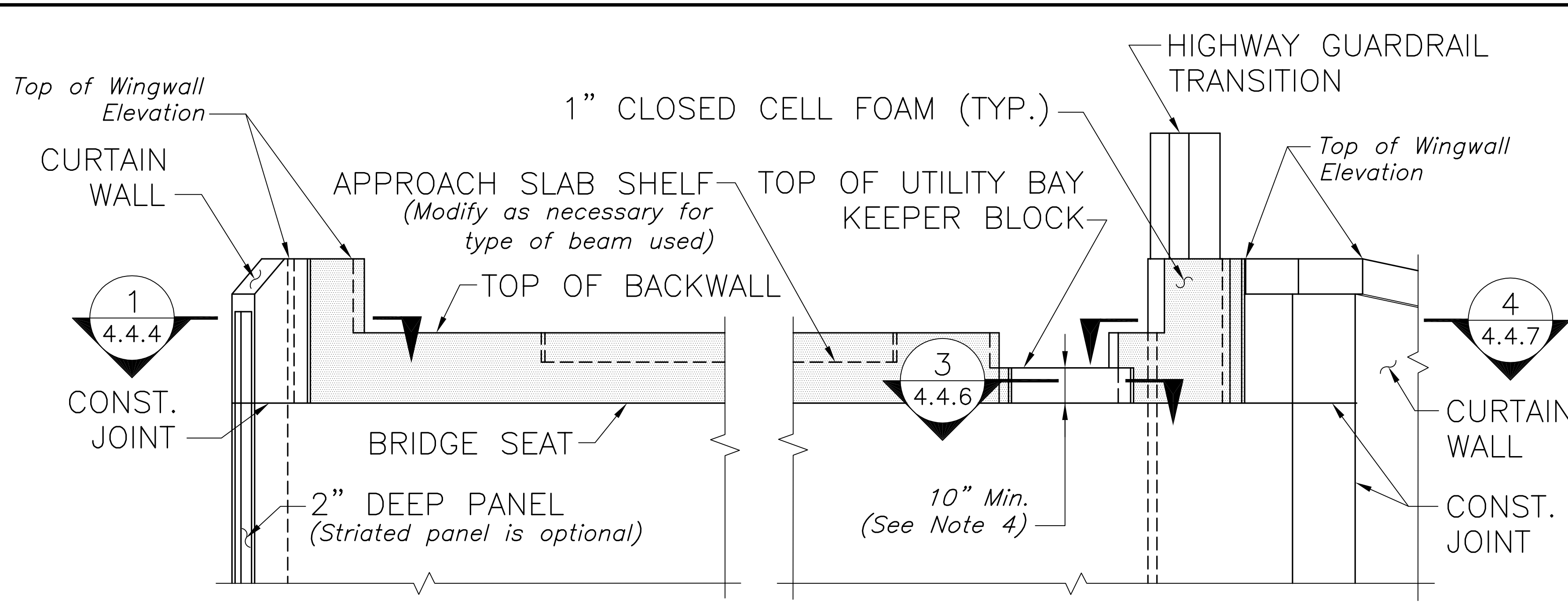
MASS HIGHWAY
BRIDGE MANUAL

ABUTMENT PLAN

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.4.1



BRIDGE WITHOUT UTILITY BAY
BRIDGE WITH U–WINGWALLS

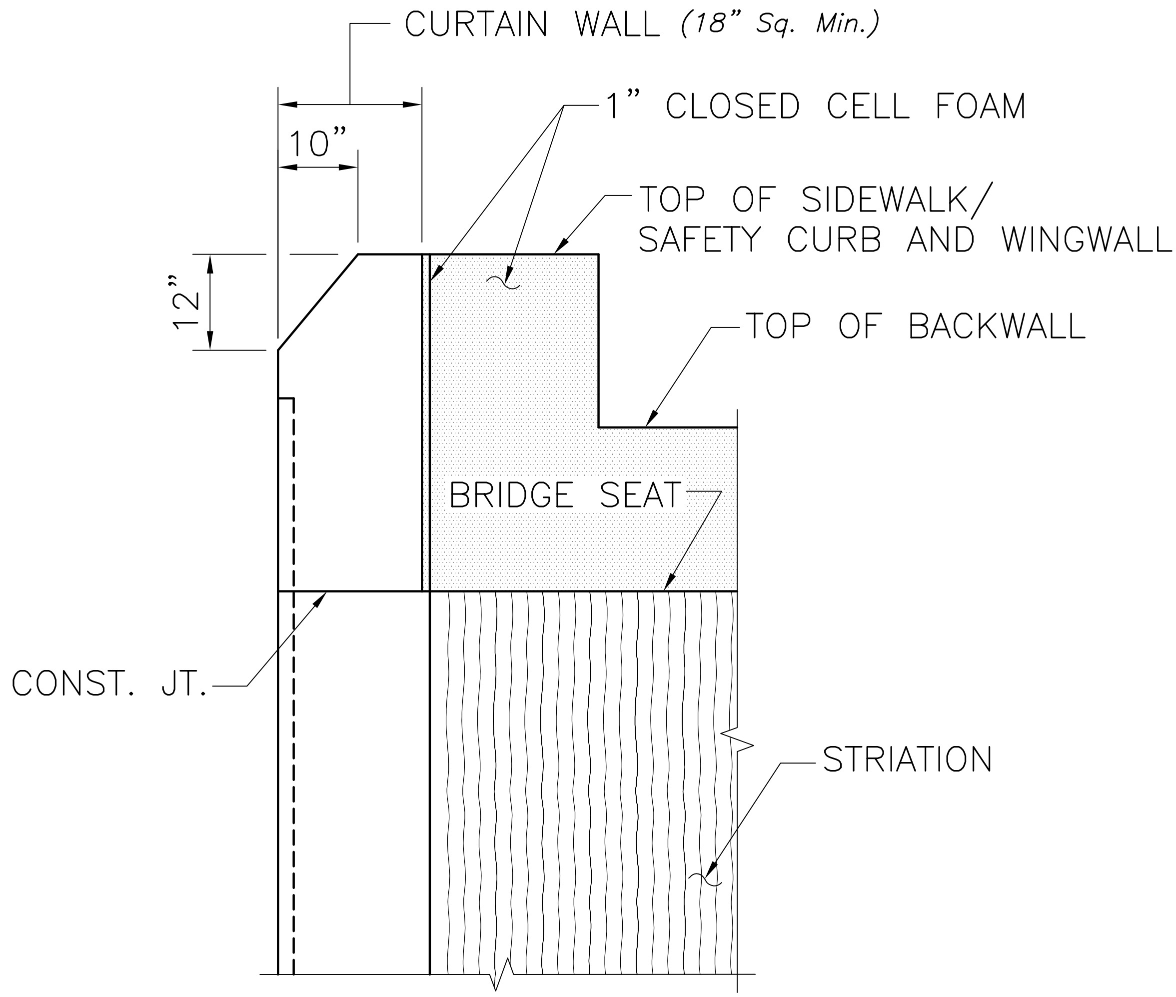
BRIDGE WITH UTILITY BAY
BRIDGE WITH SPLAYED WINGWALLS

ABUTMENT ELEVATION

SCALE: ($\frac{1}{4}$" = 1'–0" Min.)

NOTES:

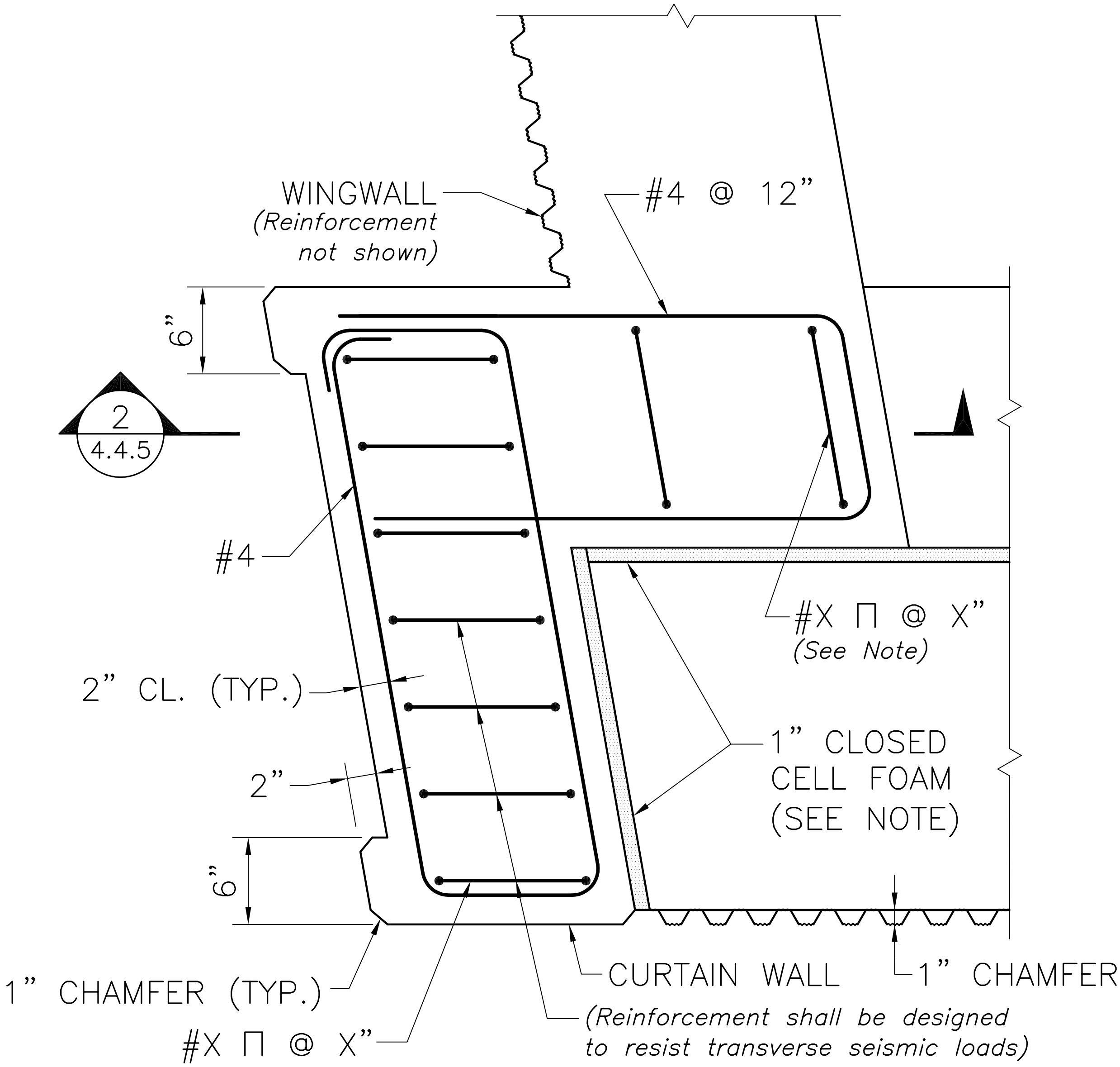
1. Utility bay details may be used with either U–wingwalls or splayed wingwalls.
2. Remainder of abutment has been omitted for clarity.
3. Abutment Elevation shall be drawn without breaks and to scale on the Construction Drawings.
4. If a 10" minimum height of the utility bay keeper block interferes with the placement of the utilities, the Designer shall design an alternate method to brace the beams laterally for seismic loads.
5. Striations are not shown for clarity, but shall be shown on the Construction Drawings.



VIEW 1

SCALE: $\frac{1}{2}$" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	DETAIL AT U-WINGWALL CORNER ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.3**



NOTE:

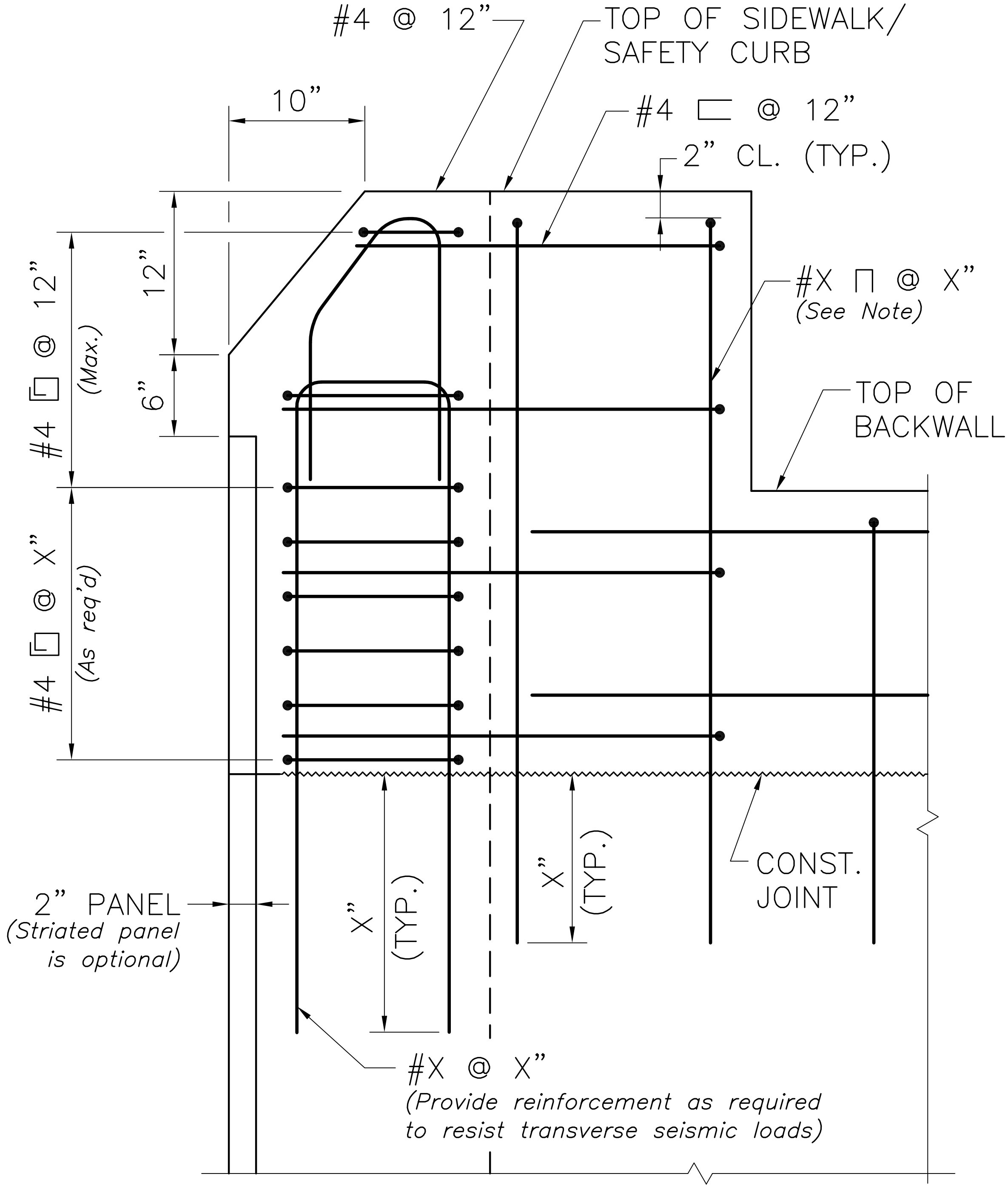
ATTACH CLOSED CELL FOAM TO THE BACK AND SIDE OF THE EXTERIOR PRECAST BEAM PRIOR TO PLACING THE CONCRETE FOR THE BACKWALL AND CURTAIN WALL.

SECTION 1

SCALE: 1" = 1'-0"

NOTE:
Backwall reinforcement extending into the top of abutment shall be designed to resist longitudinal seismic loads. At a minimum, provide #5 @ 12".

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION AT ABUTMENT END U-WINGWALLS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.4**



NOTE:

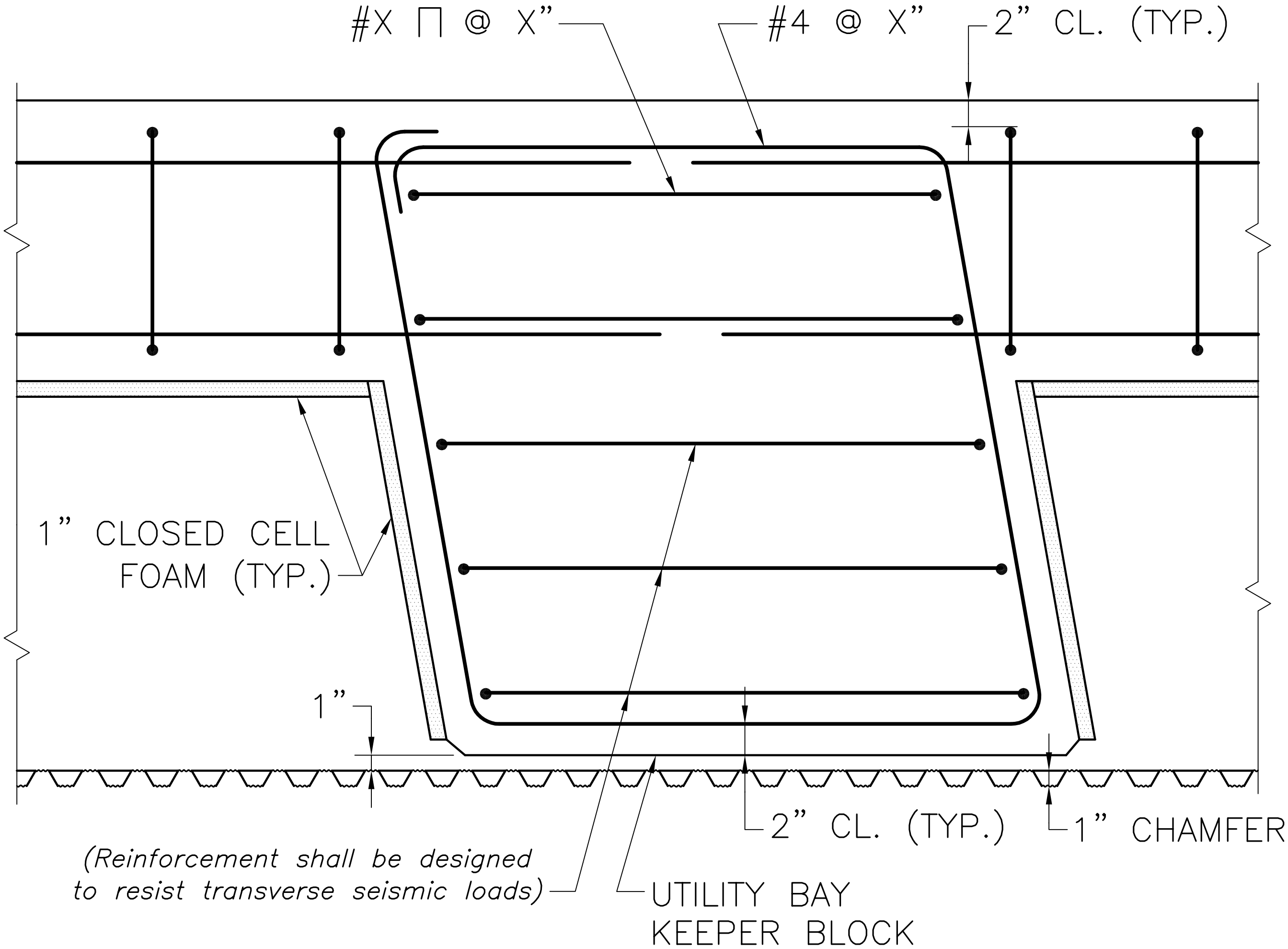
REINFORCEMENT BELOW CONSTRUCTION JOINT HAS BEEN OMITTED FOR CLARITY.

SECTION 2

SCALE: 1" = 1'-0"

NOTE:
Backwall reinforcement extending into the top of abutment shall be designed to resist longitudinal seismic loads. At a minimum, provide #5 @ 12".

MASS HIGHWAY BRIDGE MANUAL	SECTION AT ABUTMENT END U-WINGWALLS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.5**



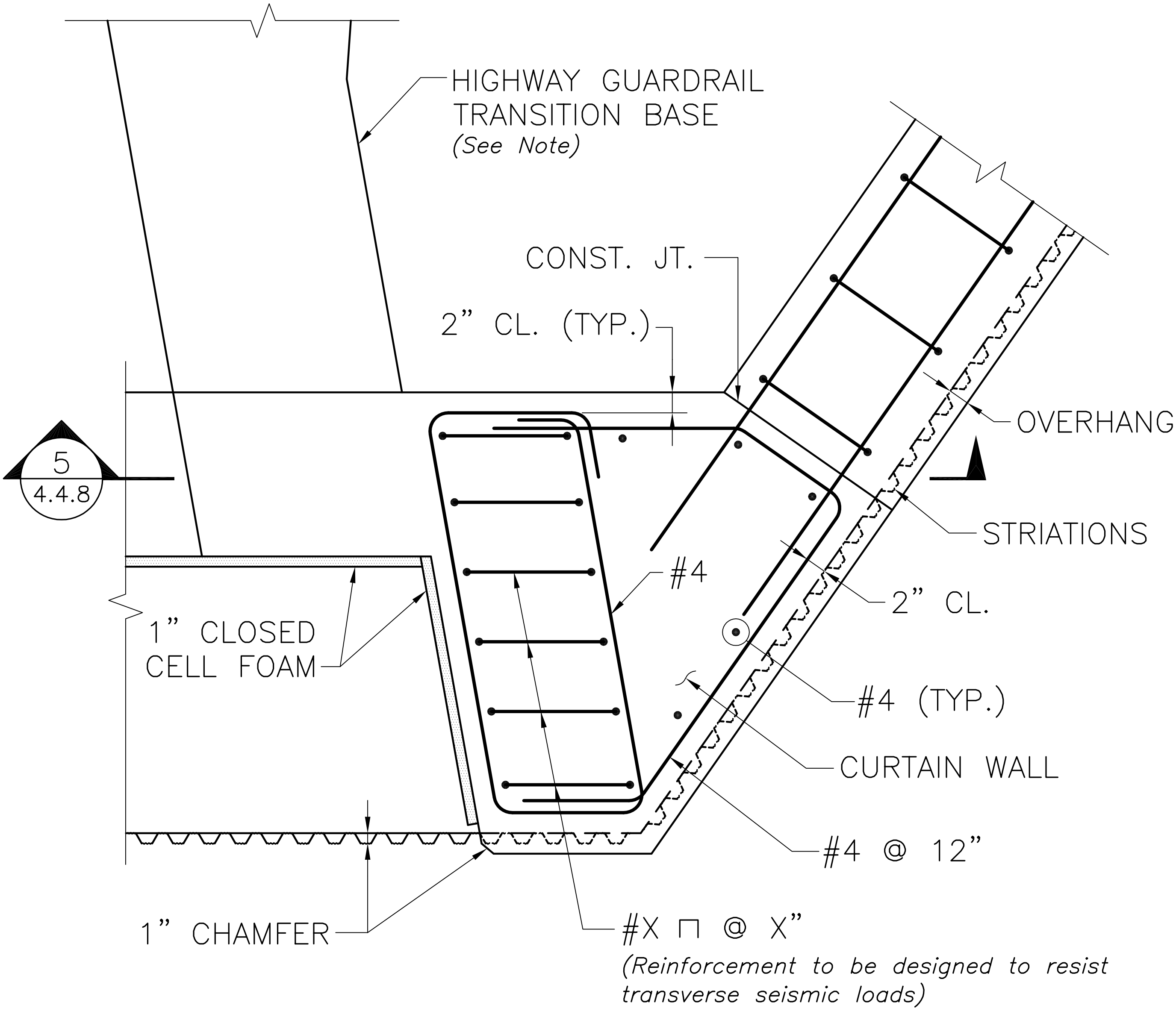
NOTE:

ATTACH CLOSED CELL FOAM TO THE BACK AND SIDE OF THE PRECAST BEAMS PRIOR TO PLACING THE CONCRETE FOR THE BACKWALL AND UTILITY BAY KEEPER BLOCK.

SECTION 3

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION AT UTILITY BAY KEEPER BLOCK ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 4.4.6



NOTE:

ATTACH CLOSED CELL FOAM TO THE BACK AND SIDE OF THE EXTERIOR PRECAST BEAM PRIOR TO PLACING THE CONCRETE FOR THE BACKWALL AND CURTAIN WALL.

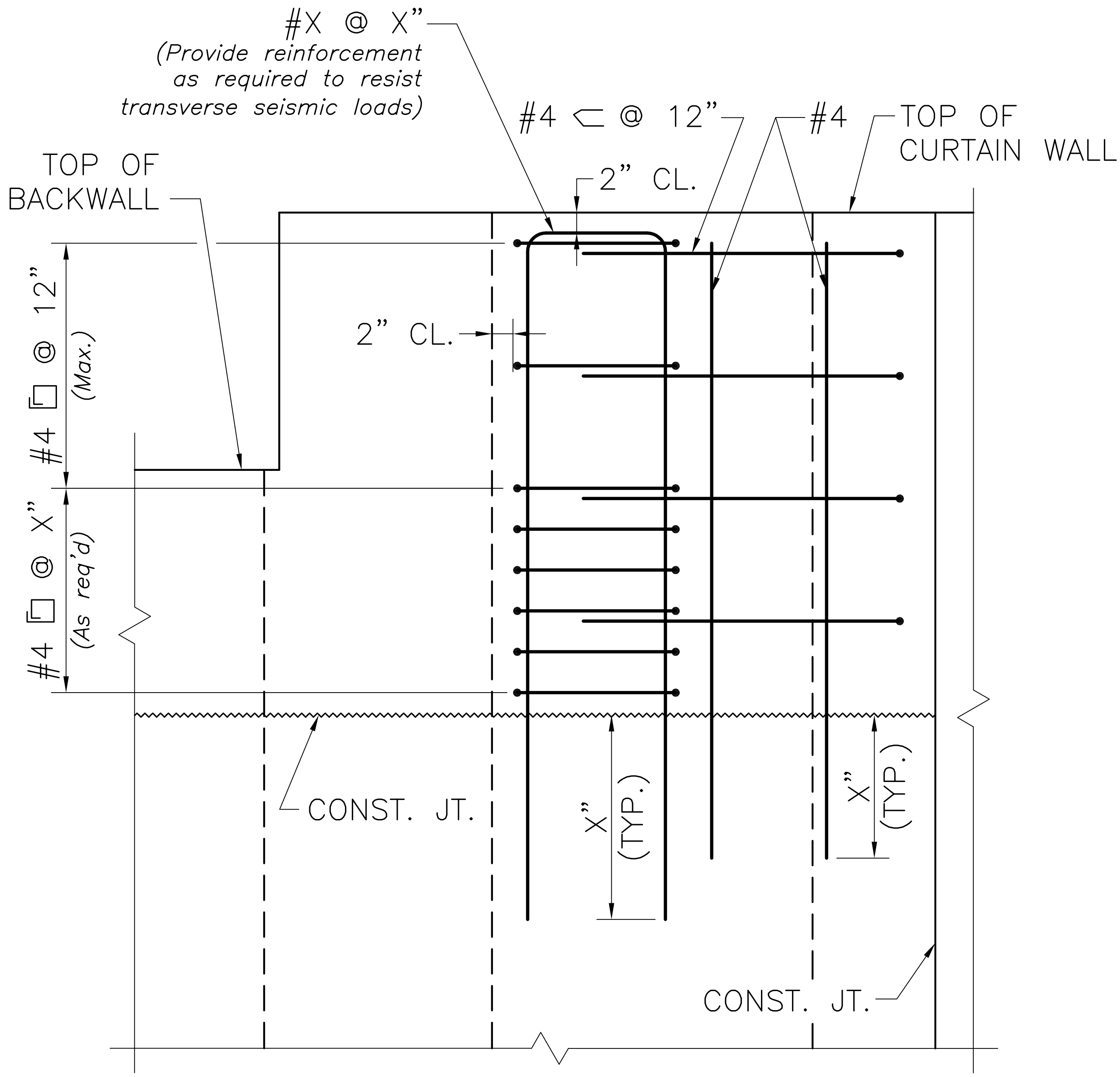
SECTION 4

SCALE: $\frac{3}{4}$"= 1'–0"

NOTE:

For Highway Guardrail Transition Base details see Dwg. No.'s 3.2.14 thru 3.2.17. The dimension and reinforcement details of Dwg. No. 3.2.17 may be combined with this drawing.

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION AT ABUTMENT END SPLAYED WINGWALLS	DATE OF ISSUE MAY 2005
	ABUTMENT DETAILS	DRAWING NUMBER **4.4.7**



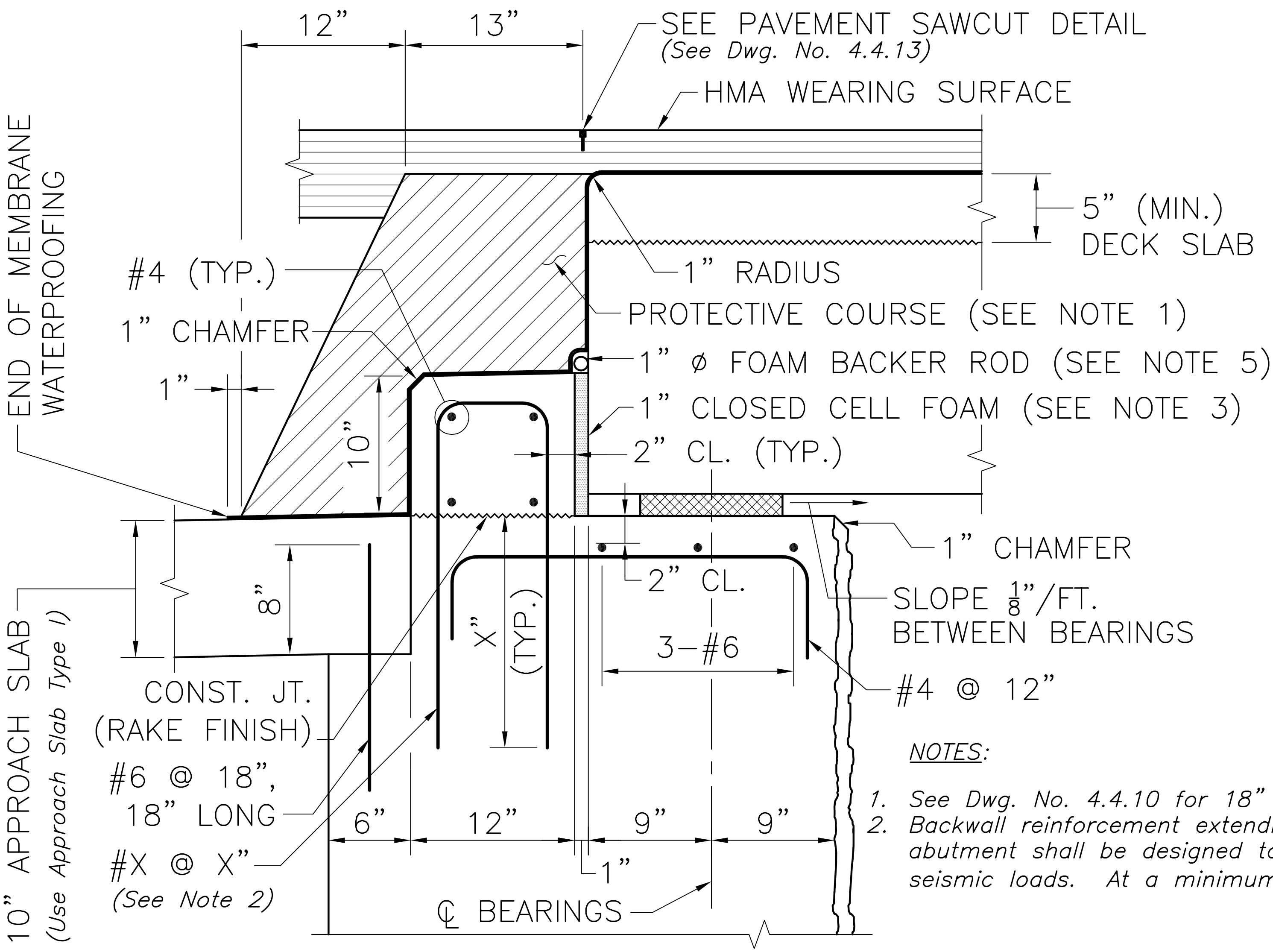
NOTE:

REINFORCEMENT BELOW HORIZONTAL CONSTRUCTION JOINT HAS BEEN OMITTED FOR CLARITY.

SECTION 5

SCALE: $\frac{3}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SECTION AT ABUTMENT END SPLAYED WINGWALLS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 4.4.8



NOTES:

1. See Dwg. No. 4.4.10 for 18" and 21" deep Beams.
2. Backwall reinforcement extending into the top of abutment shall be designed to resist longitudinal seismic loads. At a minimum, provide #5 @ 12".

NOTES:

(See Dwg. No. 4.4.12 for Notes to be included on Construction Drawings)

DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL

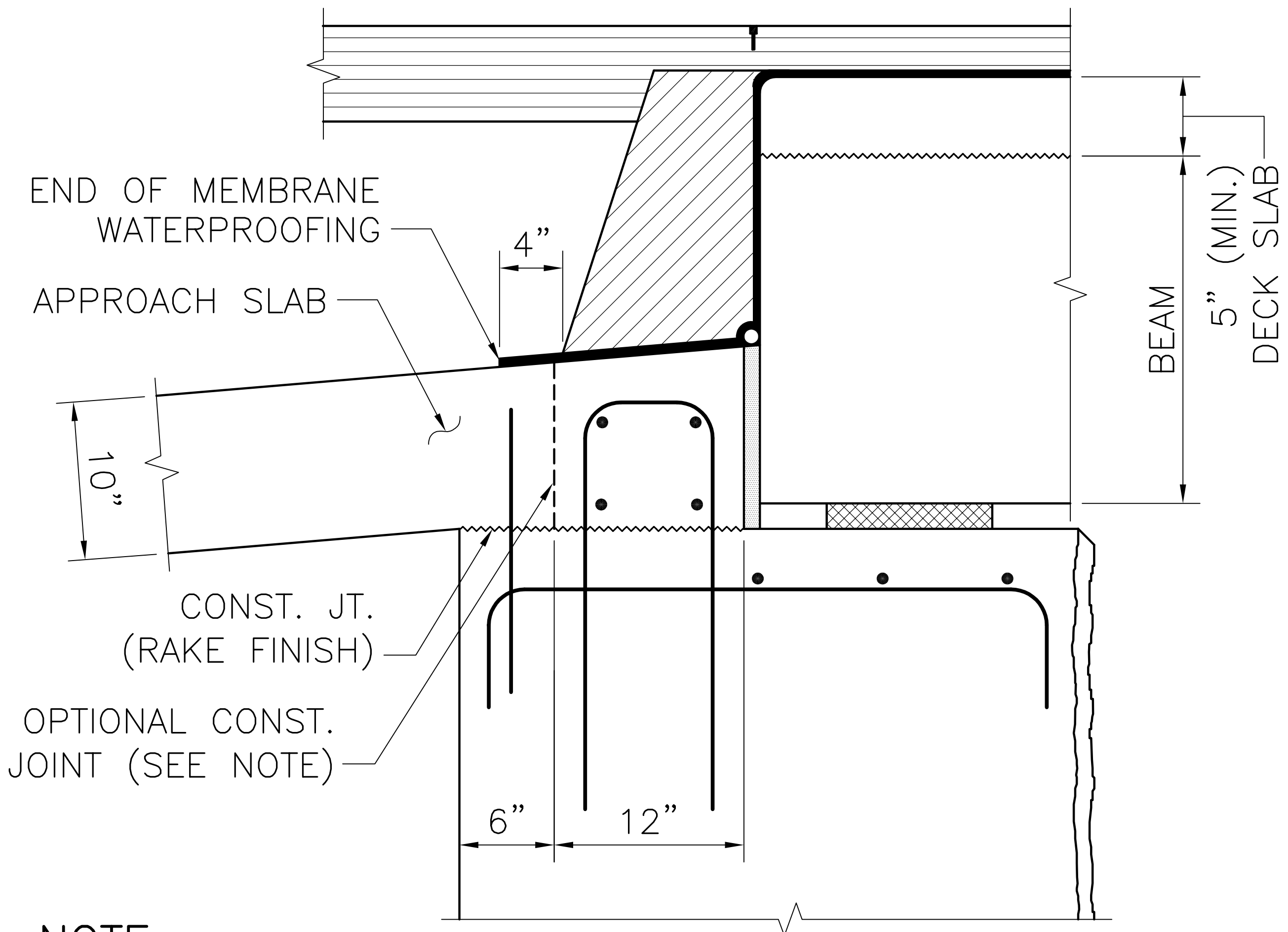
ROADWAY SECTION FOR 12" & 15" DEEP DECK BEAMS

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.4.9

MODIFICATIONS FOR 18" AND 21" DEEP DECK BEAMS:



NOTE:

IF THE APPROACH SLAB IS POURED MONOLITHICALLY WITH THE BACKWALLS, MAKE A 2" DEEP BY $\frac{1}{8}$" WIDE SAWCUT IN THE TOP OF THE SLAB AT THE OPTIONAL CONSTRUCTION JOINT LOCATION. FILL SAWCUT WITH CONCRETE JOINT SEALER.

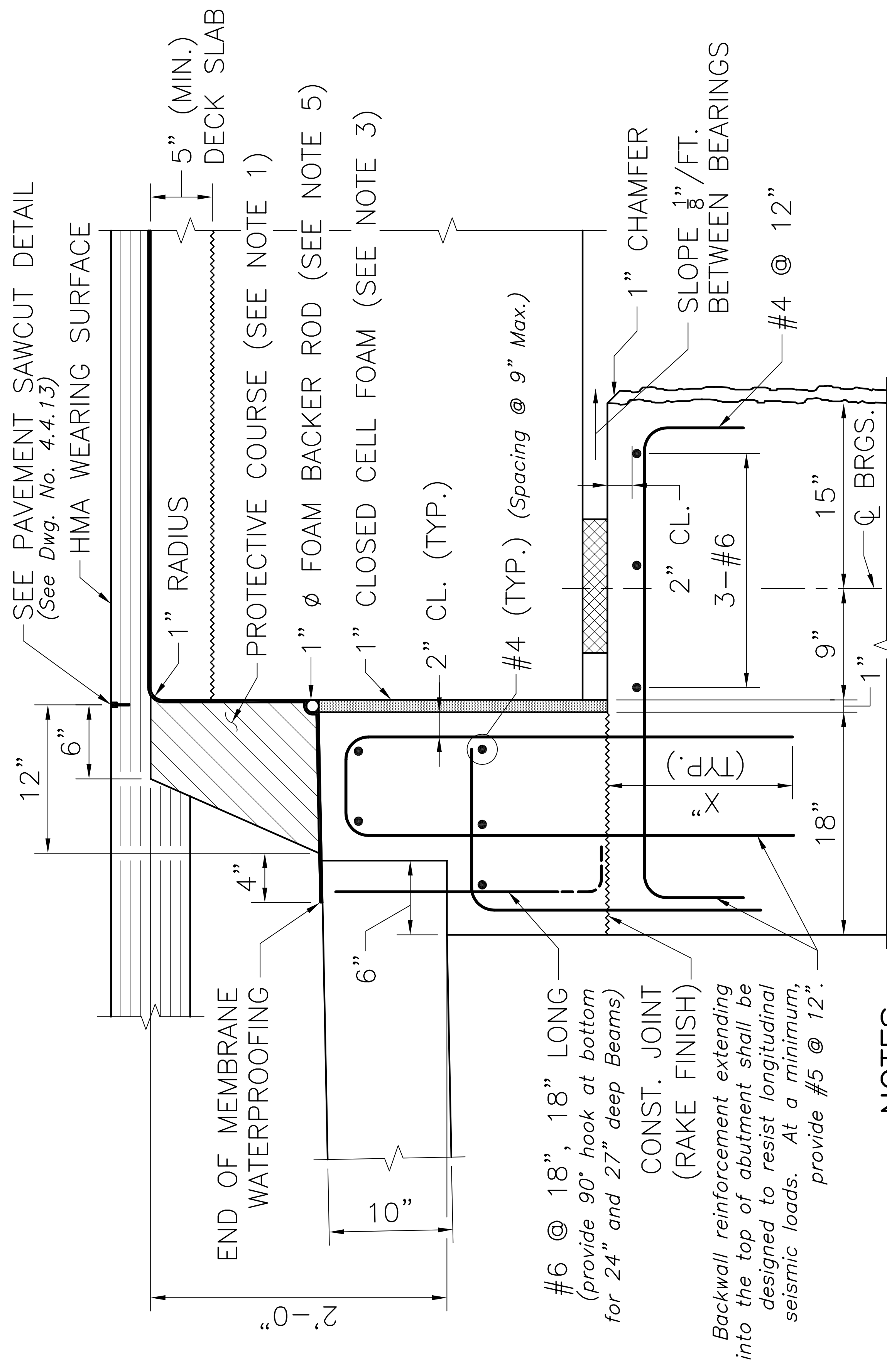
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTE:

For 18" and 21" deep Beams, modify Dwg. No. 4.4.9 to the reinforcing and construction joint details shown above. Add the note above to the Construction Notes. All other items not detailed or designated above shall be as shown on Dwg. No. 4.4.9.

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION FOR 18" & 21" DEEP DECK BEAMS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.10**



NOTES:

(See Dwg. No. 4.4.12 for Notes to be included on Construction Drawings)

DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION BOX BEAMS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.11**

NOTES: *(Include these Notes with details shown on Dwg. No.'s 4.4.9, 4.4.11, and 4.4.14.)*

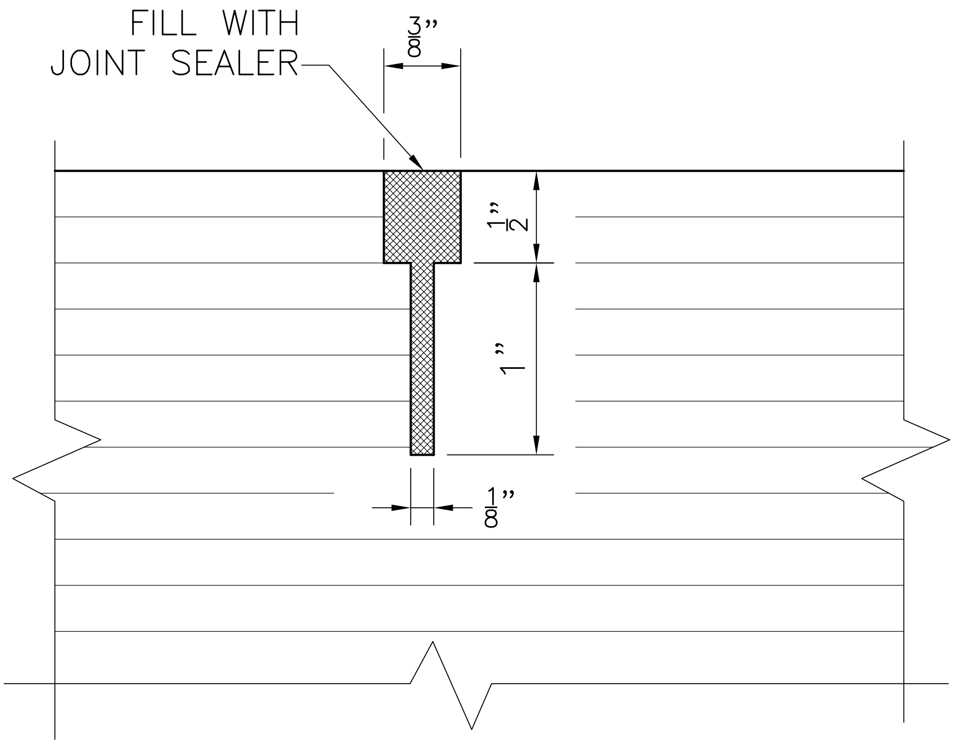
1. PROTECTIVE COURSE TO BE CLASS I DENSE BINDER COURSE FOR BRIDGES, PLACED IN 2" LAYERS AND COMPACTED WITH A MECHANICAL HAND–GUIDED TAMPER WITHIN 12 HOURS AFTER PLACING MEMBRANE WATERPROOFING.

2. ALL REINFORCING SHOWN IN THIS DETAIL SHALL BE COATED BARS, EXCEPT FOR APPROACH SLAB REINFORCEMENT.

3. ATTACH CLOSED CELL FOAM TO BACK OF PRECAST BEAM WITH ADHESIVE.

4. ALL KEEPER BLOCK AND BACKWALL CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE AND SHALL BE PLACED AFTER ALL BEAMS HAVE BEEN ERECTED.

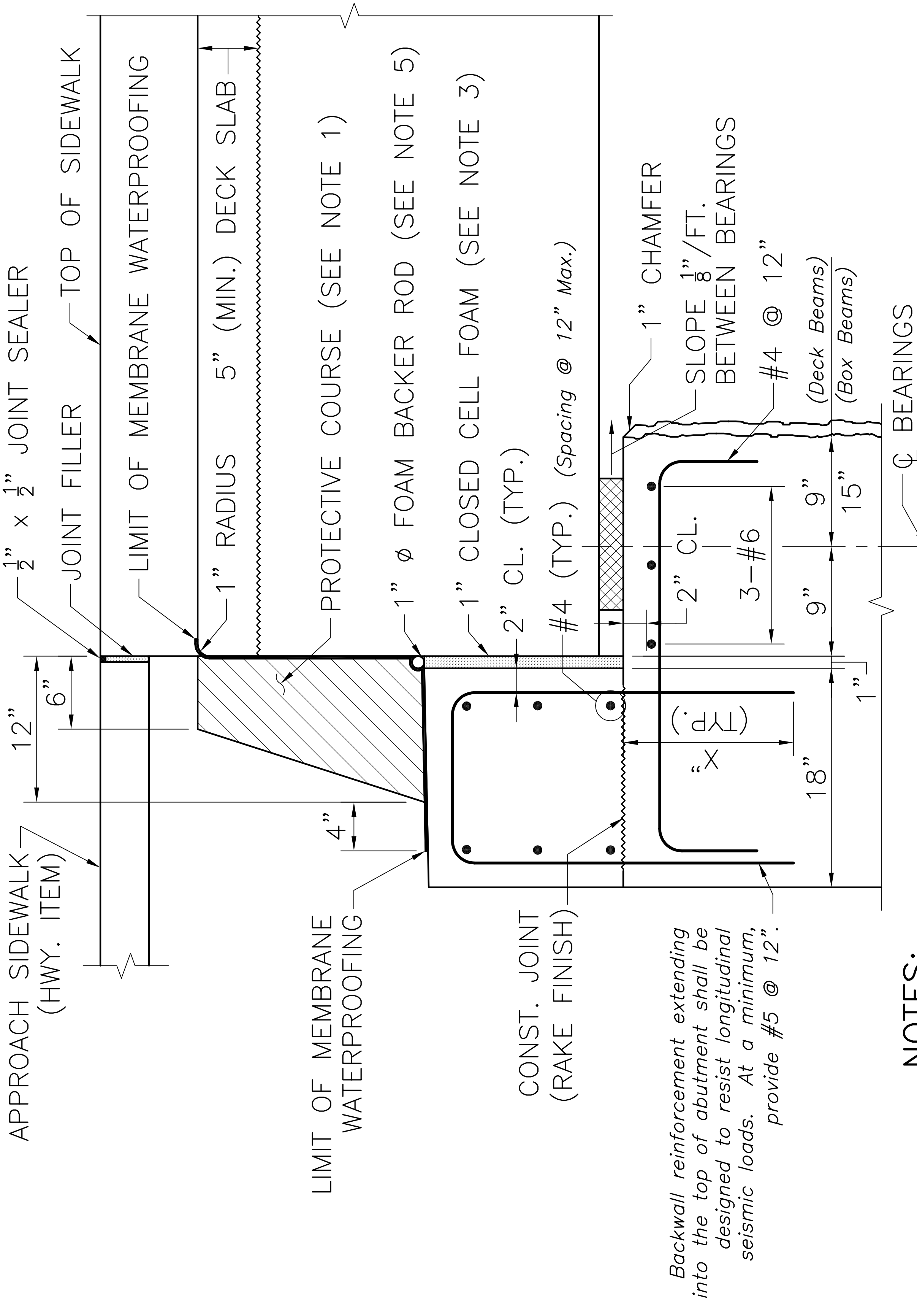
5. DRAPE MEMBRANE WATERPROOFING OVER CLOSED CELL FOAM BACKER ROD.



PAVEMENT SAWCUT DETAIL

FULL SIZE

MASS HIGHWAY BRIDGE MANUAL	PAVEMENT SAWCUT DETAIL	DATE OF ISSUE MAY 2005
	ABUTMENT DETAILS	DRAWING NUMBER **4.4.13**



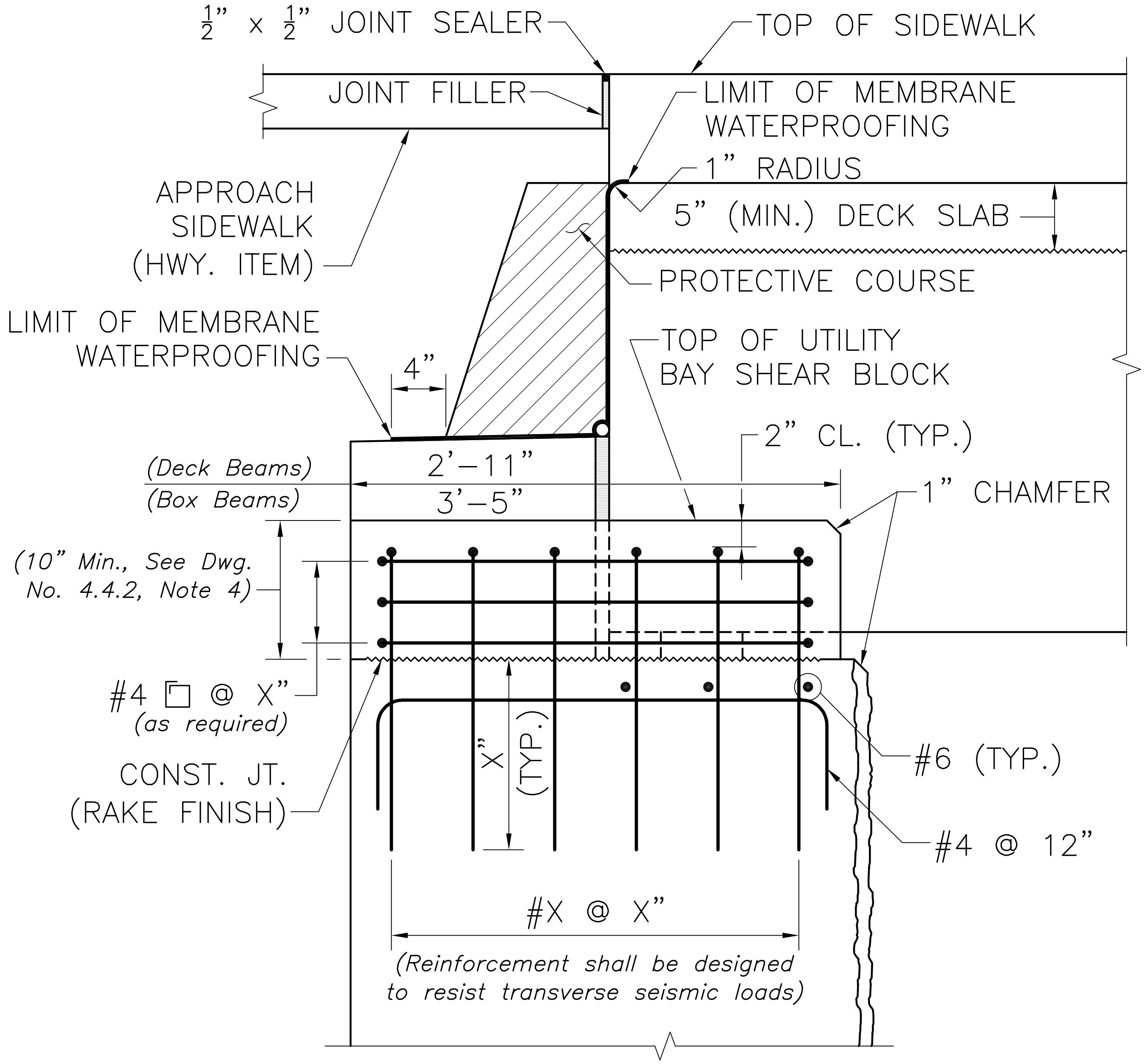
NOTES:

(See Dwg. No. 4.4.12 for Notes to be included on Construction Drawingss, modify as necessary)

DETAILS AT ABUTMENT – SIDEWALK SECTION

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK SECTION DECK AND BOX BEAMS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.14**



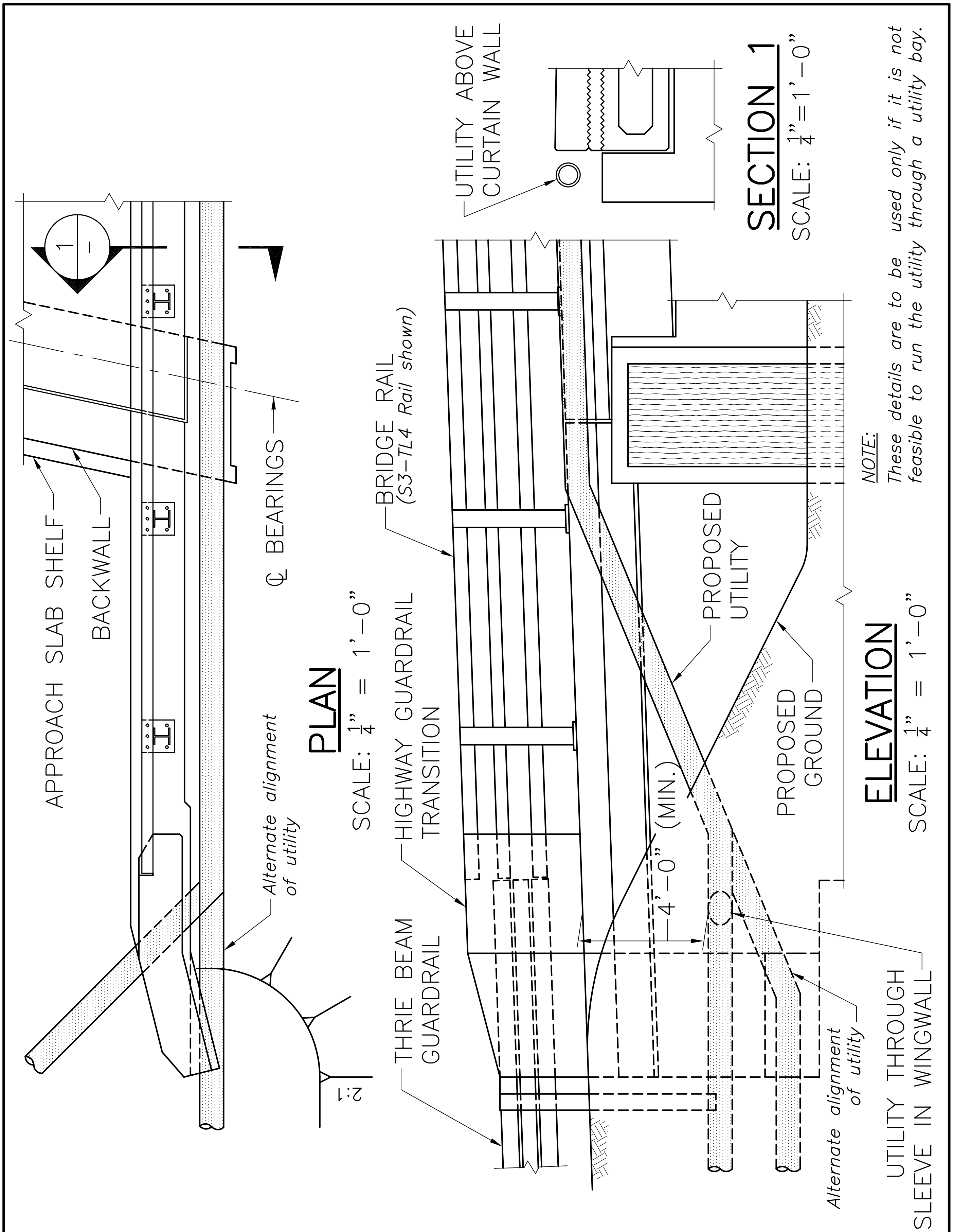
NOTES:

1. BRICK–UP AROUND UTILITIES AFTER BEAMS ARE IN PLACE AND AFTER THE BACKWALL AND THE UTILITY BAY SHEAR BLOCK HAVE BEEN CONSTRUCTED.
2. UTILITIES ARE NOT SHOWN FOR CLARITY. *(Designer shall verify proper fit)*

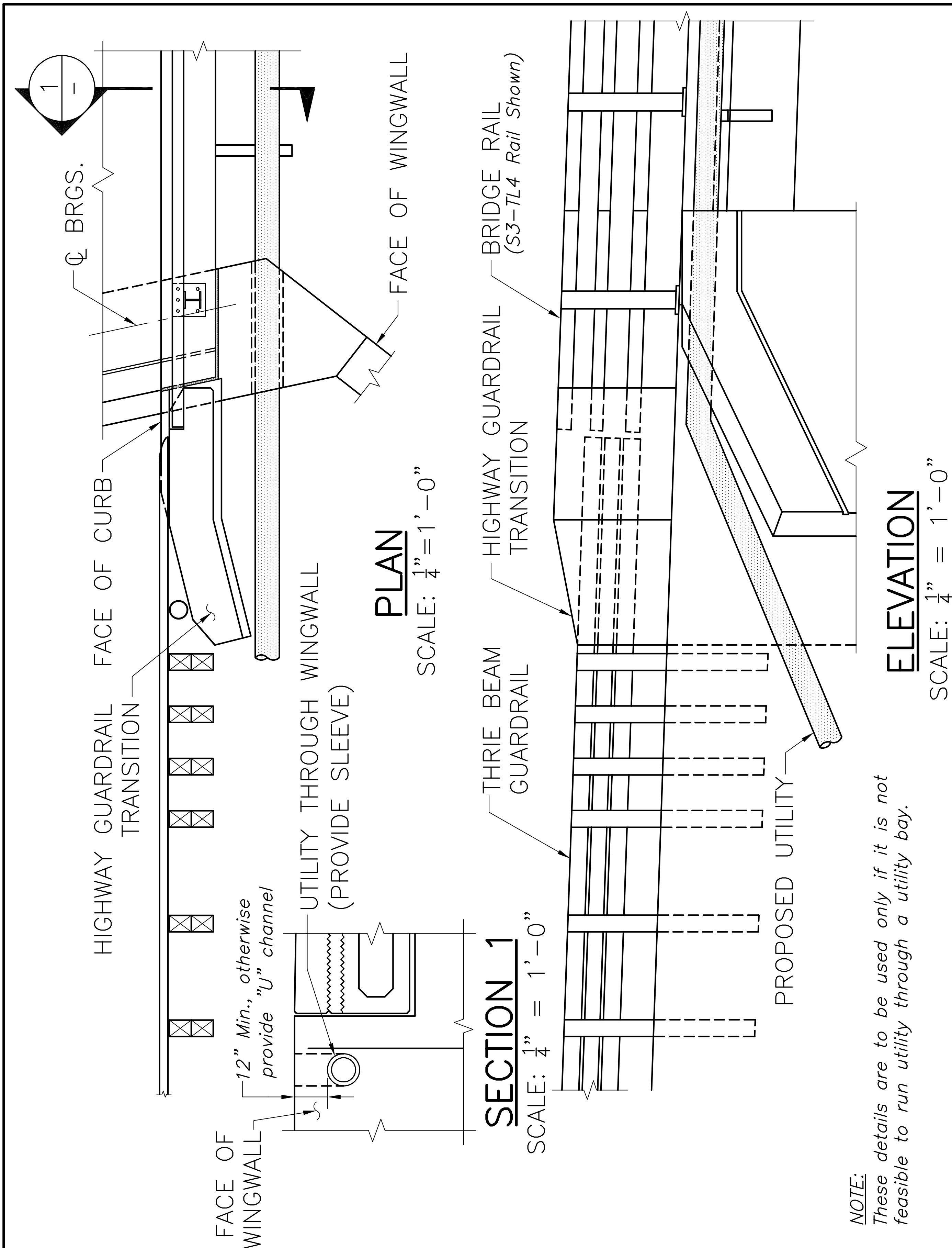
DETAILS AT ABUTMENT – UTILITY BAY SECTION

SCALE: 1" = 1'–0"

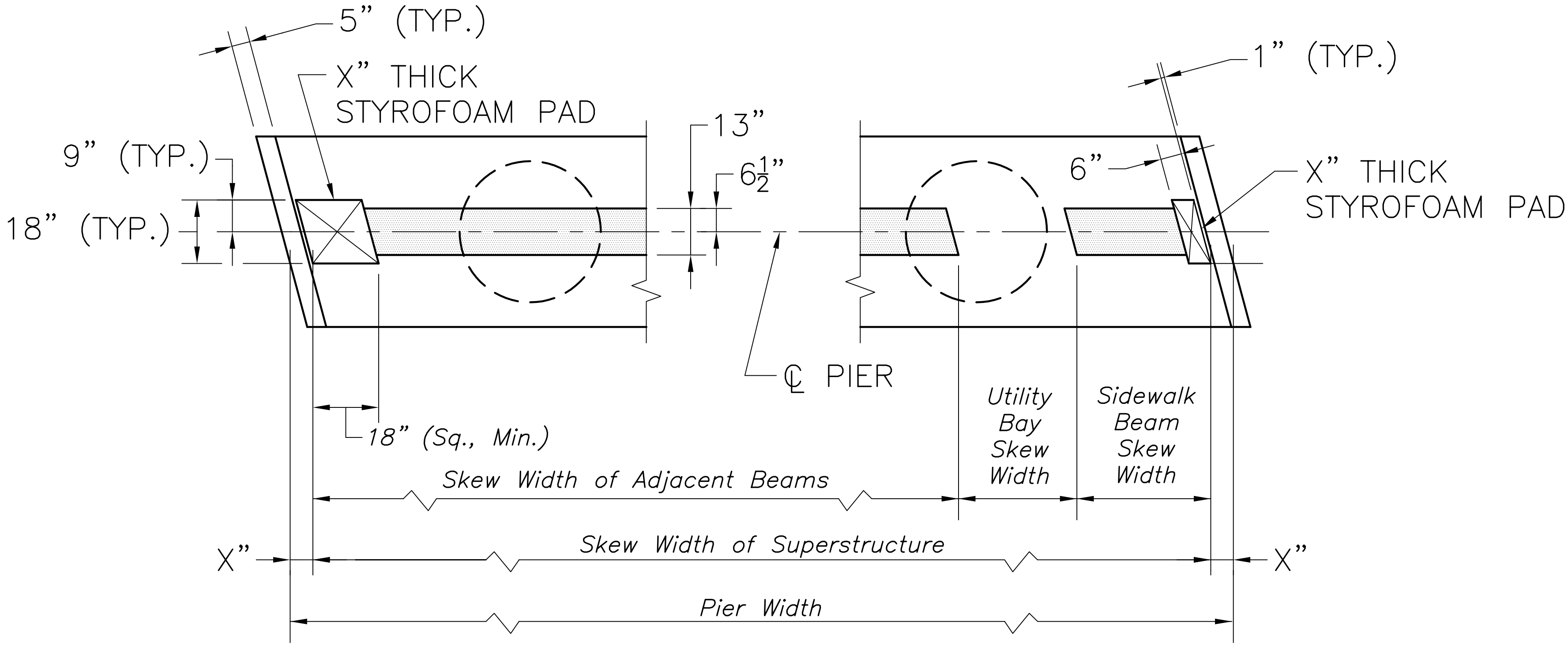
MASS HIGHWAY BRIDGE MANUAL	UTILITY BAY SECTION DECK AND BOX BEAMS ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.4.15**



MASS HIGHWAY BRIDGE MANUAL	UTILITY THRU U-WINGWALL	DATE OF ISSUE MAY 2005
	ABUTMENT DETAILS	DRAWING NUMBER **4.4.16**



MASS HIGHWAY BRIDGE MANUAL	UTILITY THRU SPLAYED WINGWALL ABUTMENT DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **4.4.17**



(BRIDGE WITHOUT UTILITY BAY) *(BRIDGE WITH UTILITY BAY)*

NOTES:

1. ▭ DENOTES LIMITS OF 11" DEEP BY 13" WIDE SHEAR KEY.
2. ALL SURFACES OF THE SHEAR KEY SHALL BE LINED WITH $\frac{1}{2}$" THICK CLOSED CELL FOAM.
3. PROVIDE ADDITIONAL STYROFOAM AS SHOWN IN DETAILS OVER PIER.

PLAN OF PIER

SCALE: ($\frac{1}{4}$" = 1'–0" Min.)

NOTES:

1. *Remainder of pier has been omitted for clarity.*
2. *Plan of pier shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant dimensions, angles, survey information and North Arrow.*

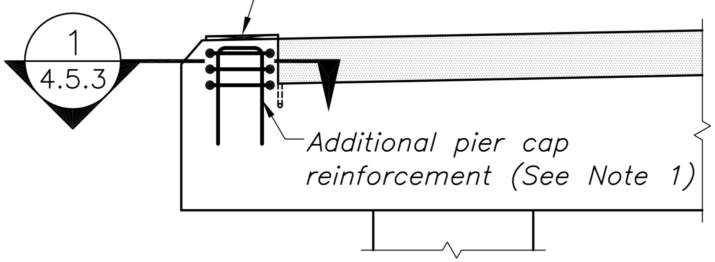
MASS HIGHWAY BRIDGE MANUAL

TYPICAL PLAN OF PIER

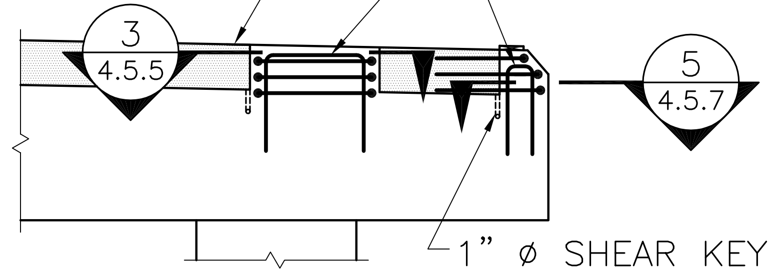
PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.5.1



(BRIDGE WITHOUT UTILITY BAY)



(BRIDGE WITH UTILITY BAY)

NOTES:

1. ▭ DENOTES LIMITS OF 11" DEEP BY 13" WIDE SHEAR KEY.

2. ALL SURFACES OF THE SHEAR KEY SHALL BE LINED WITH $\frac{1}{2}$" THICK CLOSED CELL FOAM JOINT FILLER.

TRANSVERSE SECTION OF PIER

SCALE: ($\frac{1}{4}$" = 1'–0" Min.)

NOTES:

1. *Additional pier cap reinforcement for transverse restraint shall be designed as a connection for seismic forces.*
2. *Remainder of pier and pier reinforcement has been omitted for clarity.*
3. *The transverse section shall be drawn without breaks and to scale on the Construction Drawings and all reinforcement shall be included.*

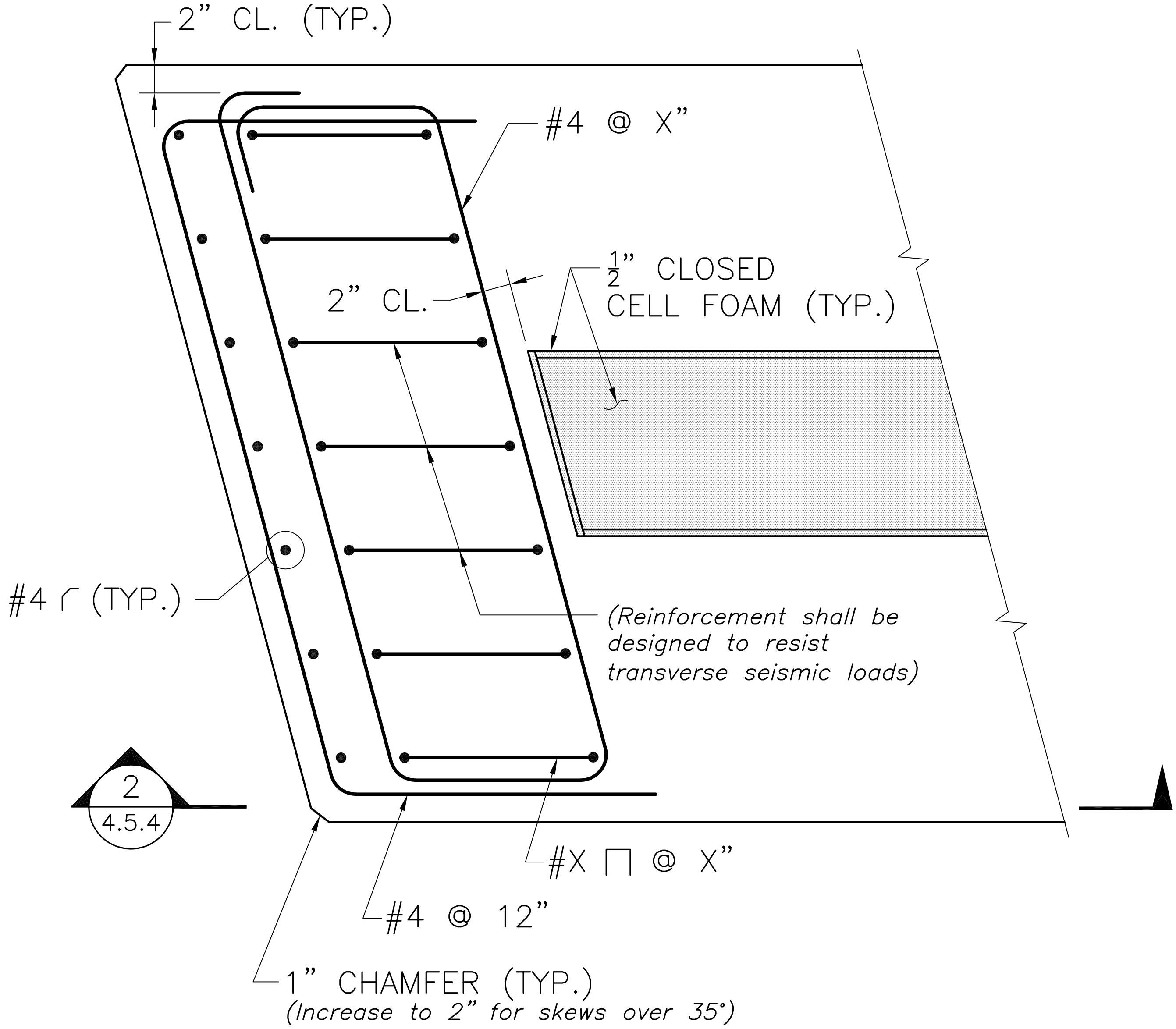
MASS HIGHWAY BRIDGE MANUAL

TYPICAL TRANSVERSE SECTION OF PIER

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
4.5.2



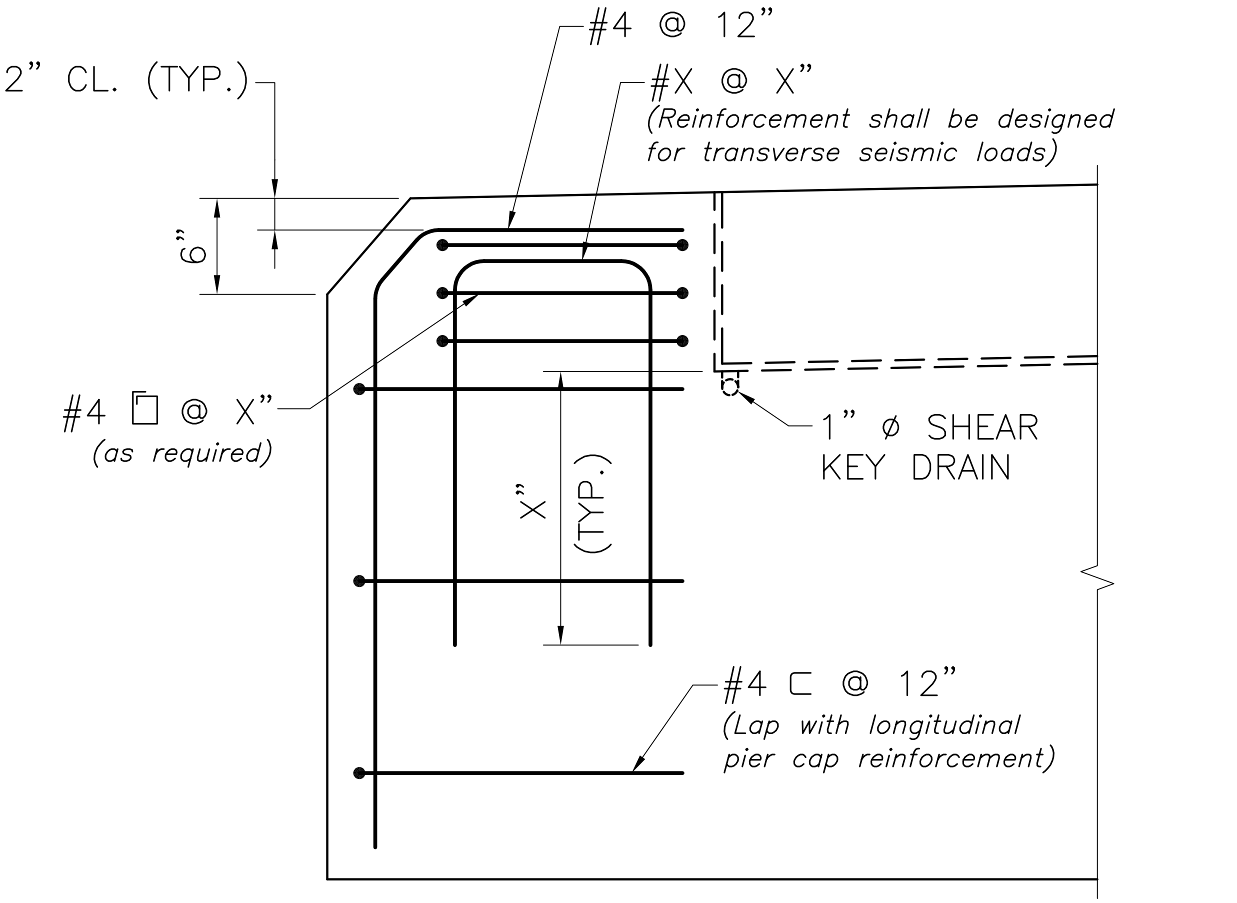
SECTION 1

SCALE: 1" = 1'–0"

NOTES:

1. *Only pier end reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION AT PIER END WITHOUT UTILITY BAY PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.5.3**



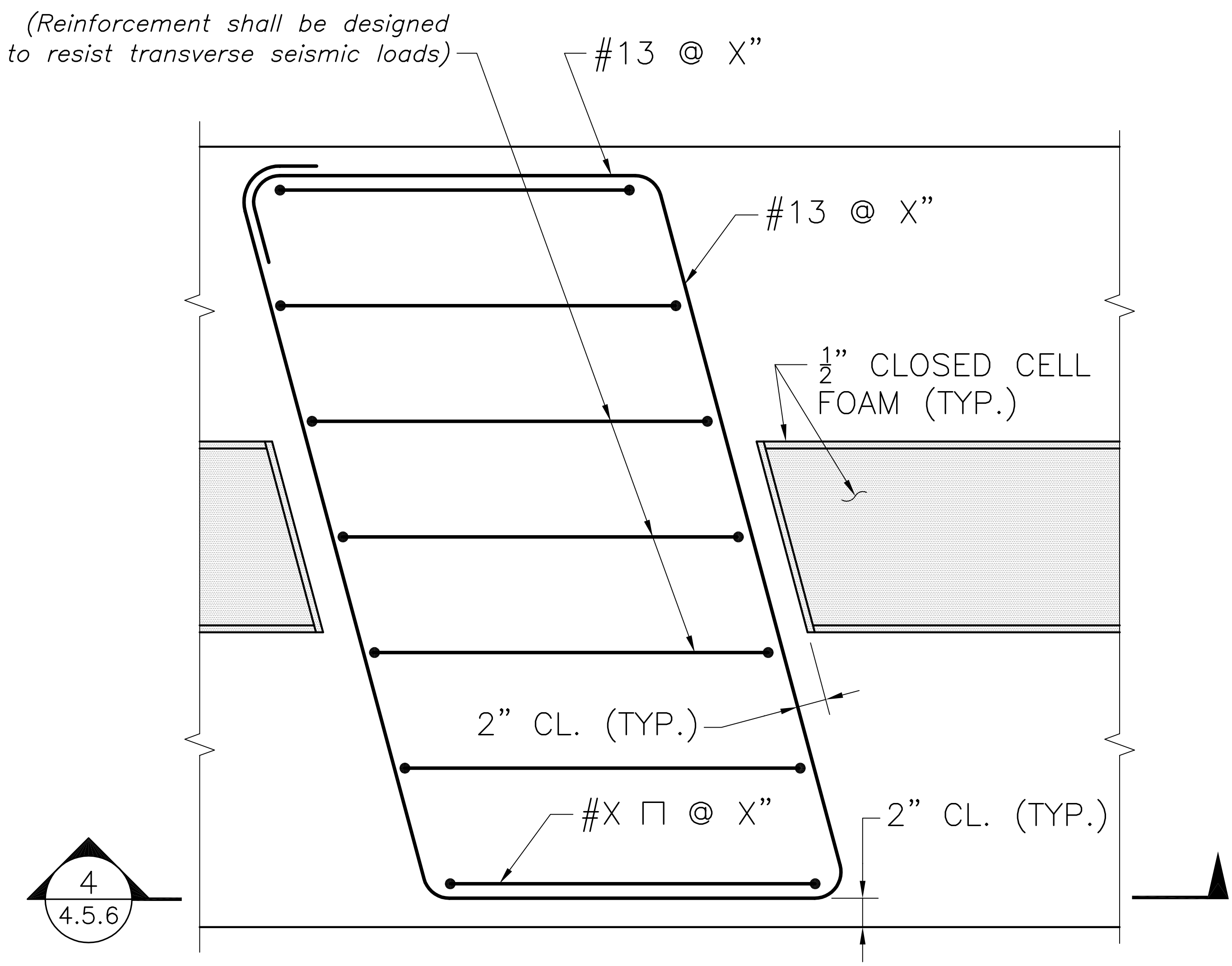
SECTION 2

SCALE: 1" = 1'–0"

NOTES:

1. *Only pier end reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION AT PIER END WITHOUT UTILITY BAY PIER DETAILS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **4.5.4**



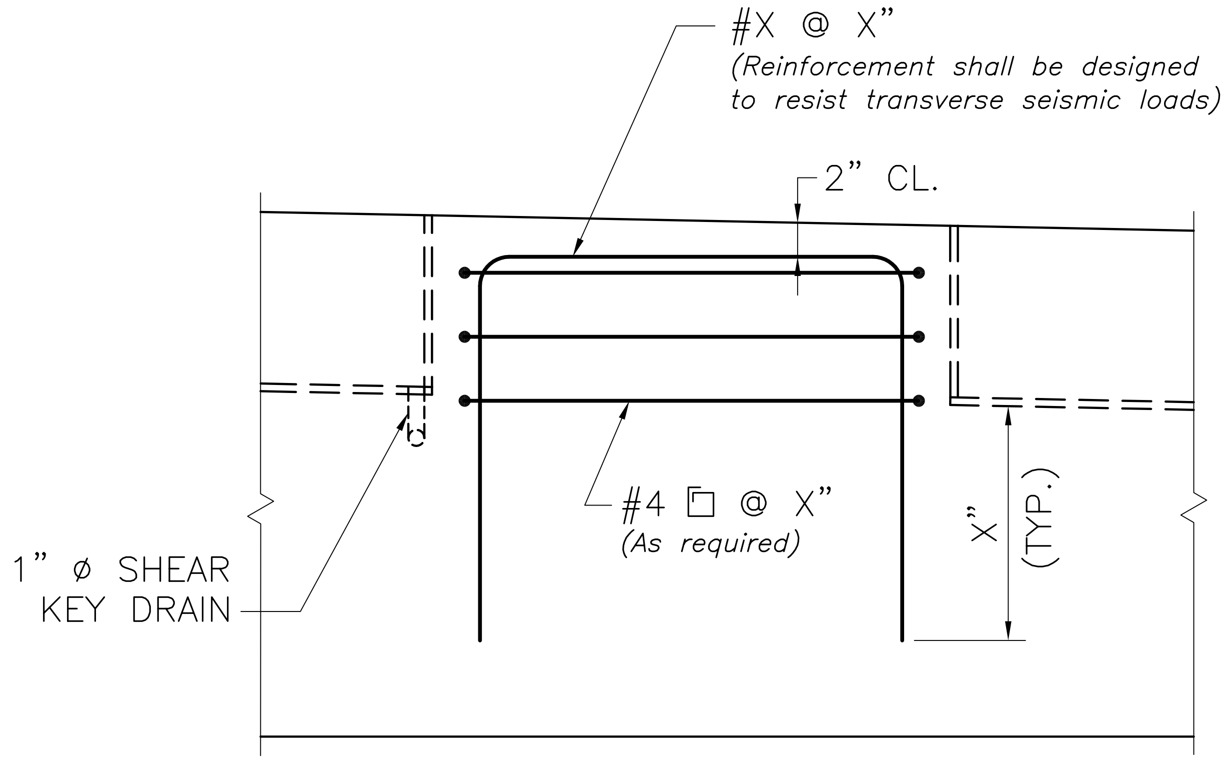
SECTION 3

SCALE: 1" = 1'-0"

NOTES:

1. *Only the transverse seismic reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION OF PIER AT UTILITY BAY PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.5.5**



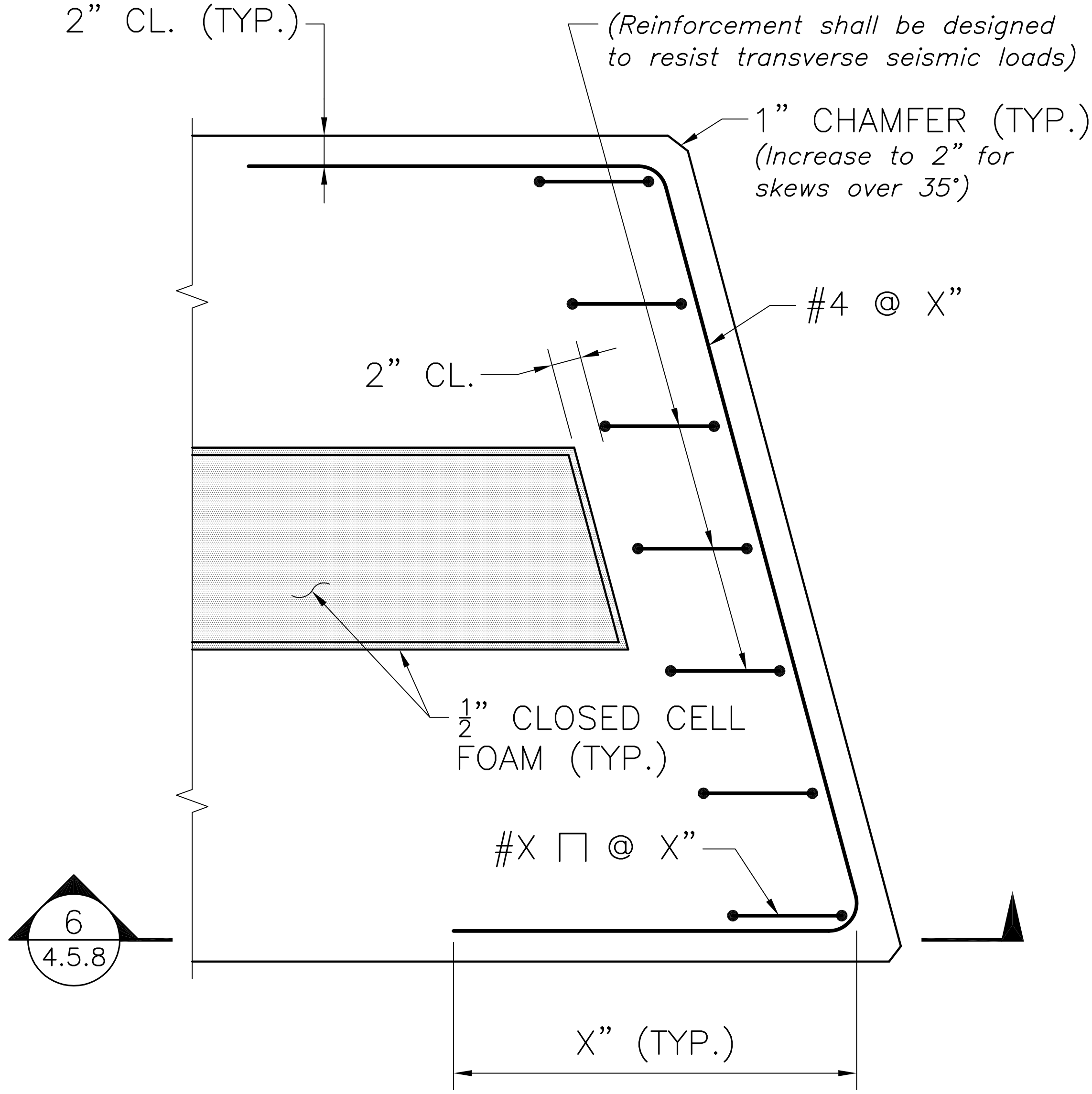
SECTION 4

SCALE: 1" = 1'–0"

NOTES:

1. *Only the transverse seismic reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION OF PIER AT UTILITY BAY PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.5.6**



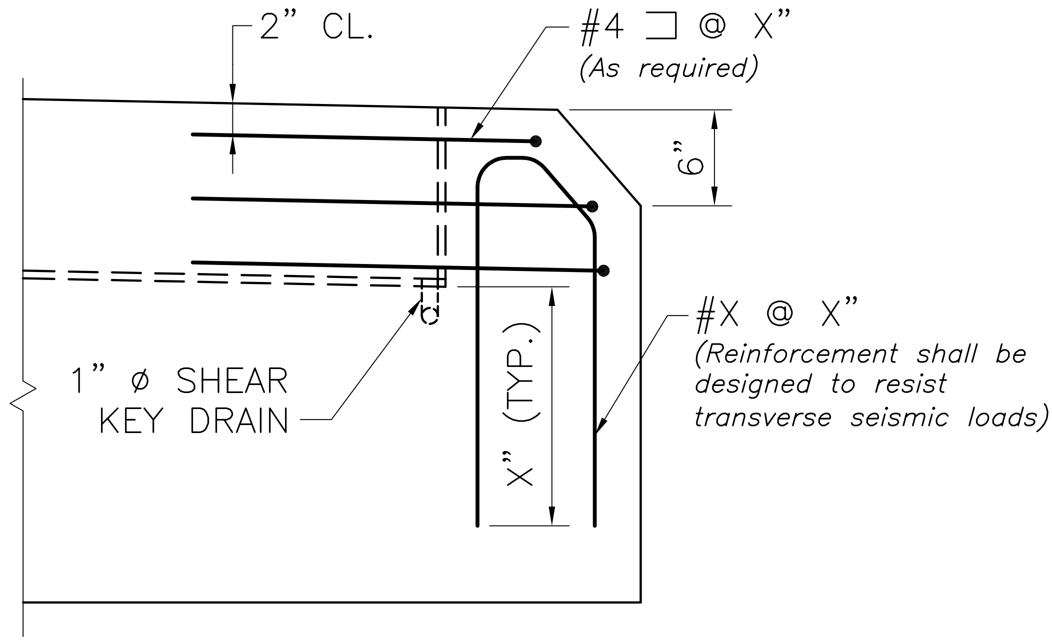
SECTION 5

SCALE: 1" = 1'-0"

NOTES:

1. *Only the end reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION AT PIER END WITH UTILITY BAY	DATE OF ISSUE MAY 2005
	PIER DETAILS	DRAWING NUMBER **4.5.7**



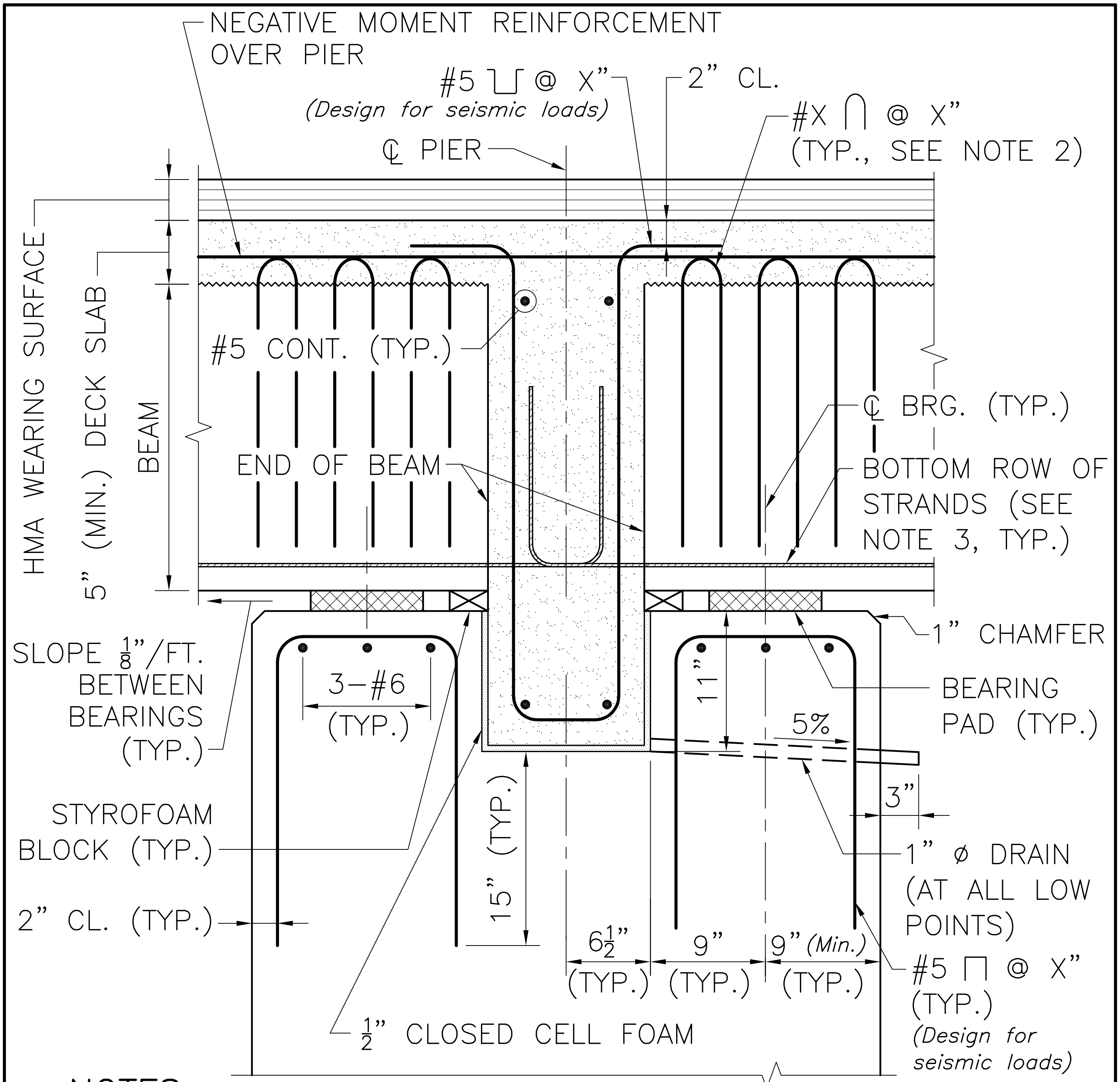
SECTION 6

SCALE: 1" = 1'-0"

NOTES:

1. *Only pier end reinforcement is shown. The rest of the pier reinforcement has been omitted for clarity.*
2. *The Designer shall verify that the reinforcement shown does not interfere with or duplicate the normal pier reinforcement and adjust as necessary.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION AT PIER END WITH UTILITY BAY PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.5.8**



NOTES:

1. [dotted box] DENOTES LIMITS OF 4000 PSI, $\frac{3}{4}$ IN., 585 HP CEMENT CONCRETE.

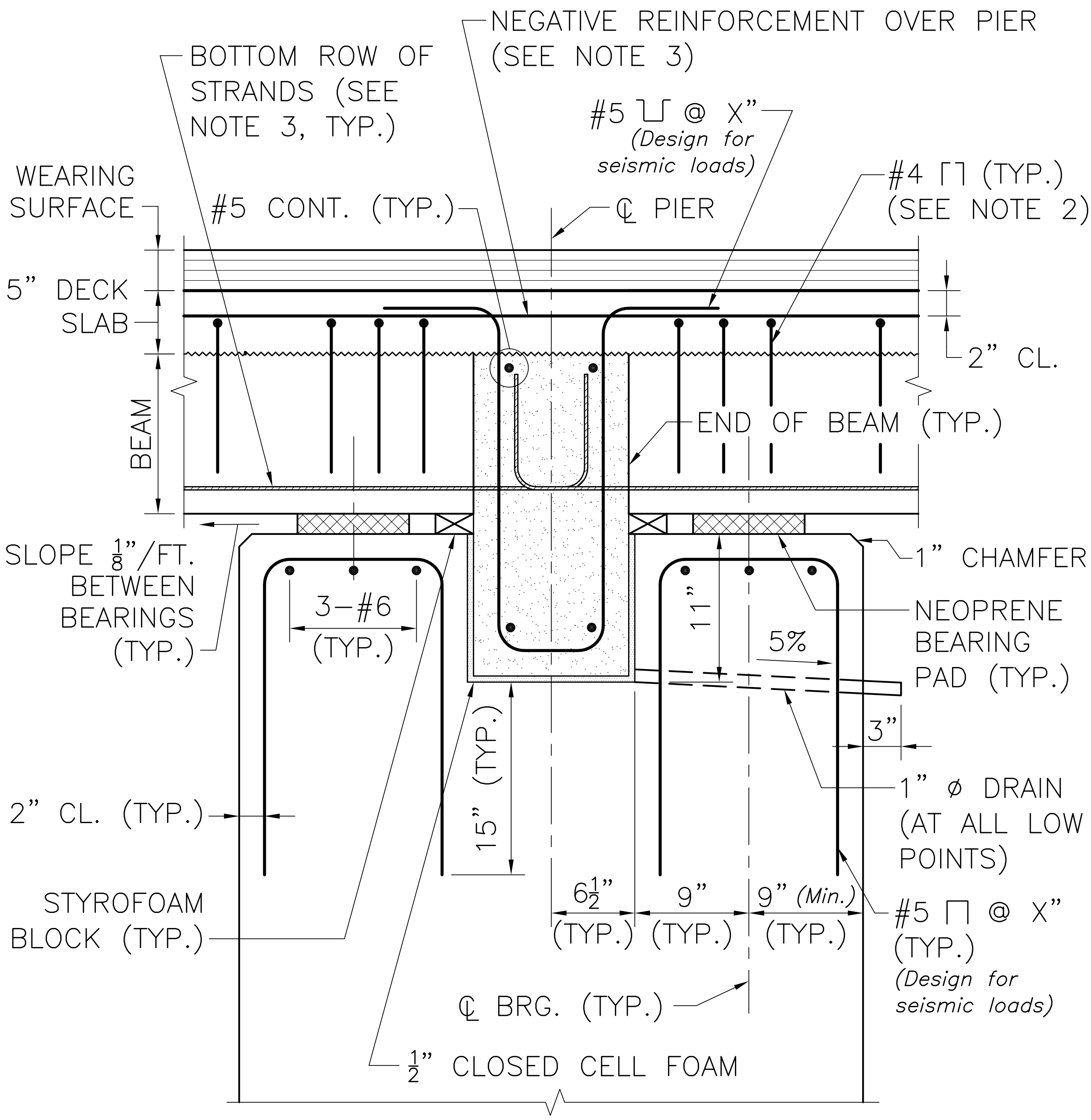
2. FOR BEAM REINFORCEMENT, SEE LONGITUDINAL SECTION OF BEAM SHEET XX.

3. DECK SLAB, PIER CAP REINFORCEMENT AND THE REMAINDER OF STRANDS IN BEAMS NOT SHOWN FOR CLARITY.

DETAILS OVER PIER

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	DETAILS OVER PIER FOR DECK AND BOX BEAMS	DATE OF ISSUE MAY 2005
	PIER DETAILS	DRAWING NUMBER **4.5.9**



NOTES:

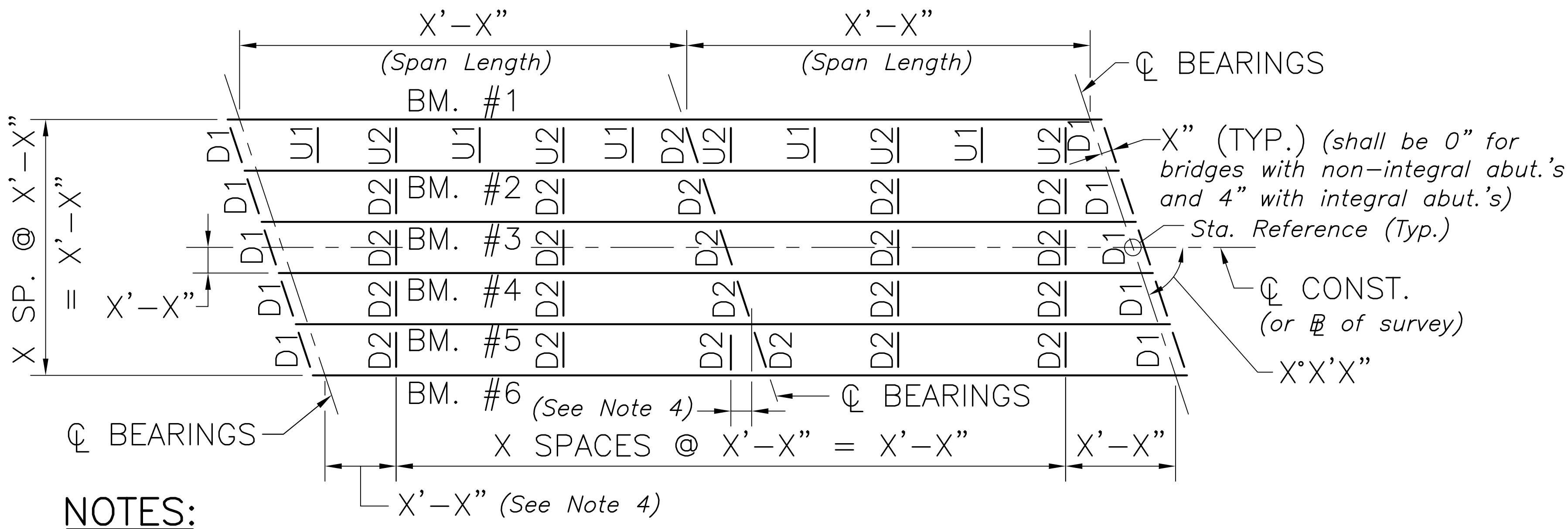
(See Dwg. No. 4.5.9 for notes to be included on construction plans.)

DETAILS OVER PIER

SCALE: 1" = 1'-0"

(Type SI & SII beams only. See Dwg. No. 4.5.9 for other beam types)

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION (S12 & S-15 BEAMS ONLY) FOR BEAM CONTINUITY PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **4.5.10**



NOTES:

1. D1 = CXxX (TYP. END DIAPHRAGM)
   D2 = CXxX (TYP. INTERMEDIATE DIAPHRAGM)
   U1 = TYPICAL UTILITY SUPPORT BETWEEN DIAPHRAGMS *(Utility under sidewalk shown)*
   U2 = TYPICAL UTILITY SUPPORT AT DIAPHRAGMS
2. SEE SHEET X FOR DIAPHRAGM AND UTILITY SUPPORT DETAILS.
3. THE MAIN LOAD CARRYING MEMBERS ARE XXX.
4. ALL STEEL SHALL CONFORM TO AASHTO M 270 GRADE XX. *(Specify grade)*

FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1"–0" *Min.*)

NOTES:

1. *The framing plan shall be drawn to an appropriate scale and, where possible, full length without breaks on the Construction Drawings. Show the extent of and label all cover plates and splices. Label beam size for each beam. Dimension the utility support locations. Include all relevant survey data and North Arrow.*
2. *Where utilities interfere with the typical end diaphragm, provide an alternative end diaphragm detail.*
3. *Continuous two–span bridge shown. Simple and multiple continuous span bridges are similar.*
4. *The minimum distance between a skewed and square diaphragm or utility support shall be 2'–0".*
5. *The beams shall be consecutively numbered from South to North for bridges oriented generally east–west and from West to East for bridges oriented generally north–south. Spans shall be consecutively numbered from West to East for bridges generally oriented east–west and from South to North for bridges generally oriented north–south.*

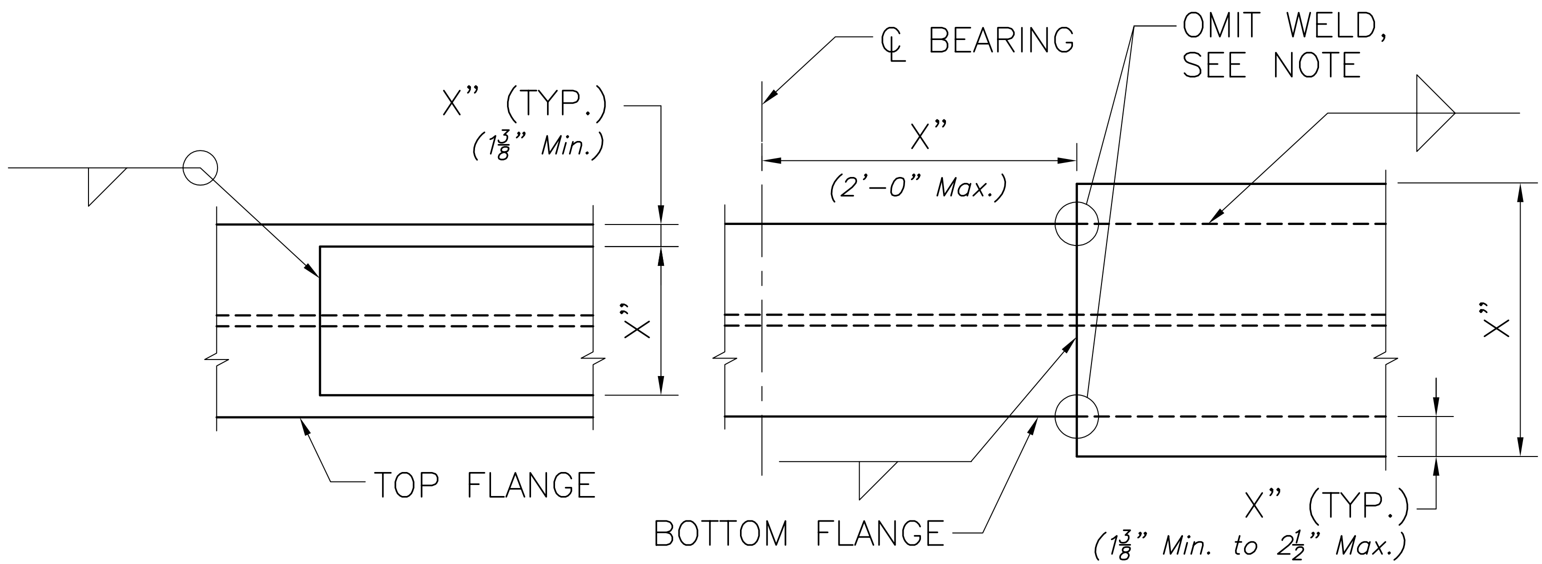
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL FRAMING PLAN

STRINGERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.1.1



AT TOP FLANGE

AT BOTTOM FLANGE

NOTE:

TERMINATE LONGITUDINAL AND TRANSVERSE WELDS 1" FROM THE INTERSECTION OF THE COVER PLATE WITH THE EDGE OF FLANGE. *(Include note as required)*

COVER PLATE DETAILS

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the details as required to suit the project.*
2. *Cover plates are to be in one piece and shall be limited to one at any flange. The minimum cover plate thickness shall be $\frac{1}{2}$".*
3. *The extent of any cover plate welded to the top flange shall be in accordance with AASHTO specifications.*
4. *Weld sizes in the table are minimum sizes only. The Designer is responsible for assuring the weld size is adequate.*

Max. Plate & Flange Thickness	*Min. Size Of Fillet Weld*
$\frac{1}{2}$" to $\frac{3}{4}$"	$\frac{1}{4}$"
over $\frac{3}{4}$"	$\frac{5}{16}$"

MASS HIGHWAY
BRIDGE MANUAL

COVER PLATE DETAILS

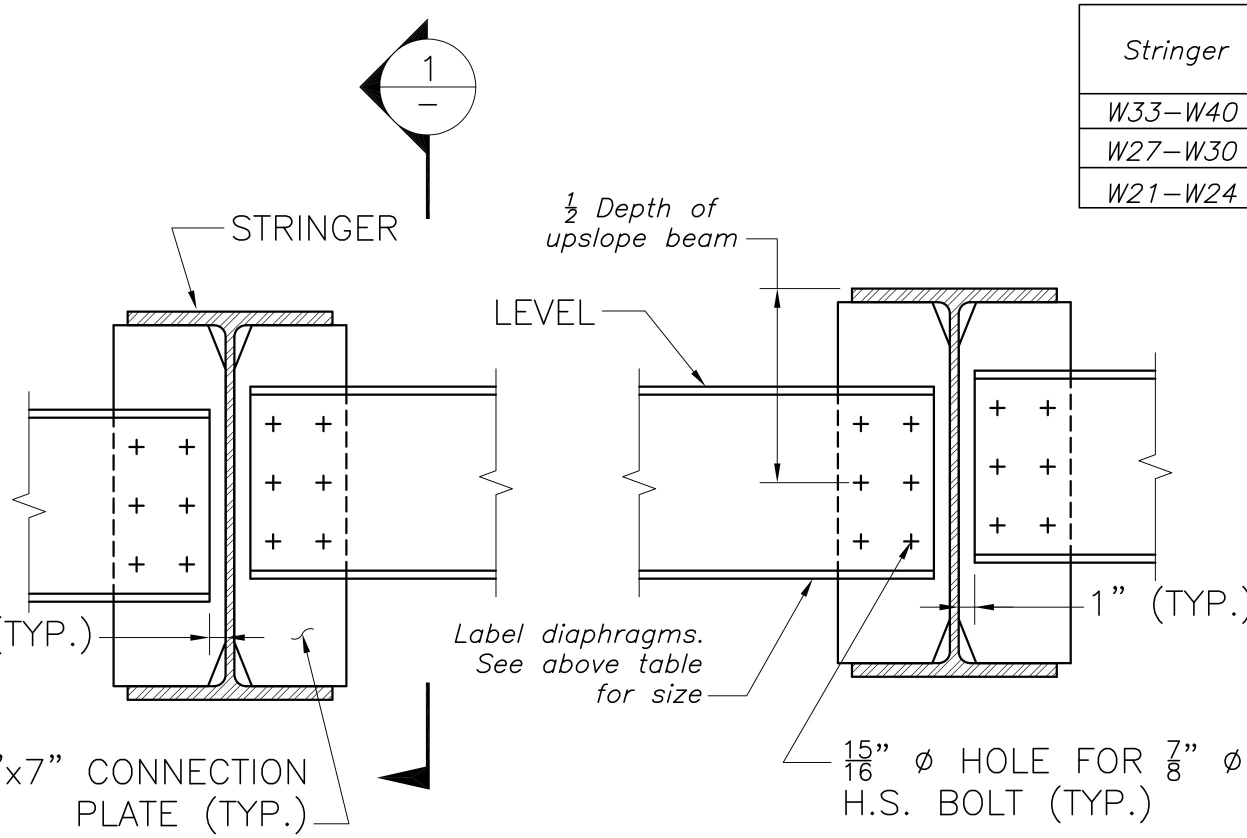
STRINGERS

DATE OF ISSUE
MAY 2005

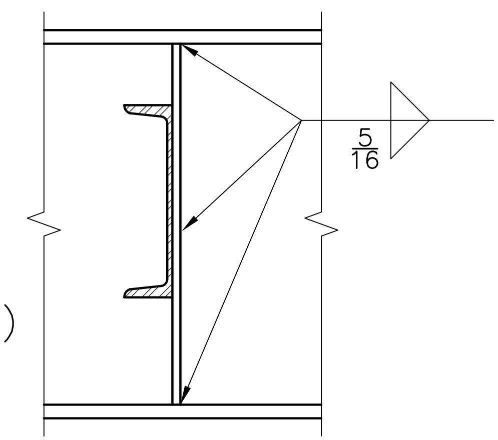
DRAWING NUMBER
5.1.2

INTERMEDIATE DIAPHRAGM DETAILS

Stringer	Diaphragm	No. of H.S. Bolts per Connection
W33–W40	MC18x42.7	10
W27–W30	C15x33.9	8
W21–W24	C12x20.7	6



ELEVATION VIEW



SECTION 1

NOTE:

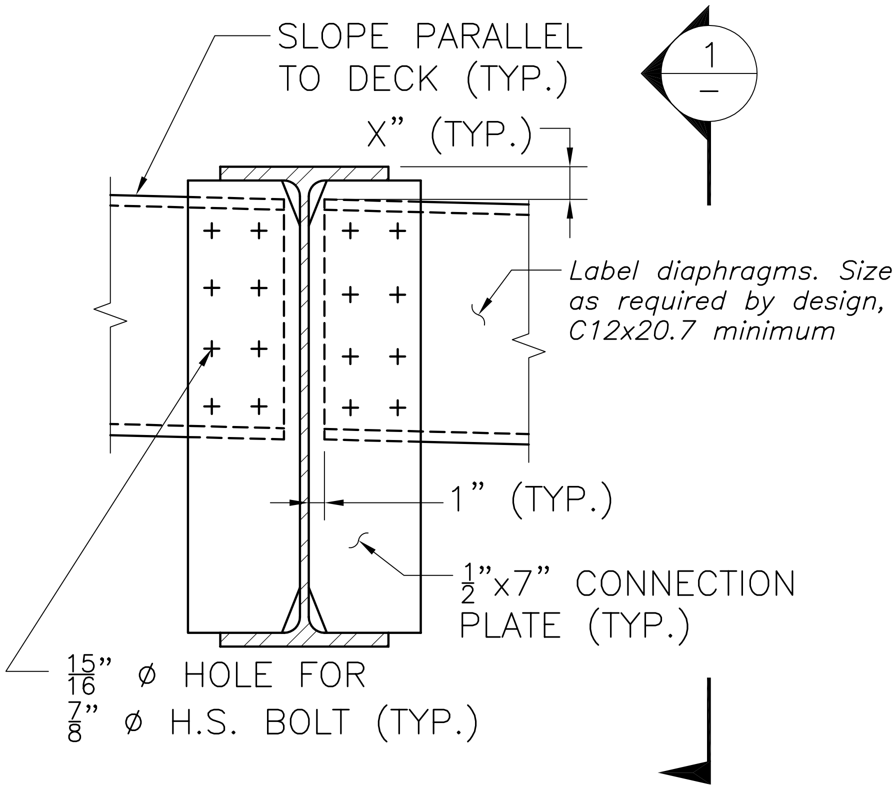
SEE CLIP DETAILS ON SHEET X. *(See Dwg. No. 5.1.9)*

INTERMEDIATE DIAPHRAGM DETAILS

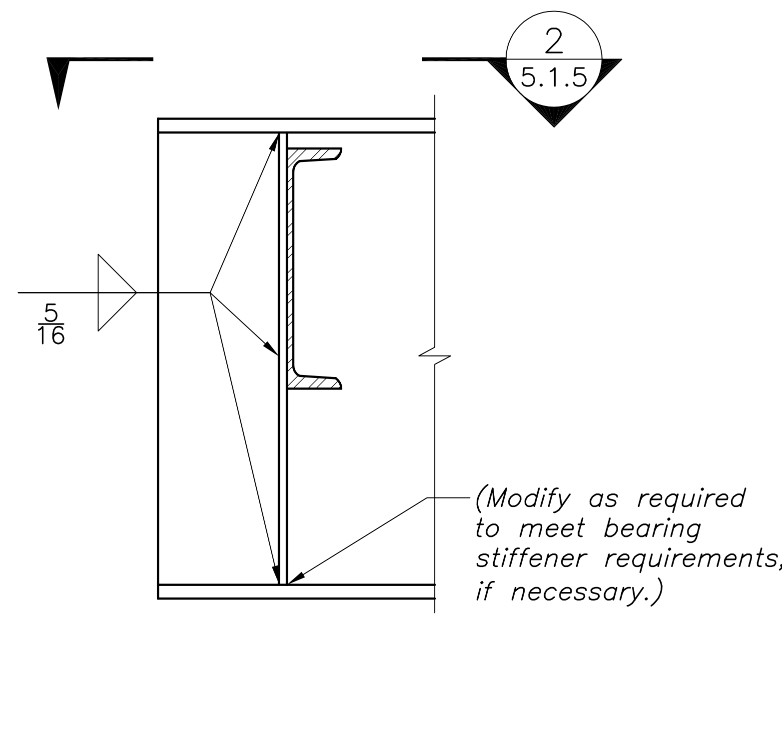
SCALE: 1" = 1'–0"

NOTES:

1. *Include bolt hole spacing and edge distances in the "Elevation View" on the Construction Drawings.*
2. *Modify the details as necessary to suit the project.*
3. *Interior diaphragms shall be centered mid–depth on the upslope stringer.*
4. *Maximum spacing of diaphragms shall be 25'–0".*



ELEVATION VIEW



SECTION 1

NOTE:

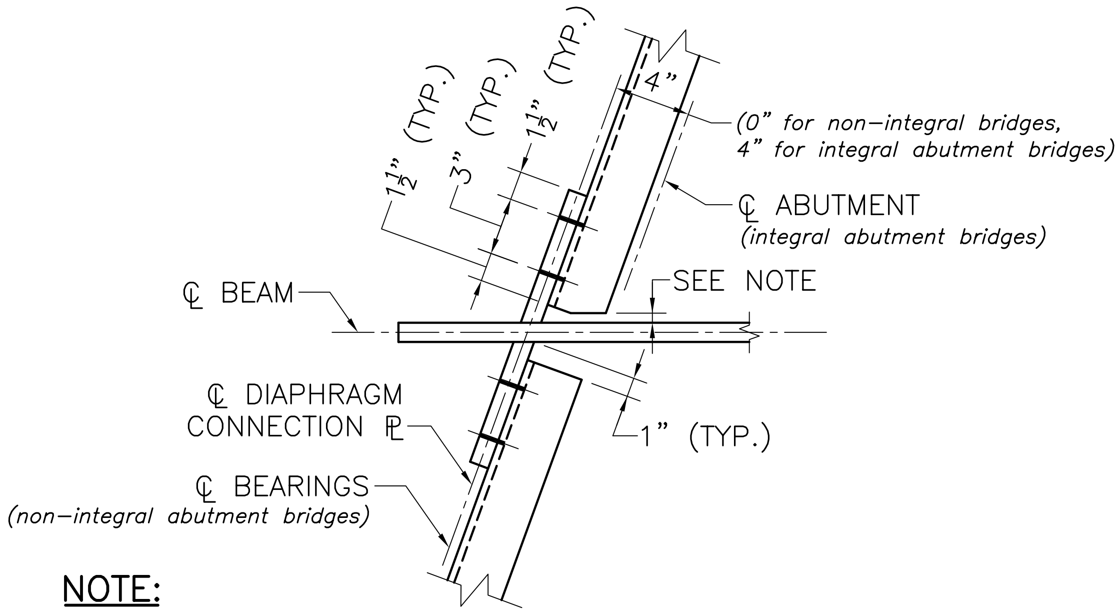
SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.1.9)*

END DIAPHRAGM DETAILS

SCALE: 1"=1'–0"

NOTES:

1. *Include the bolt hole spacing and edge distances in the "Elevation View" on the Construction Drawings.*
2. *Modify the details as necessary to suite the project. If connection plate is also required as a bearing stiffener, make all necessary changes to plate size and attachments to meet AASHTO requirements.*
3. *Locate the end diaphragm as close to the top flange as possible.*
4. *End diaphragms shall be placed parallel to the centerline of bearings as shown in the Framing Plan.*
5. *Details shown on Drawing No. 5.2.7 shall be used if transverse seismic loads exceed the capacity of the details shown on this drawing.*
6. *Designer shall take into account reduced stiffness if diaphragm connection plates are also required as bearing stiffeners and are not perpendicular to web.*



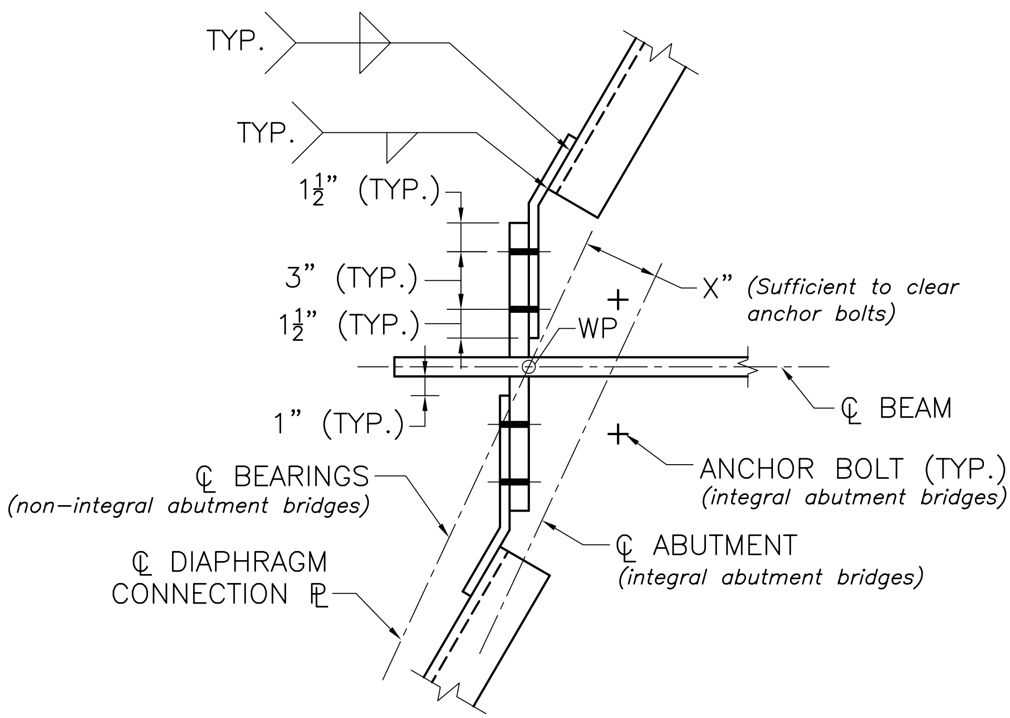
NOTE:

FLANGE OF CHANNEL MAY BE CLIPPED TO AVOID INTERFERENCE WITH WEB.

SKEWS ⩽ 20°

SECTION 2

SCALE: 1½" = 1'-0"

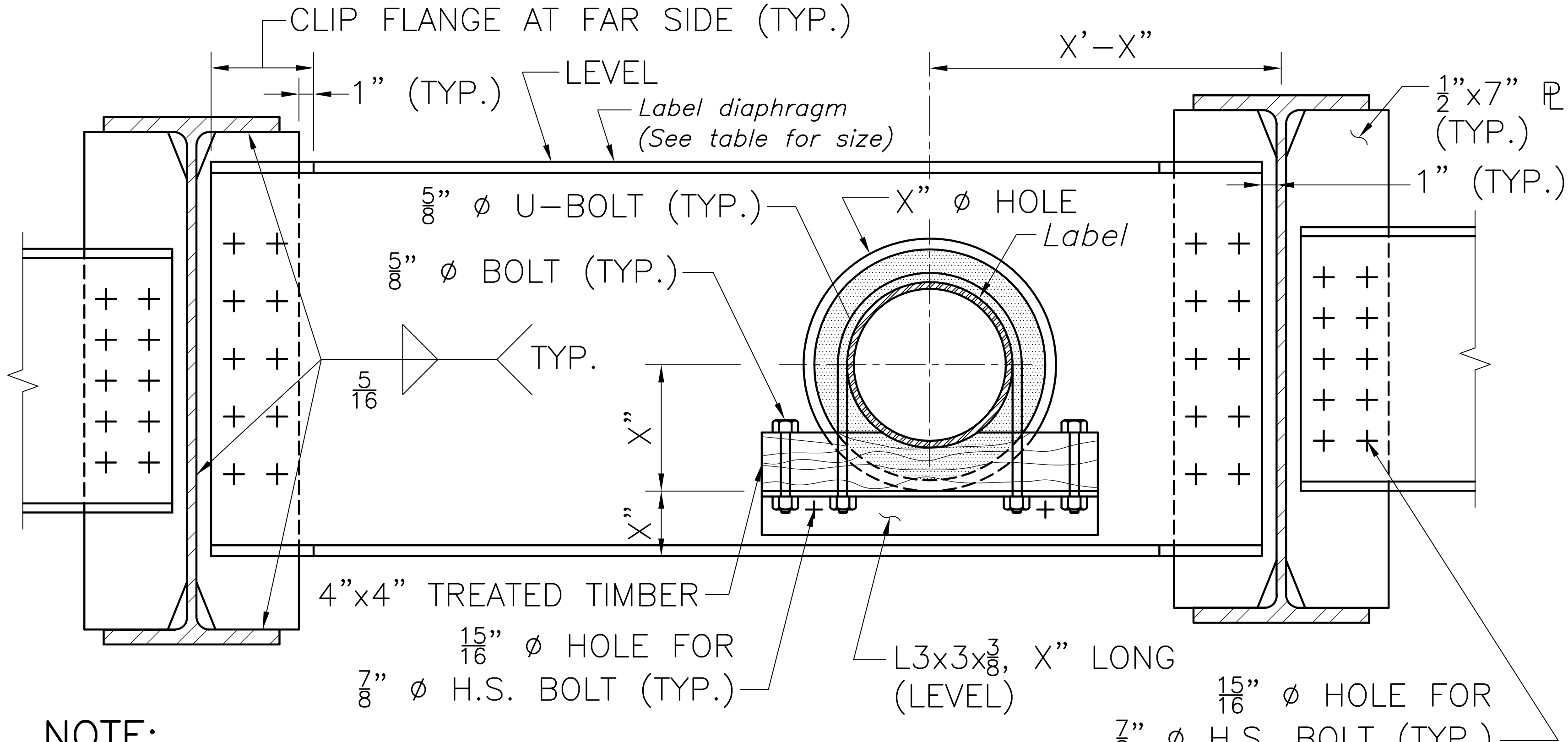


SKEWS > 20°

SECTION 2

SCALE: 1½" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	END DIAPHRAGM DETAILS STRINGERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.1.5**



NOTE:

SEE DIAPHRAGM CONNECTION PLATE CLIP DETAILS ON SHEET X. *(See Dwg. No. 5.1.9)*

UTILITY SUPPORT DETAILS AT INTERMEDIATE DIAPHRAGMS LOCATIONS

SCALE: 1" = 1'–0"

Stringer	*Diaphragms*
W40	*W30x99*
W36	*W27x94*
W33	*W27x94*
W30	*W24x76*
W27	*W24x76*
W24	*W18x60*
W21	*W18x60*

NOTES:

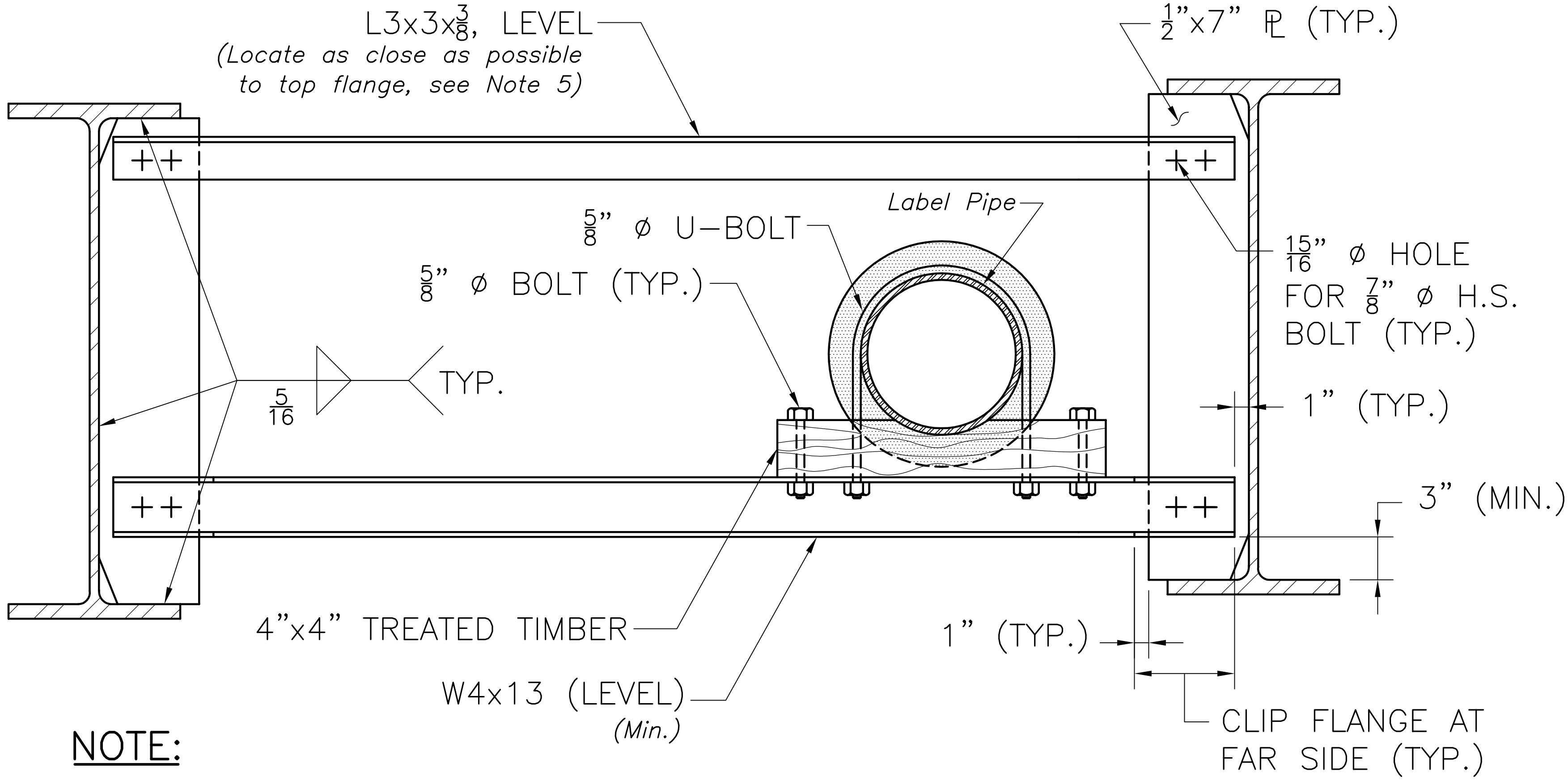
1. *Modify the details as necessary to suit project.*
2. *Combine the above detail with the detail for utility supports between diaphragms (Dwg. No. 5.1.8). For a utility bay located under a sidewalk, see Dwg. No. 5.1.7.*
3. *Provide at least as many bolts for the attachment of the diaphragm utility support as required for a normal diaphragm. Include the bolt hole spacing and edge distances.*
4. *Dimension the circular opening as well as the location of support angle and bolts. Water pipe is shown. For other utilities, provide the main supports only.*

MASS HIGHWAY BRIDGE MANUAL

UTILITY SUPPORT DETAILS
INTERMEDIATE DIAPHRAGMS
STRINGERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.1.6



NOTE:

SEE DIAPHRAGM CONNECTION PLATE CLIP DETAILS ON SHEET X. *(See Dwg. No. 5.1.9)*

UTILITY SUPPORT DETAILS DIAPHRAGMS UNDER SIDEWALK

SCALE: 1" = 1'–0"

NOTES:

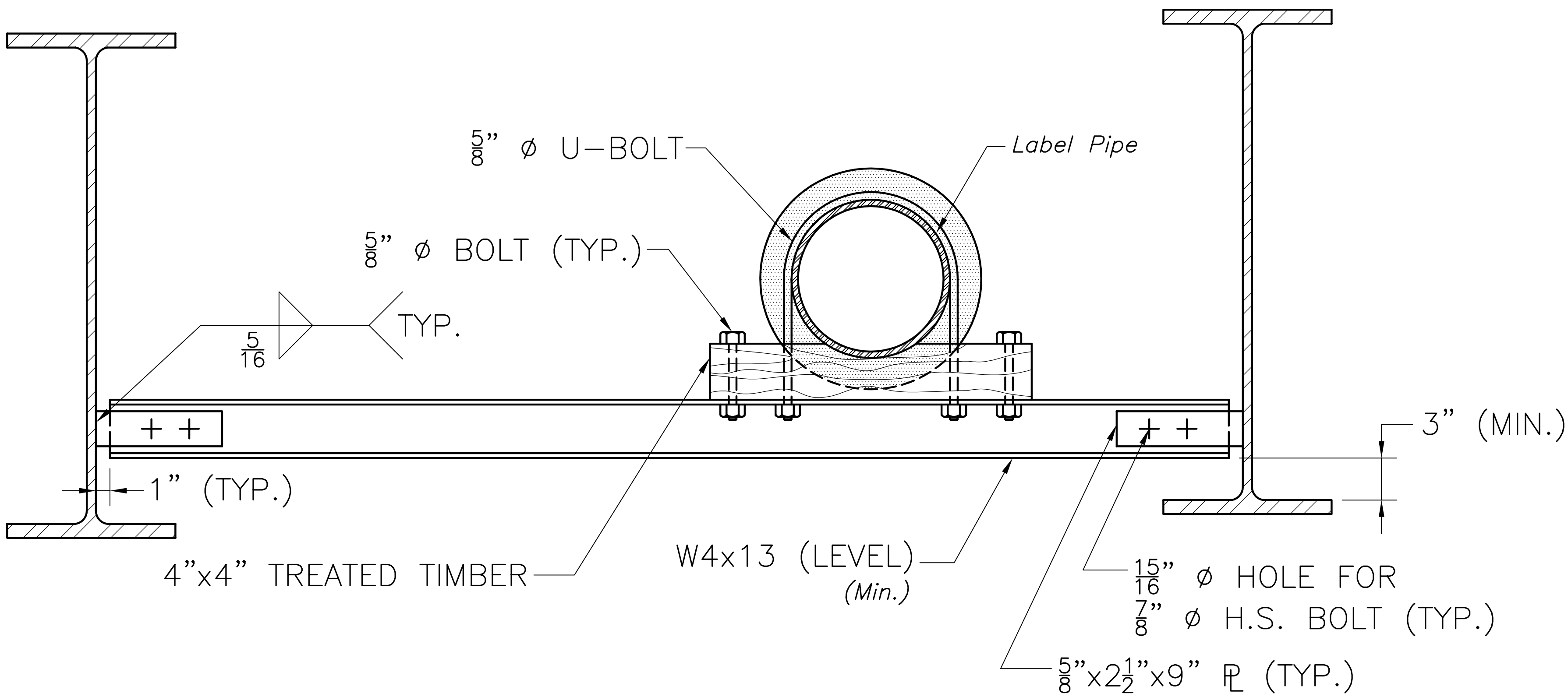
1. *Modify the details as necessary to suit project.*
2. *This detail is for utility bays located under sidewalks only. For utility bays located under roadway or safety curb, see Dwg. No. 5.1.6.*
3. *Combine the above detail with the detail for utility supports between diaphragms (Dwg. No. 5.1.8).*
4. *Utilities located under sidewalks shall be placed as close as possible to the exterior beam to minimize interference with the approach slab.*
5. *Dimension the locations of all supports and bolts (with edge distances) on the Construction Drawings. Water pipe shown. For other utilities, provide the main supports only.*

MASS HIGHWAY
BRIDGE MANUAL

UTILITY SUPPORT DETAILS
DIAPHRAGMS UNDER SDWK.
STRINGERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.1.7

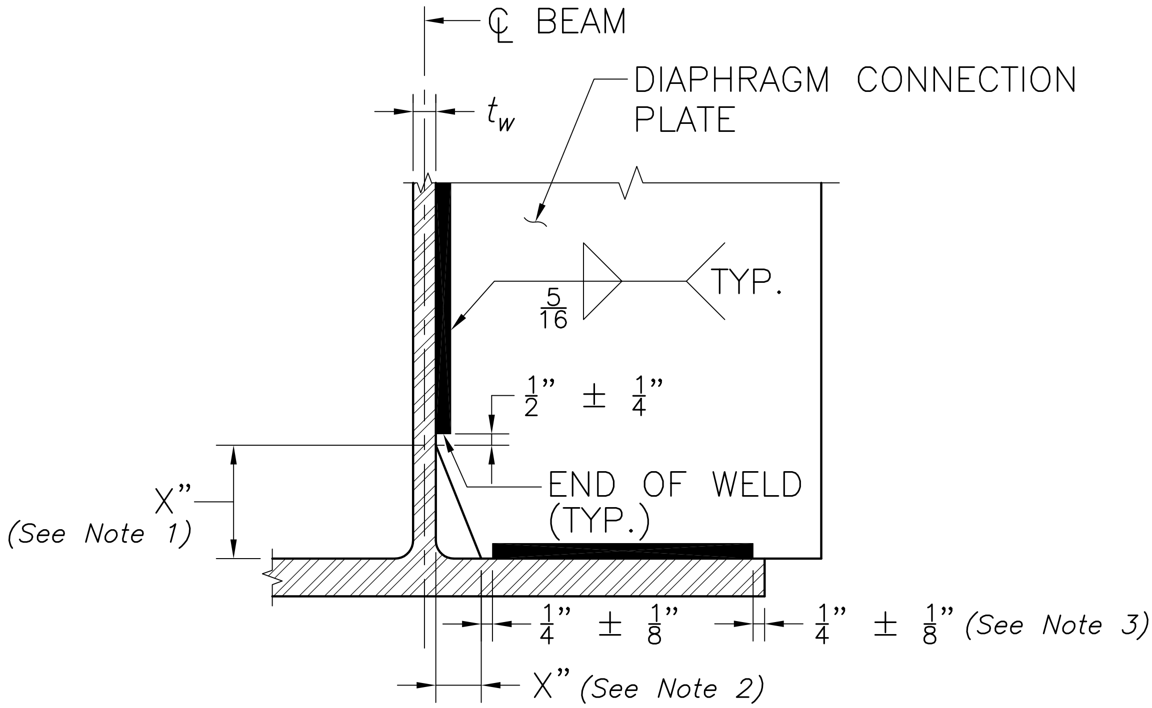


UTILITY SUPPORT DETAILS BETWEEN DIAPHRAGMS

SCALE: 1" = 1'-0"

NOTES:

1. *Modify the details as necessary to suit project.*
2. *For utility bays located under the roadway or safety curb, combine this detail with the detail shown on Dwg. No. 5.1.6.*
3. *For utility bay located under the sidewalk, combine this detail with the detail shown on Dwg. No. 5.1.7.*
4. *Dimension the locations of the supports and bolts (with edge distances) on the Construction Drawings. Water pipe shown. For other utilities, provide the main supports only.*
5. *The minimum size of the utility support beam is shown. Actual size shall be as required by design.*



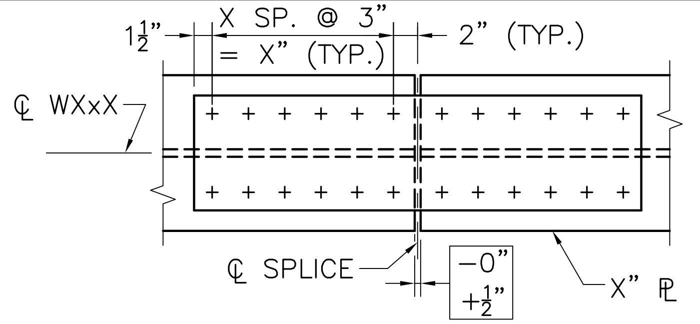
CLIP DETAIL

NOT TO SCALE

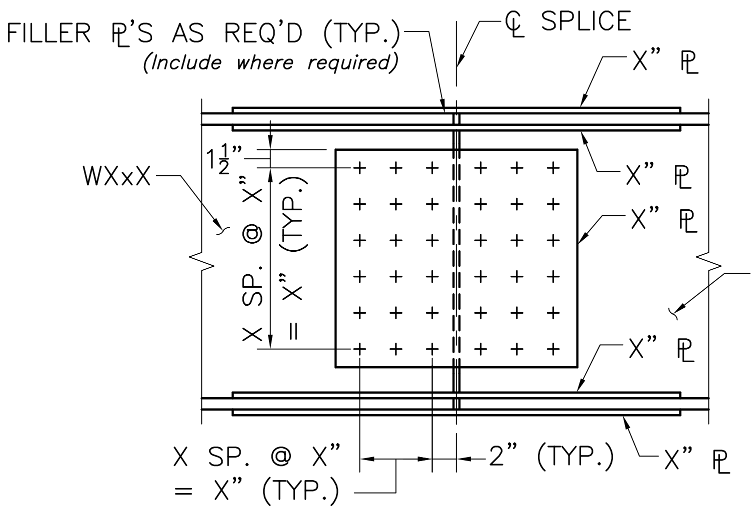
NOTES:

1. *Height of clip shall be 5 x t_w*
2. *Width of clip shall be 2 x t_w*
3. *Terminate weld $\frac{1}{4}$" from edge of flange or connection plate, whichever is encountered first.*
4. *Where the end connection plate is also required as a bearing stiffener, the bottom of the connection plate shall be either milled to fit the bottom flange and fillet welded, or attached to the bottom flange with a full penetration weld. Modify the above detail with construction notes as required.*

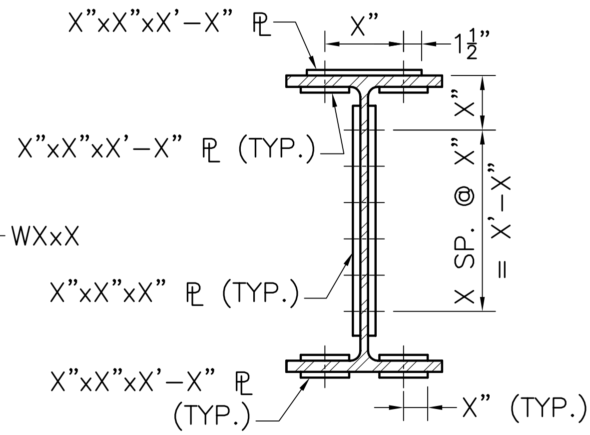
MASS HIGHWAY BRIDGE MANUAL	CLIP DETAIL FOR DIAPHRAGM CONNECTION PLATES STRINGERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.1.9**



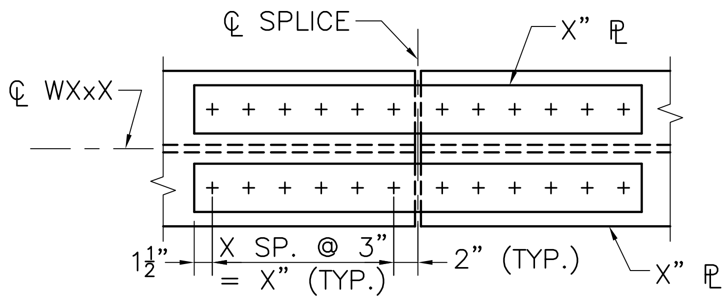
TOP FLANGE



ELEVATION



SECTION



BOTTOM FLANGE

NOTES:

1. BOLTED FIELD SPLICES SHALL BE CONSIDERED SLIP−CRITICAL CONNECTIONS WITH CLASS B FAYING SURFACES. *(Change to Class C for galvanized surfaces.)*

2. + DENOTES $\frac{7}{8}$" ø AASHTO M 164 HIGH STRENGTH BOLT IN $\frac{15}{16}$" ø HOLE.

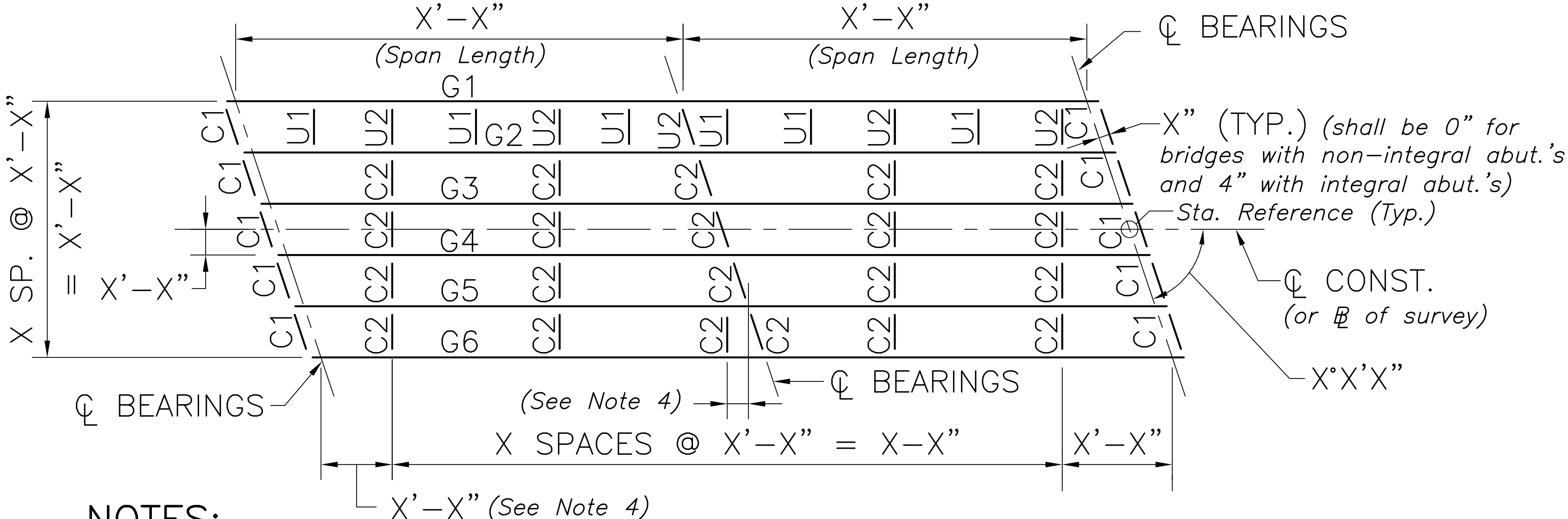
3. THICKNESS DIFFERENCES OF $\frac{1}{16}$" OR LESS DO NOT REQUIRE FILLER PLATES. FILLER PLATES SHALL CONFORM TO AASHTO M 270 GRADE 50W OR ASTM A606. *(Include where required.)*

4. ONE ROW OF STUD SHEAR CONNECTORS SHALL BE PLACED ALONG THE CENTERLINE OF THE TOP FLANGE SPLICE PLATE.

BOLTED FIELD SPLICE DETAILS

SCALE: 1"=1'−0"

MASS HIGHWAY BRIDGE MANUAL	BOLTED FIELD SPLICE DETAILS STRINGERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.1.10**



NOTES:

1. C1 = TYPICAL END CROSS FRAME
   C2 = TYPICAL INTERMEDIATE CROSS FRAME
   U1 = TYPICAL UTILITY SUPPORT BETWEEN CROSS FRAMES
   U2 = TYPICAL UTILITY SUPPORT AT CROSS FRAMES
2. SEE SHEET X FOR CROSS FRAME AND UTILITY SUPPORT DETAILS.
3. THE MAIN LOAD CARRYING MEMBERS ARE XXX.
4. ALL STEEL SHALL CONFORM TO AASHTO M 270 GRADE XX. *(Specify grade)*

FRAMING PLAN

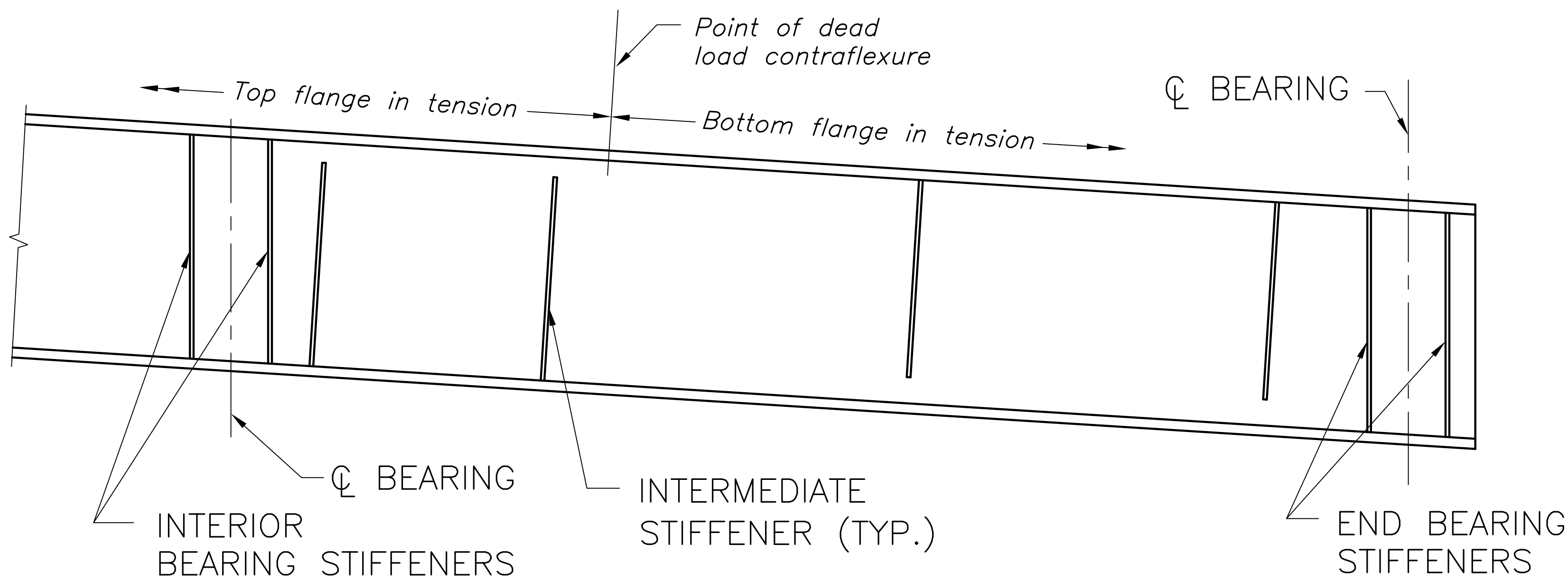
SCALE: ($\frac{1}{8}$" = 1"–0" Min.)

NOTES:

1. *The framing plan shall be drawn to an appropriate scale and, where possible, full length without breaks on the Construction Drawings. Show the extent of and label all longitudinal stiffeners and splices. Dimension the utility support locations. Include all relevant survey data and North Arrow.*
2. *Where utilities interfere with the typical end cross frame, provide an alternative end cross frame detail.*
3. *Continuous two–span bridge shown. Simple and multiple continuous span bridges are similar.*
4. *The minimum distance between a skewed and square cross frame or utility support shall be 2'–0".*
5. *The girders shall be consecutively numbered from South to North for bridges oriented generally east–west and from West to East for bridges oriented generally north–south. Spans shall be consecutively numbered from West to East for bridges generally oriented east–west and from South to North for bridges generally oriented north–south.*

NOTES:

1. For the design of welded girders, the span to depth ratio shall be as specified in Part I of the Bridge Manual.
2. The flanges shall be sized as required by design and as follows:
   - For shipping and erection safety, the ratio of the length to width of the compression flange shall be limited to 100 where practical (even at the expense of some additional steel).
   - The flange width may vary over the length of the girder, however constant width flanges are preferred. The top and bottom flanges need not be of the same width.
   - The minimum thickness of any flange shall be $\frac{3}{4}$".
3. The web plate thickness shall not be less than $\frac{1}{2}$". The Designer shall consider thicker web plates to eliminate transverse stiffeners (see Part I of the Bridge Manual).
4. Where they are required, intermediate stiffeners shall:
   - Be cut short of the tension flange, unless they also serve as cross frame connection plates (see Dwg. No. 5.2.4).
   - Be placed in pairs on both sides of the web, unless a longitudinal stiffener is employed on one side.
   - Not be placed on the outside face of the exterior girders.
   - Have a minimum plate size of $\frac{3}{8}$" x 5" for spans 90' up to 120' and $\frac{3}{8}$" x 6" for spans 121' to 150'.
   - Shall be located a minimum of 3' from the ℄ of a splice.
5. The use of longitudinal stiffeners shall be avoided, unless required by design. The longitudinal stiffener shall be placed on the opposite side of the web from the transverse stiffeners. For exterior girders, the longitudinal stiffener should be placed on the outside face.



NOTES:

1. ALL INTERMEDIATE STIFFENERS SHALL BE PERPENDICULAR TO THE WEB AND TO THE GIRDER FLANGES.

2. ALL BEARING STIFFENERS SHALL BE PLUMB.

3. ENDS OF BEAMS SHALL BE FABRICATED SO THAT UNDER FULL DEAD LOAD THE ENDS WILL BE PLUMB.

GIRDER ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Include girder elevation for each girder type on the Construction Drawings.*
2. *All main plates, welds and dimensions shall be labeled on the Construction Drawings for each girder type. Show location of any splices and stiffeners.*

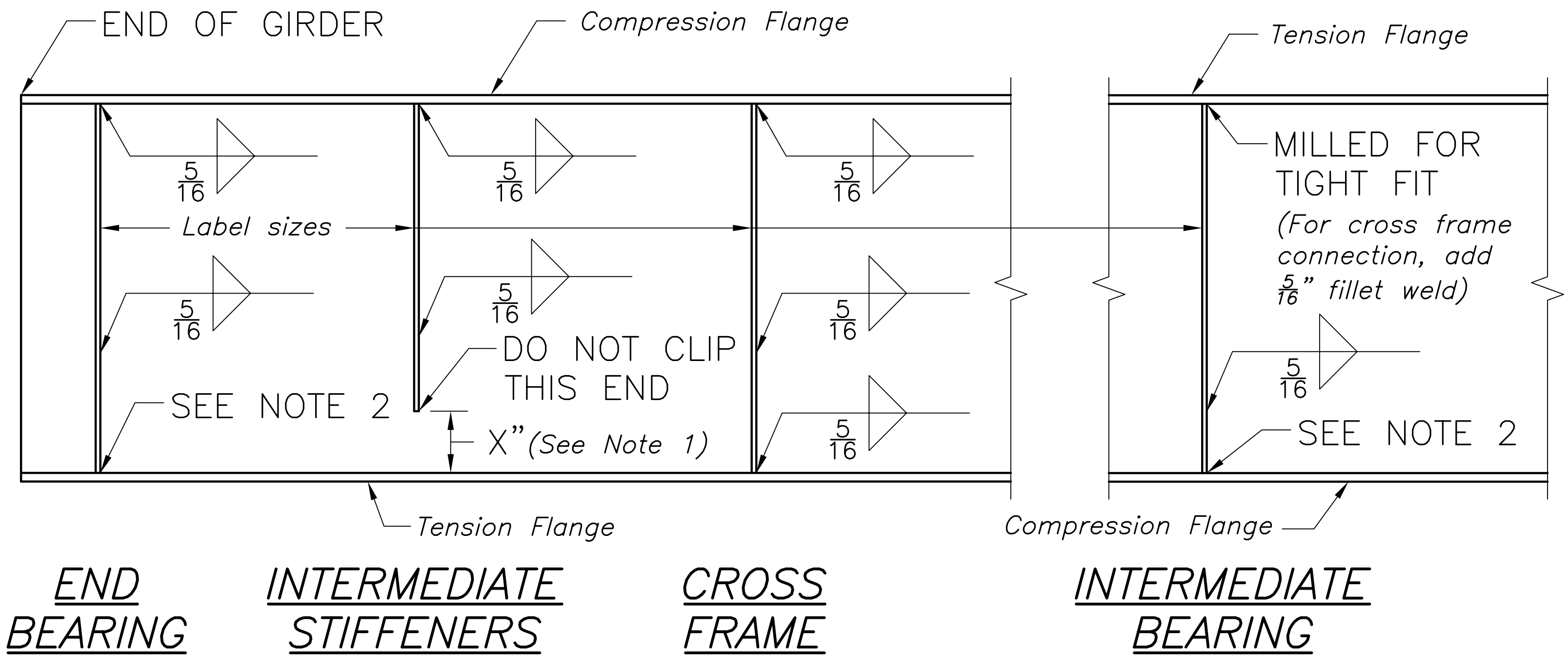
MASS HIGHWAY BRIDGE MANUAL

TYPICAL WELDED GIRDER ELEVATION

PLATE GIRDERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.2.3



NOTES:

1. SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.2.5)*
2. BEARING STIFFENER PLATE AT BOTTOM FLANGE SHALL BE MILLED FOR TIGHT FIT AND WELDED WITH $\frac{5}{16}$" FILLET WELDS BOTH SIDES OF PLATE.

STIFFENER ATTACHMENT DETAILS

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Intermediate stiffeners shall be terminated above the tension flange a distance of 4 to 6 times the web thickness. Show the dimension on the Construction Drawings.*
2. *Bearing stiffener plates shall be wide enough to extend to the outer edges of flange as a minimum.*

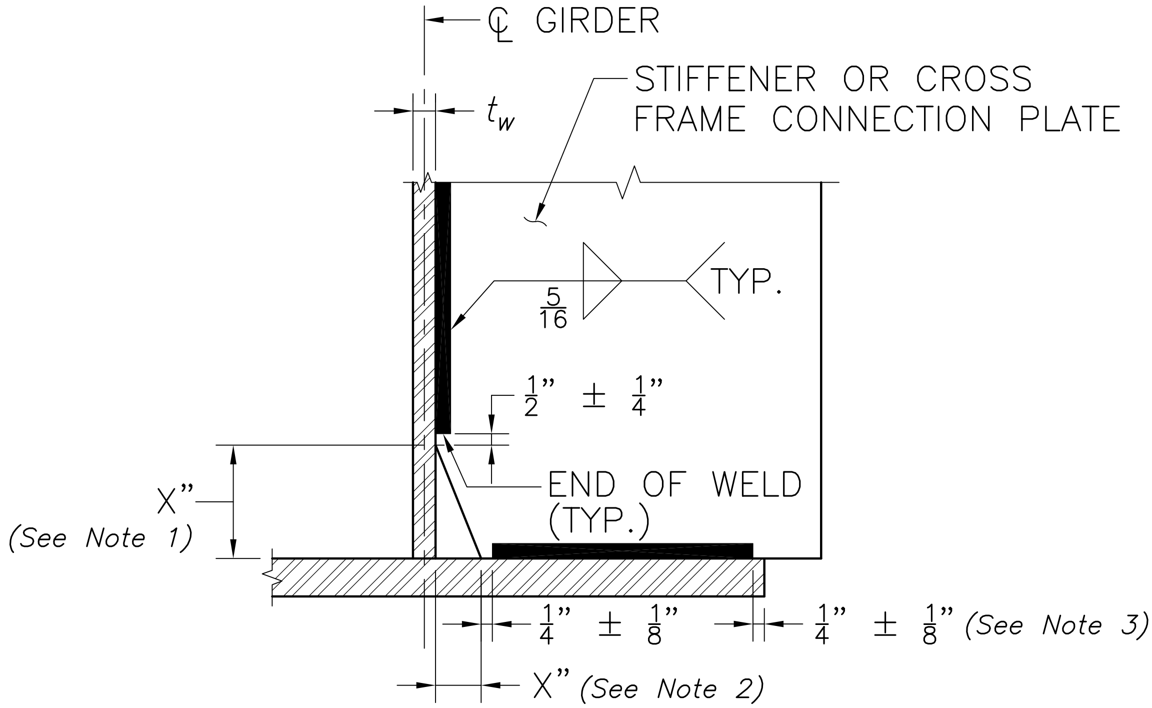
MASS HIGHWAY BRIDGE MANUAL

STIFFENER ATTACHMENT DETAILS

PLATE GIRDERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.2.4



NOTE:

AT STIFFENER LOCATIONS, MODIFY THE PLATE ATTACHMENT TO THE FLANGES AS SHOWN IN THE TYPICAL STIFFENER ATTACHMENTS ON SHEET X.

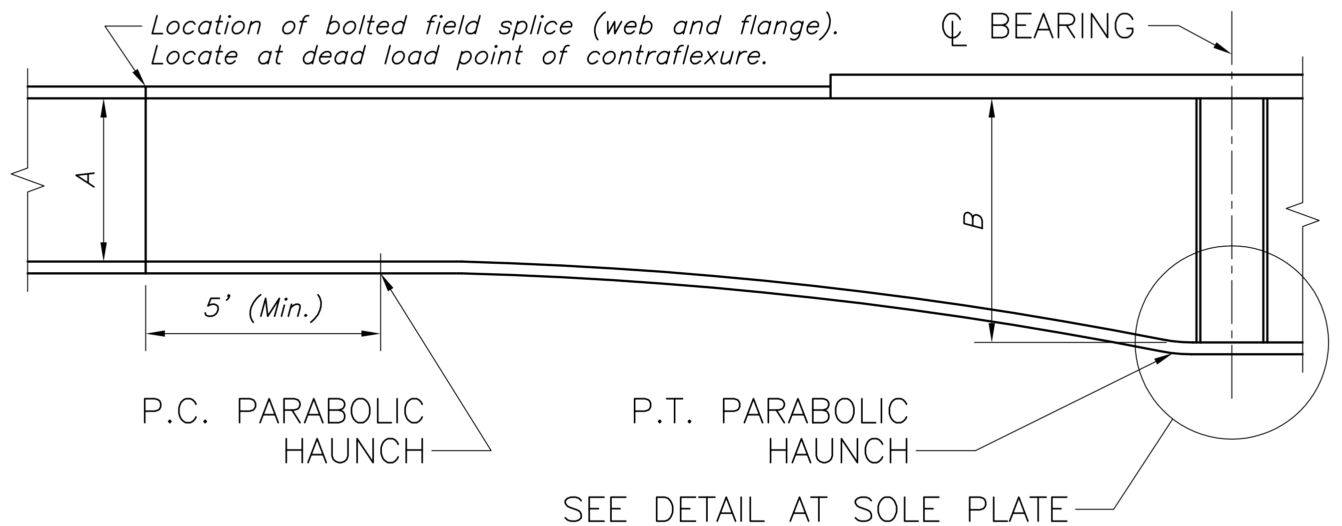
CLIP DETAIL

NOT TO SCALE

NOTES:

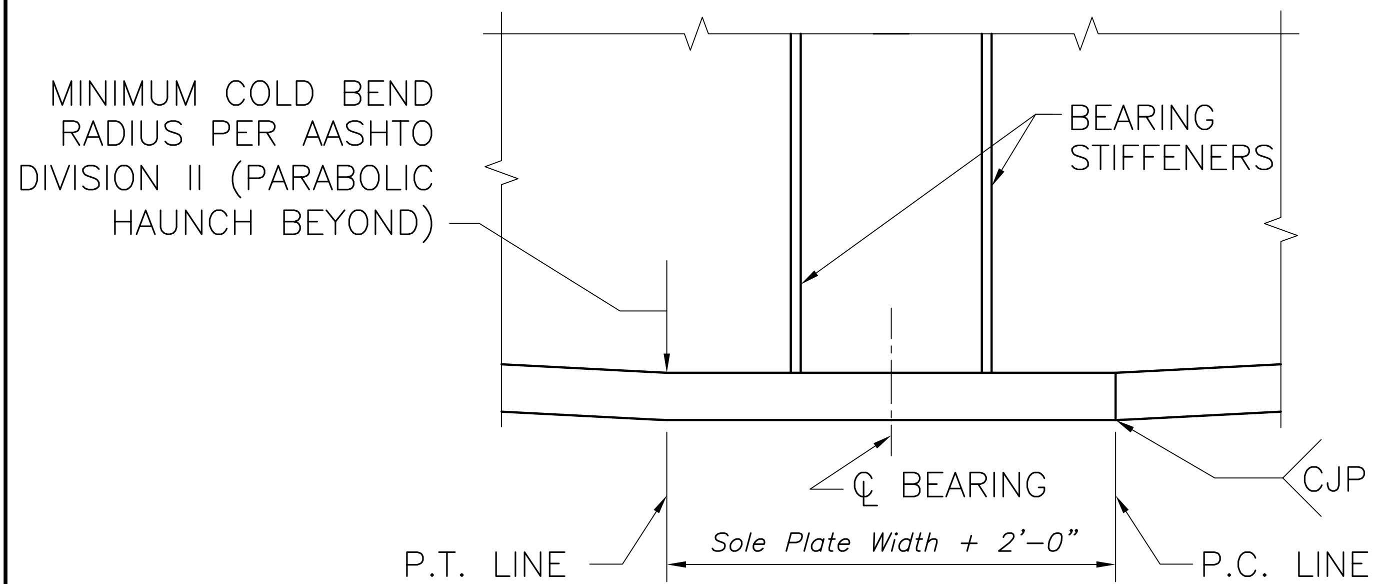
1. *Height of clip shall be 5 x t_W*
2. *Width of clip shall be 2 x t_W*
3. *Terminate weld $\frac{1}{4}$" from edge of flange or connection plate, whichever is encountered first.*

MASS HIGHWAY BRIDGE MANUAL	CLIP DETAIL FOR TRANSVERSE PLATES PLATE GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.2.5**



GIRDER ELEVATION

SCALE: $\frac{1}{2}$" = 1'–0"



NOTE:

FABRICATOR MAY PROVIDE A WELDED JOINT AT THE END OF THE HAUNCH IN LIEU OF THE BEND.

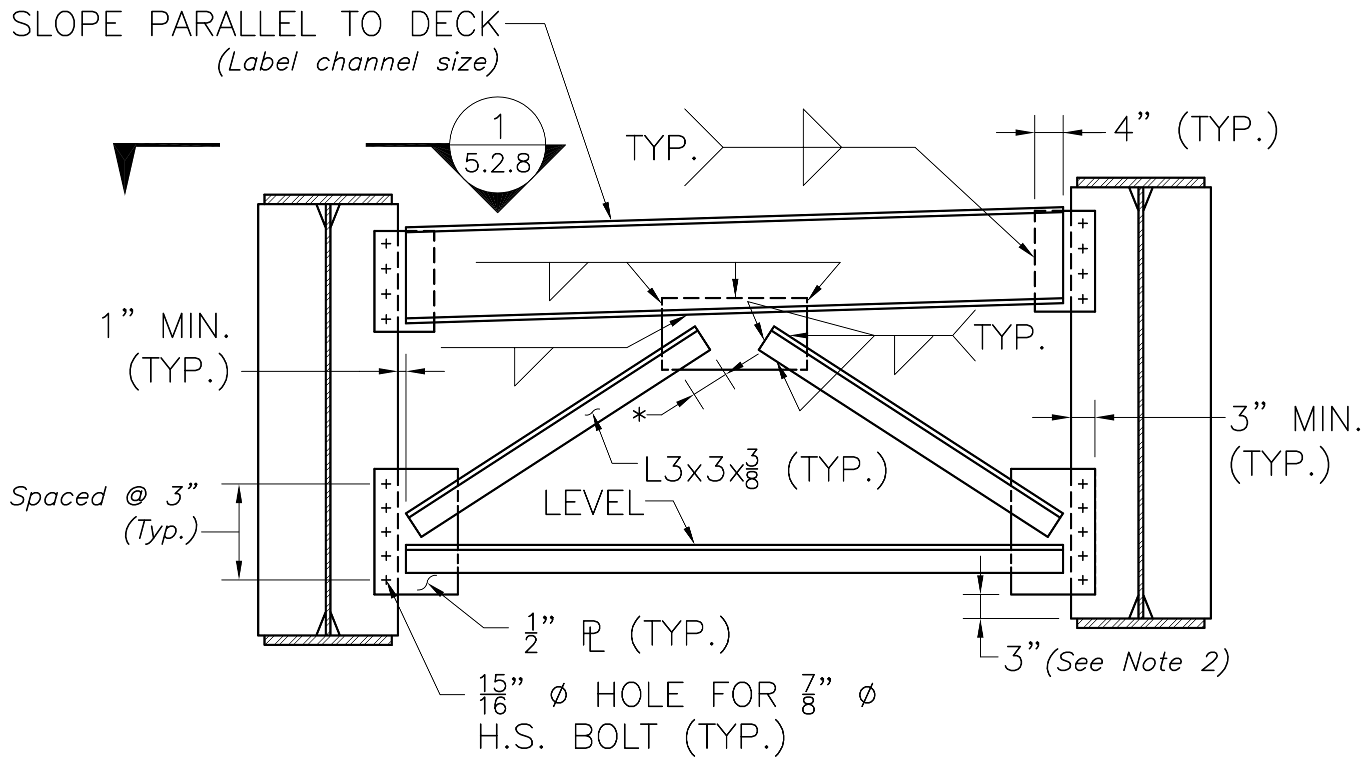
DETAIL AT SOLE PLATE

SCALE: 1" = 1'–0"

NOTES:

1. *Include the above details on the Construction Drawings with all relevant dimensions and plate sizes labeled.*
2. *Where feasible, the haunch shall be proportioned such that the ratio of web depths A/B = 0.7.*
3. *Intermediate stiffeners and connection plates shall be spaced so that they do not interfere with bolted field splices.*
4. *The location of splices shall be shown on the Framing Plan.*
5. *If girders are considered fracture critical, areas in tension shall be shown on Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	PARABOLIC HAUNCH GIRDERS PLATE GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.2.6**



* – 6" MIN. (TYP.)

NOTES:

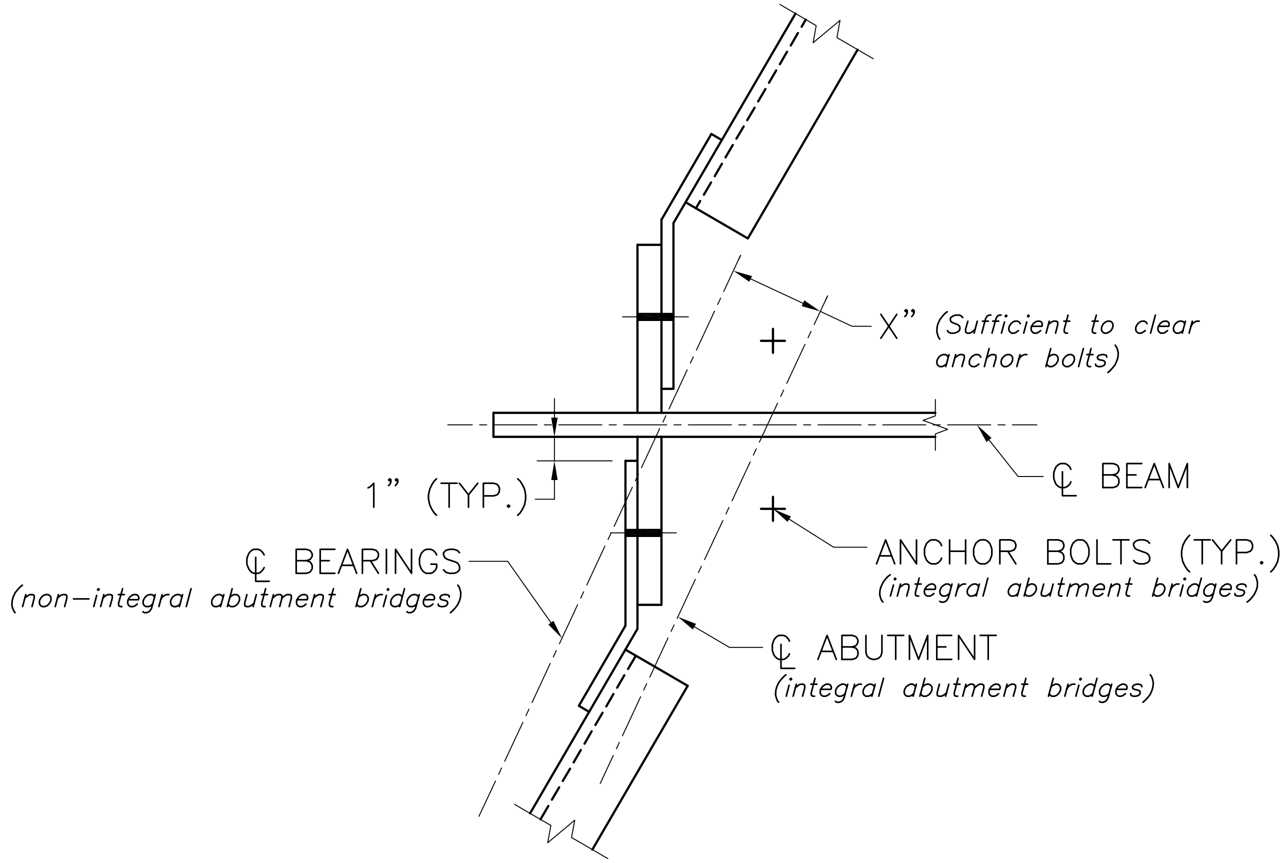
1. SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.2.5)*
2. TERMINATE FILLET WELDS ½" SHORT OF ALL PLATE EDGES.

END CROSS FRAME DETAILS

SCALE: ½" = 1'–0"

NOTES:

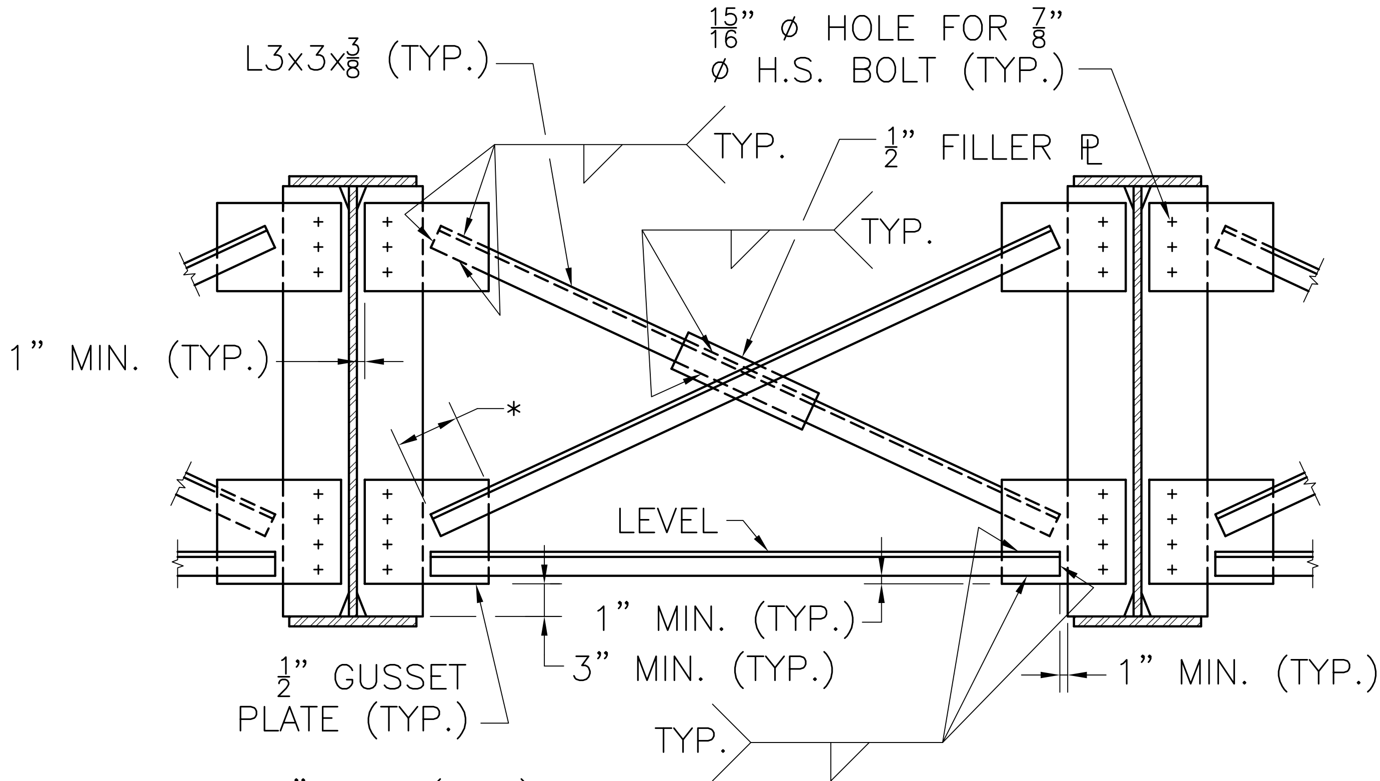
1. *Modify the details as necessary to suit project.*
2. *Cross frame shall be as deep as practical. Dimension the location of the angles and bolts (with edge distances) on this detail. Channel, angles, weld sizes, and number of bolts to be as required by design.*
3. *End cross frames shall be placed parallel to the centerline of bearings as shown in the Framing Plan.*
4. *Size connection plate width as required for attachment of cross frame. If connection plates also serve as bearing stiffeners they shall be at least as wide as flange and shall meet AASHTO size requirements at a minimum. Modify the attachment of the plate to the bottom flange as required (see Dwg. No. 5.2.4).*



SECTION 1

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	END CROSS FRAME DETAILS PLATE GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.2.8**



* – 6" MIN. (TYP.)

NOTES:

1. SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.2.5)*

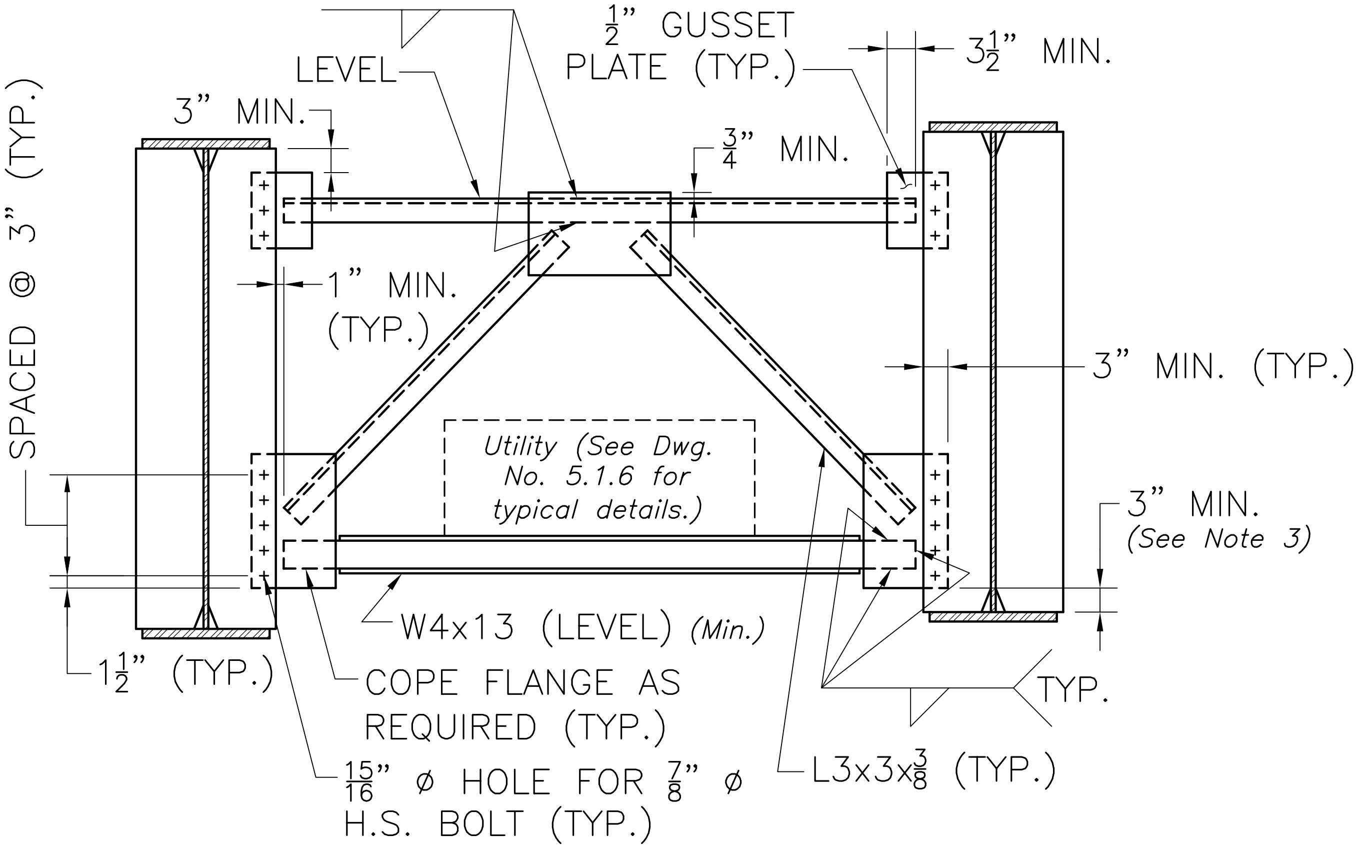
2. TERMINATE FILLET WELDS 1/2" SHORT OF ALL PLATE EDGES.

INTERMEDIATE CROSS FRAME DETAILS

SCALE: 1/2" = 1'–0"

NOTES:

1. *Cross frame shall be as deep as practical. Dimension the location of the angles and bolts (with edge distances) on this detail. Channel, angles, weld sizes, and number of bolts to be as required by design.*
2. *Maximum spacing of cross frames shall not exceed 25'–0".*
3. *Size the connection plate width as required for attachment of angles. If connection plates also serve as web stiffeners, plate size shall at a minimum meet AASHTO and the Bridge Manual requirements (See Dwg. No. 5.2.2).*



NOTE:

SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.2.5)*

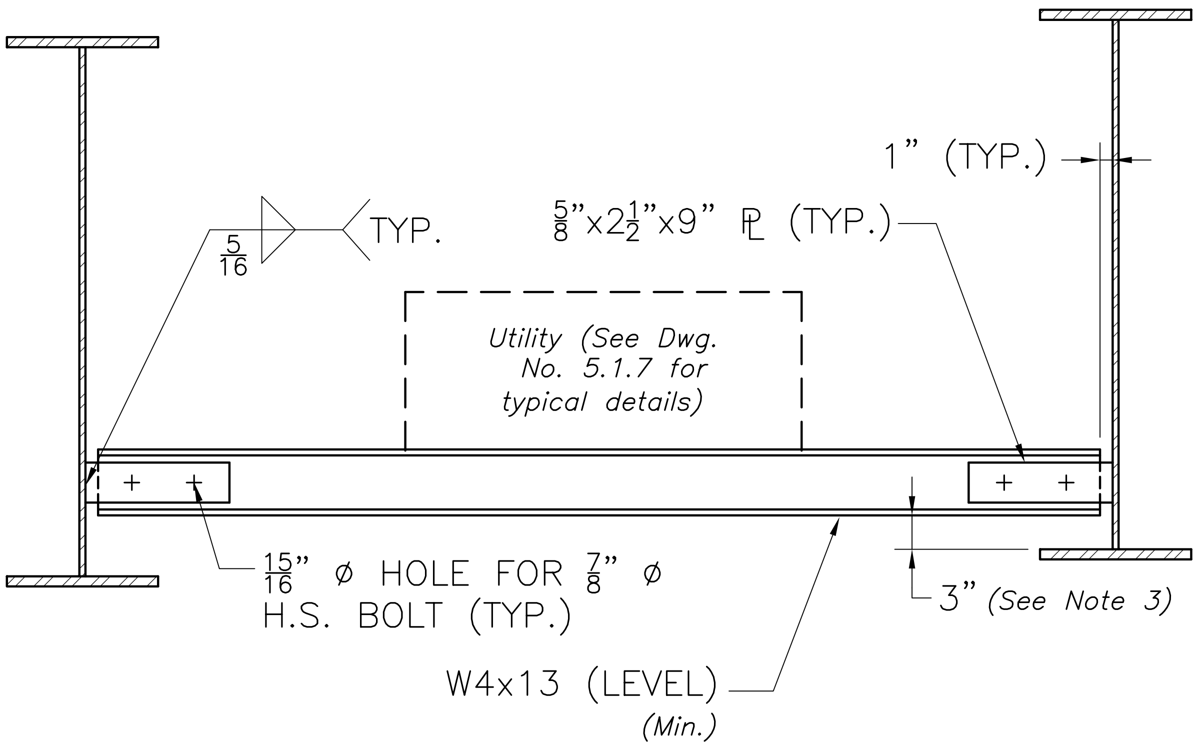
UTILITY SUPPORT DETAILS AT INTERMEDIATE CROSS FRAMES

SCALE: ½" = 1'–0"

NOTES:

1. *Modify the details as necessary to suit project.*
2. *Combine this drawing with the details shown on Dwg. No. 5.2.11.*
3. *Intermediate support frames shall be as deep as practical. Dimension the location of the angles, support, and bolt holes (with edge distances) on this detail.*
4. *Size the connection plate width as required for the attachment of angles and support. If the connection plates also serve as web stiffeners, plate size shall at a minimum meet AASHTO and the Bridge Manual requirements (see Dwg. No. 5.2.2).*
5. *A minimal size of the utility support beam is shown. Actual size shall be as required by design.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY SUPPORT DETAILS AT CROSS FRAMES PLATE GIRDERS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **5.2.10**

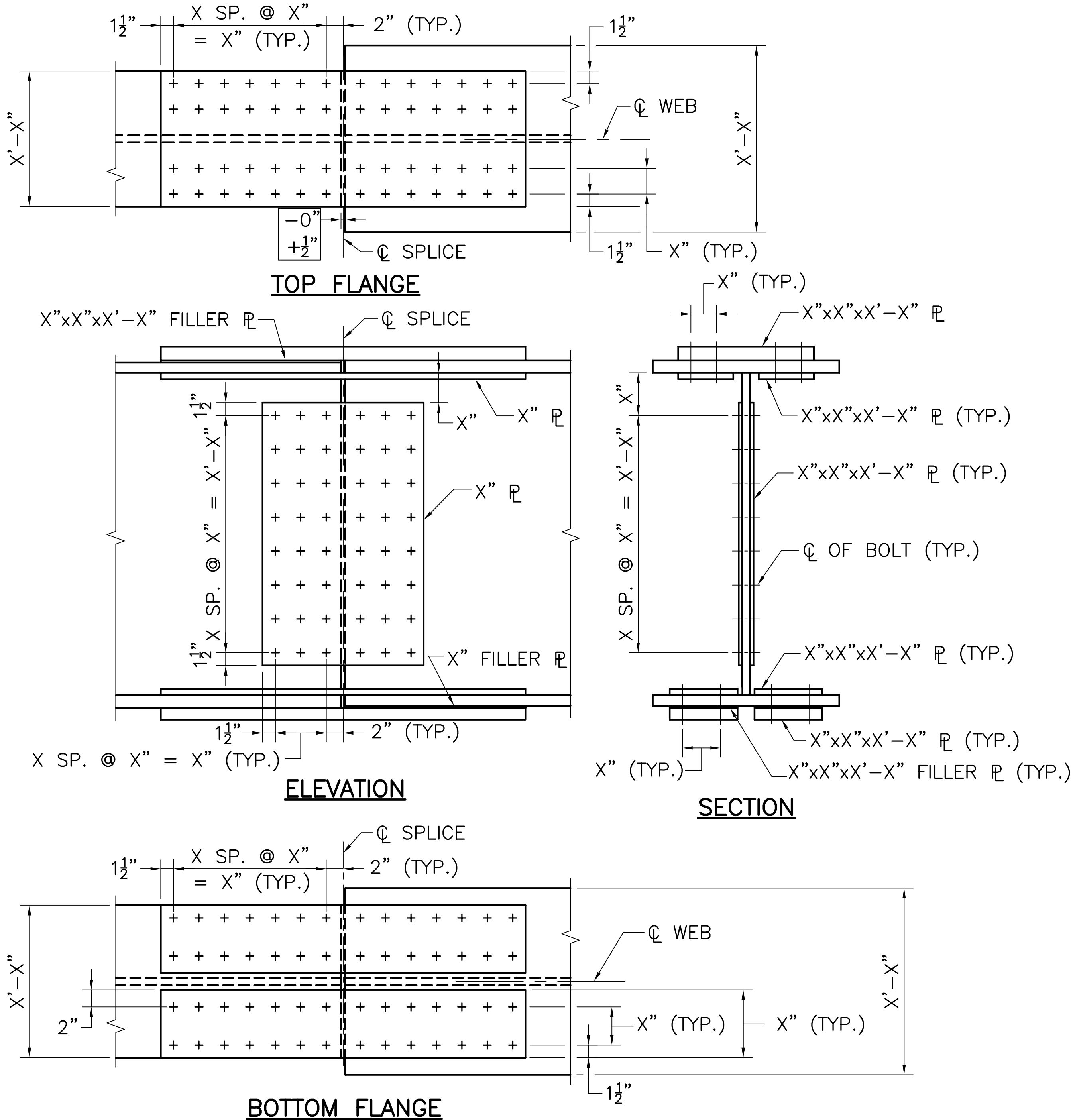


UTILITY SUPPORT DETAILS BETWEEN CROSS FRAMES

SCALE: 1" = 1'-0"

NOTES:

1. *Modify the details as necessary to suit project.*
2. *Combine this drawing with the details shown on Dwg. No. 5.2.10.*
3. *Dimension the location of the support and bolt holes (with edge distances) on this detail. Location of W4x13 shall be compatible with detail of utility supports at intermediate cross frames.*
4. *A minimal size of the utility support beam is shown. Actual size shall be as required by design.*



NOTES:

1. BOLTED FIELD SPLICES SHALL BE CONSIDERED SLIP CRITICAL CONNECTIONS WITH CLASS B FAYING SURFACES. *(Change to Class C for galvanized surfaces.)*

2. + DENOTES ⅞" ø AASHTO M 164 HIGH STRENGTH BOLT IN $\frac{15}{16}$" ø HOLE.

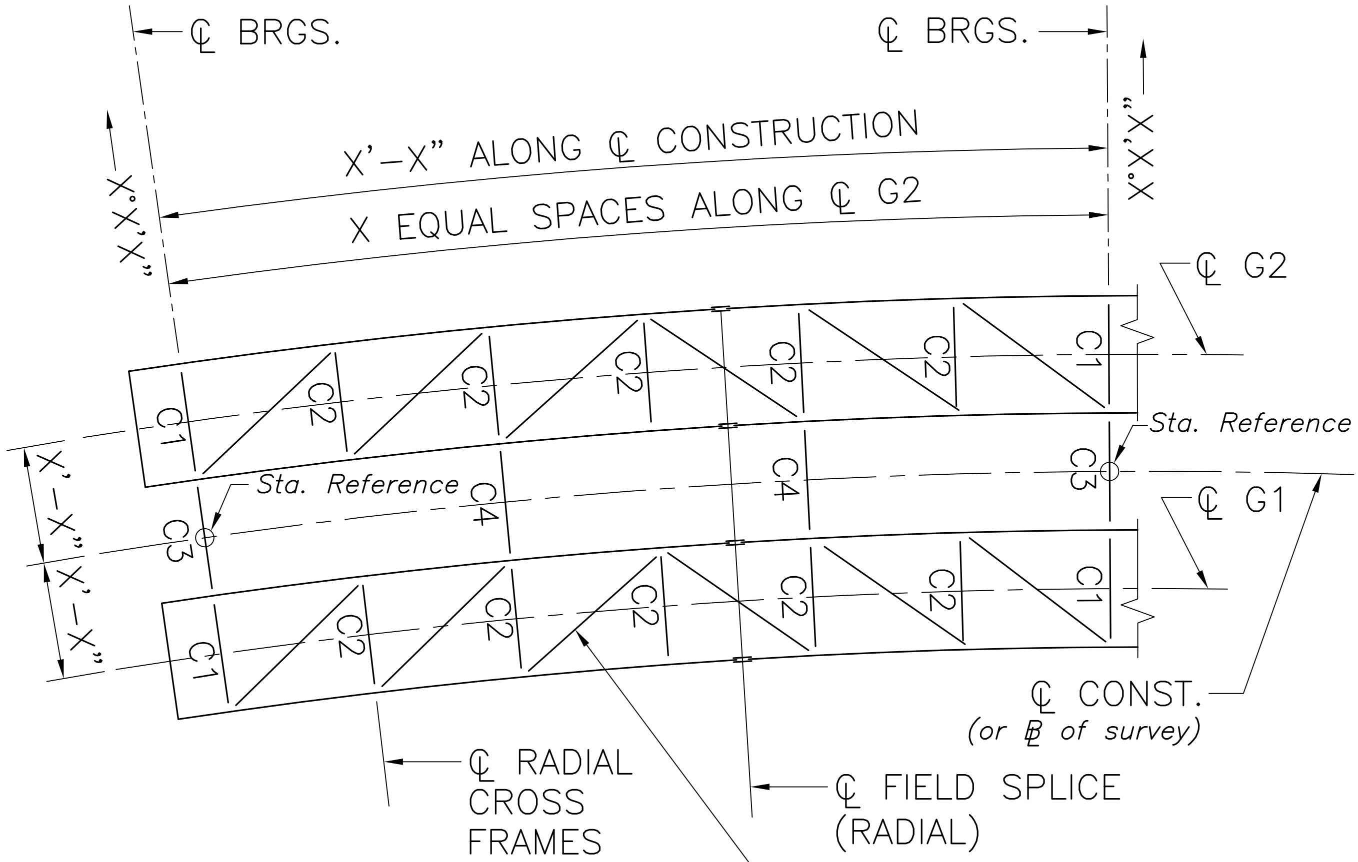
3. THICKNESS DIFFERENCES OF $\frac{1}{16}$" OR LESS DO NOT REQUIRE FILLER PLATES. FILLER PLATES SHALL CONFORM TO AASHTO M 270 GRADE 50W OR ASTM A606. *(Include where required.)*

4. ONE ROW OF STUD SHEAR CONNECTORS SHALL BE PLACED ALONG THE CENTERLINE OF THE TOP FLANGE SPLICE PLATE.

BOLTED FIELD SPLICE DETAILS

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	BOLTED FIELD SPLICE DETAILS PLATE GIRDERS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **5.2.12**



NOTES:

1. C1 = TYPICAL INTERIOR END CROSS FRAME.
   C2 = TYPICAL INTERIOR INTERMEDIATE CROSS FRAME.
   C3 = TYPICAL EXTERIOR END CROSS FRAME.
   C4 = TYPICAL EXTERIOR INTERMEDIATE CROSS FRAME.
2. SEE SHEET X FOR CROSS FRAME AND UTILITY SUPPORT DETAILS.
3. THE MAIN LOAD CARRYING MEMBERS ARE XXX.

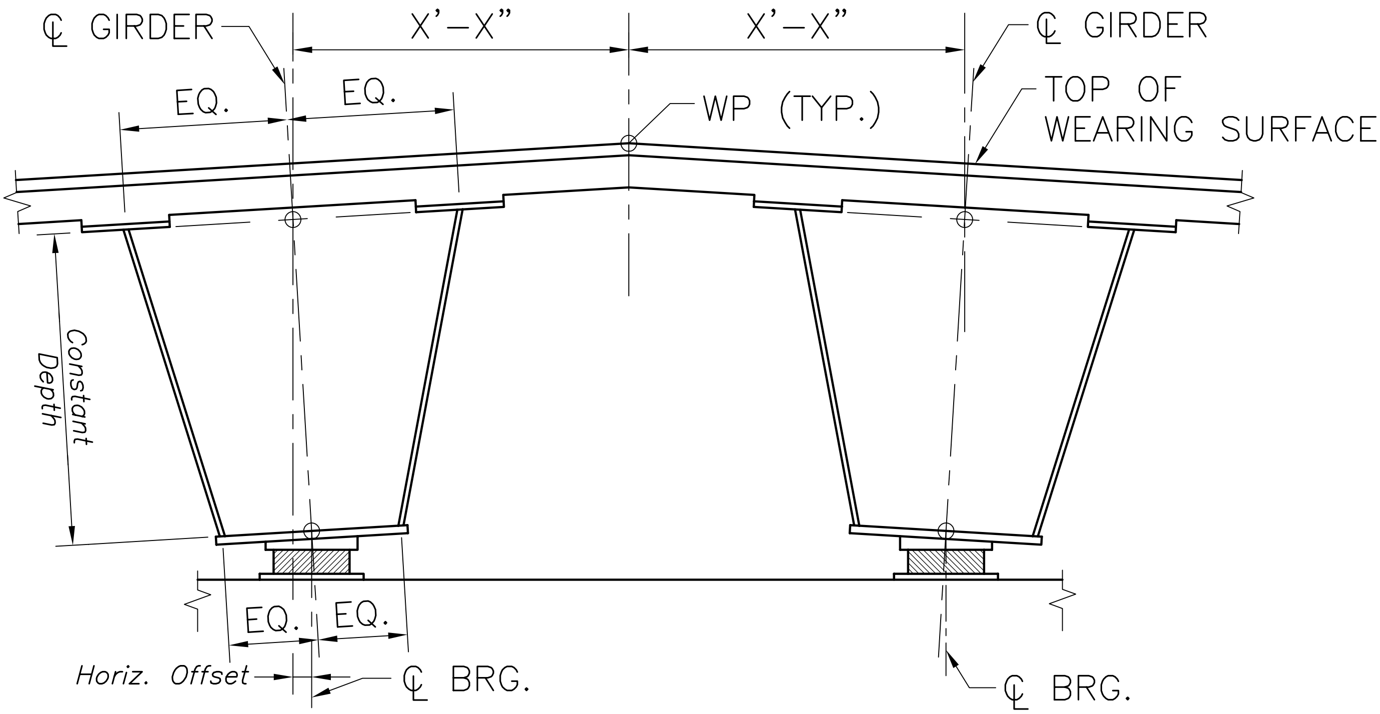
FRAMING PLAN

SCALE: $\frac{1}{8}$" = 1'–0"

NOTES:

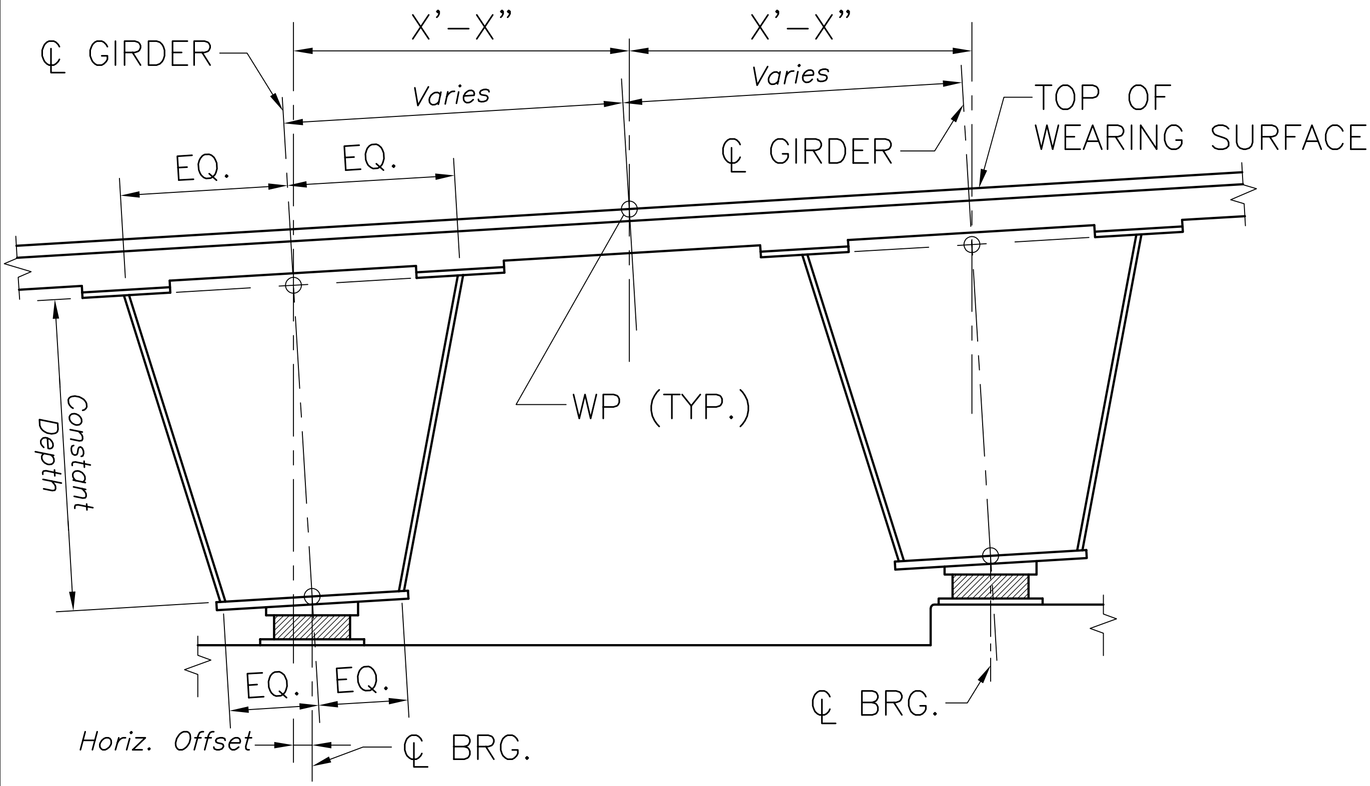
1. *See additional notes on Dwg. No.'s 5.2.1. and 5.2.2.*
2. *Exterior cross frame spacing shall be governed by design requirements.*
3. *Framing plan shows preferred top flange internal bracing configuration.*
4. *Space cross frames along center line of longest girder.*
5. *Radial layout preferred.*
6. *The girders shall be consecutively numbered from South to North for bridges oriented generally east–west and from West to East for bridges oriented generally north–south. Spans shall be consecutively numbered from West to East for bridges generally oriented east–west and from South to North for bridges generally oriented north–south.*
7. *Dimension locations of inspection access hatches in bottom flanges. Provide 1 hatch per steel box girder per substructure.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL FRAMING PLAN STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.1**



CROWNED ROADWAY SECTION

SCALE: $\frac{1}{4}$" = 1'–0"



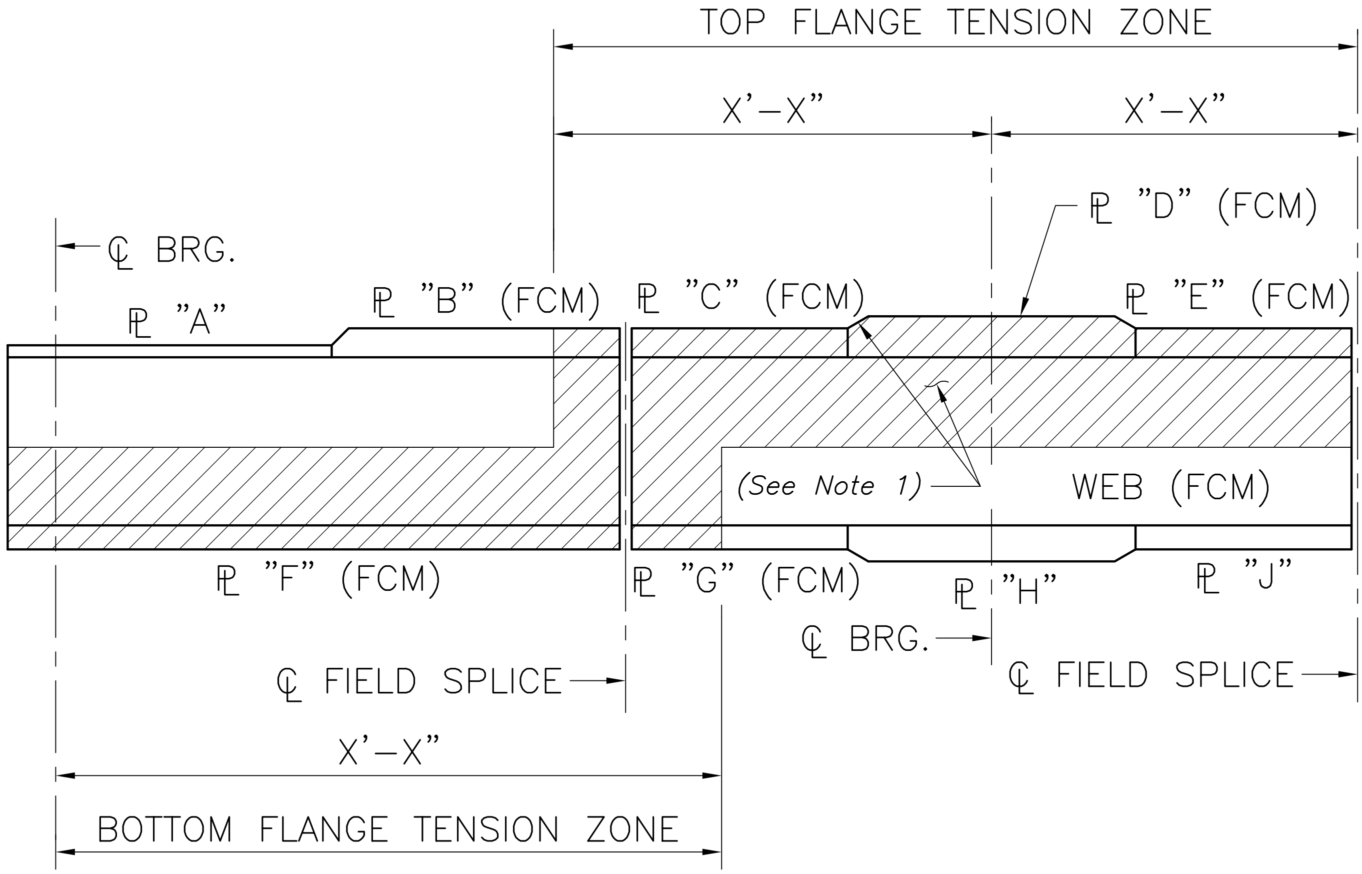
SUPERELEVATED ROADWAY SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Rotate boxes to follow cross slope.*
2. *Maintain constant trapezoidal shape.*
3. *WP indicates working point. Working points shall be defined on Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL GEOMETRY STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.2**



NOTES:

1. FCM DENOTES FRACTURE CRITICAL MEMBERS OR MEMBER COMPONENTS.

2. HATCHED AREA DENOTES TENSION ZONES. WELDS WITHIN THESE ZONES ARE SUBJECT TO FRACTURE CRITICAL TESTING REQUIREMENTS.

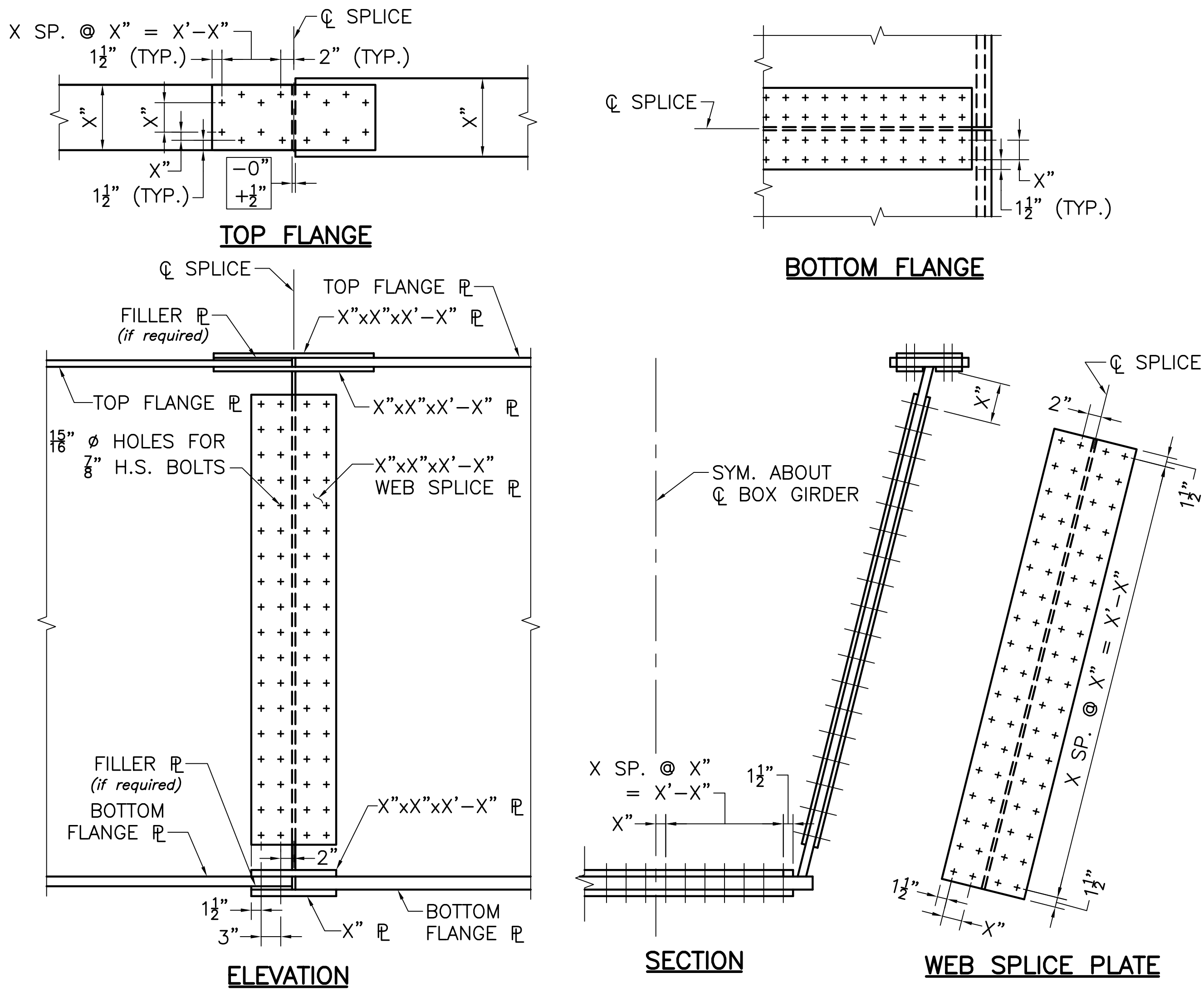
SCHEMATIC GIRDER ELEVATION

NOT TO SCALE

NOTES:

1. *Fracture critical requirements for top flange tension zone apply only to single box girder bridges.*
2. *Provide a table of plate sizes.*

MASS HIGHWAY BRIDGE MANUAL	FRACTURE CRITICAL MEMBERS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.3**



NOTES:

1. BOLTED FIELD SPLICES SHALL BE CONSIDERED SLIP–CRITICAL CONNECTIONS WITH CLASS B FAYING SURFACES. *(Change to Class C for galvanized surfaces.)*

2. + DENOTES 7/8" ø AASHTO M 164 HIGH STRENGTH BOLT IN 15/16" ø HOLE.

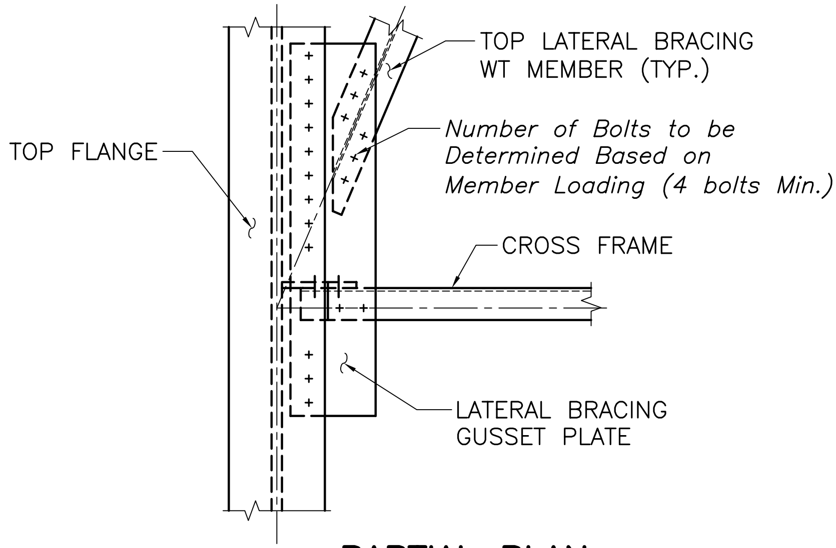
3. THICKNESS DIFFERENCES OF 1/16" OR LESS DO NOT REQUIRE FILLER PLATES. FILLER PLATES SHALL CONFORM TO AASHTO M 270 GRADE 50W OR ASTM A606. *(Include where required.)*

4. ONE ROW OF STUD SHEAR CONNECTORS SHALL BE PLACED ALONG THE CENTERLINE OF THE TOP FLANGE SPLICE PLATES.

BOLTED FIELD SPLICE DETAILS

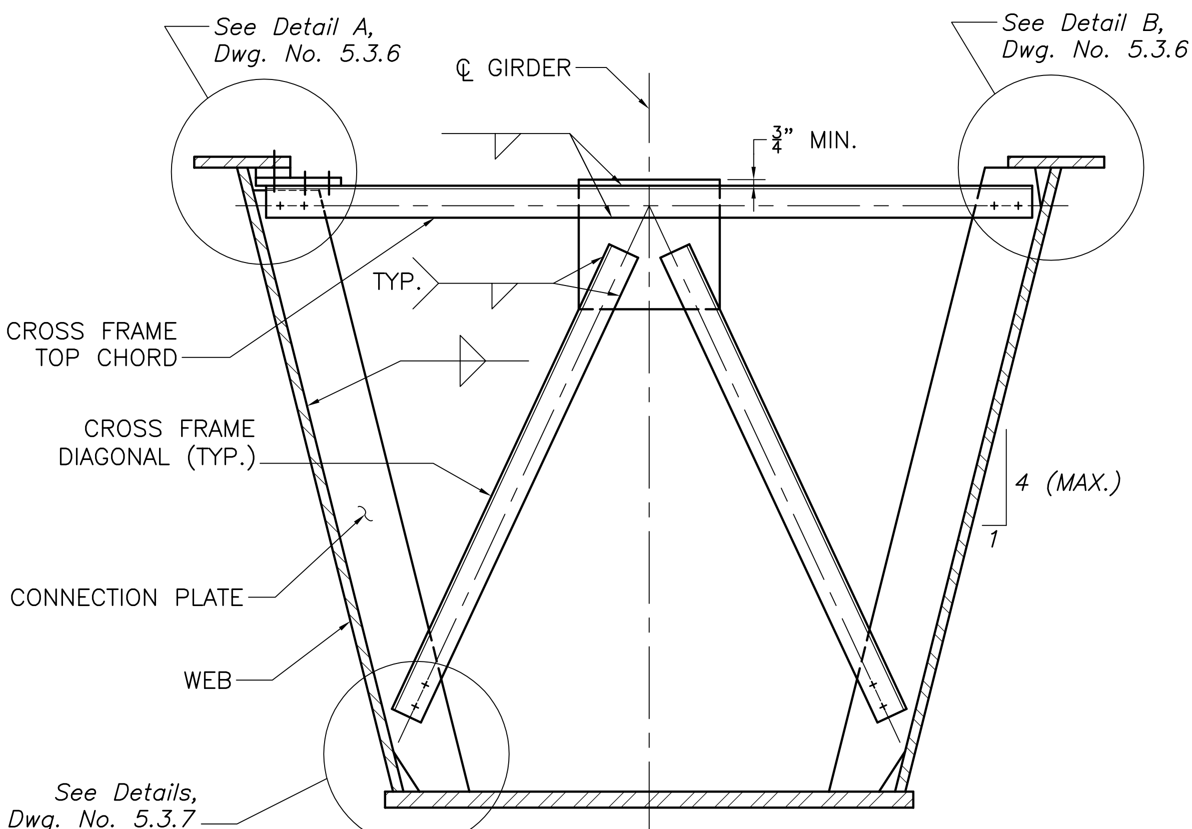
SCALE: 3/4" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	BOLTED FIELD SPLICE DETAILS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 5.3.4



PARTIAL PLAN

SCALE: $\frac{3}{4}$" = 1'–0"



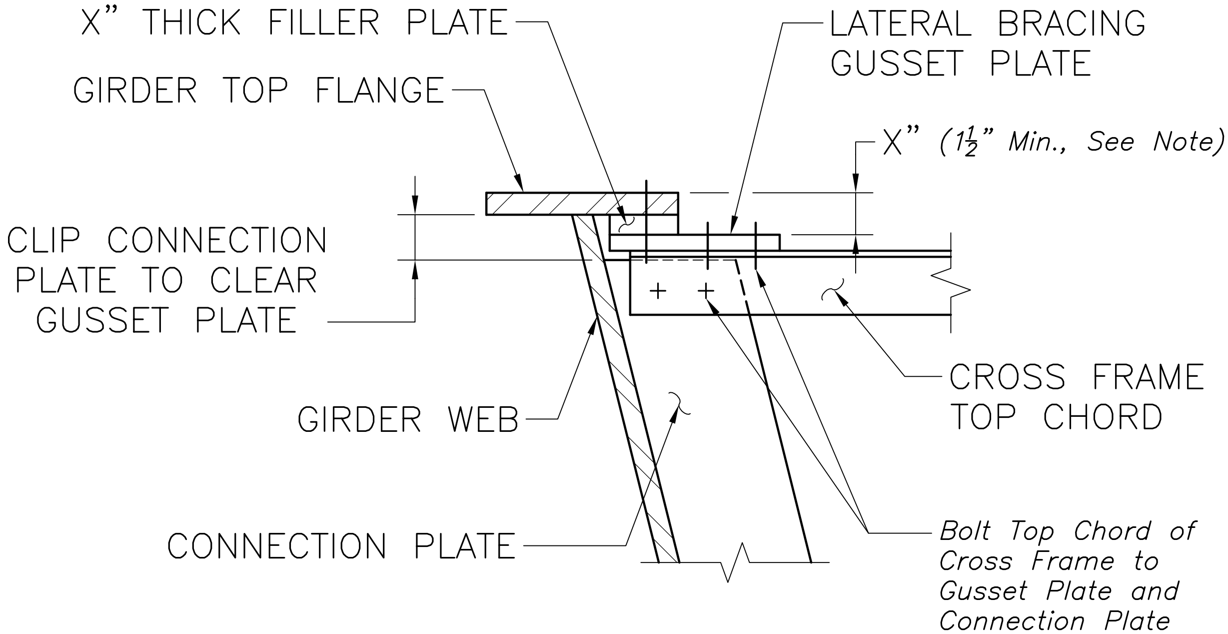
INTERIOR INTERMEDIATE CROSS FRAME DETAILS

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *The top lateral bracing may be bolted directly to the flange without a gusset plate where the flange width permits.*
2. *Single angles are preferred for intermediate cross frames. Double angles may be required as the design dictates.*
3. *Rectangular gusset plates are preferred.*

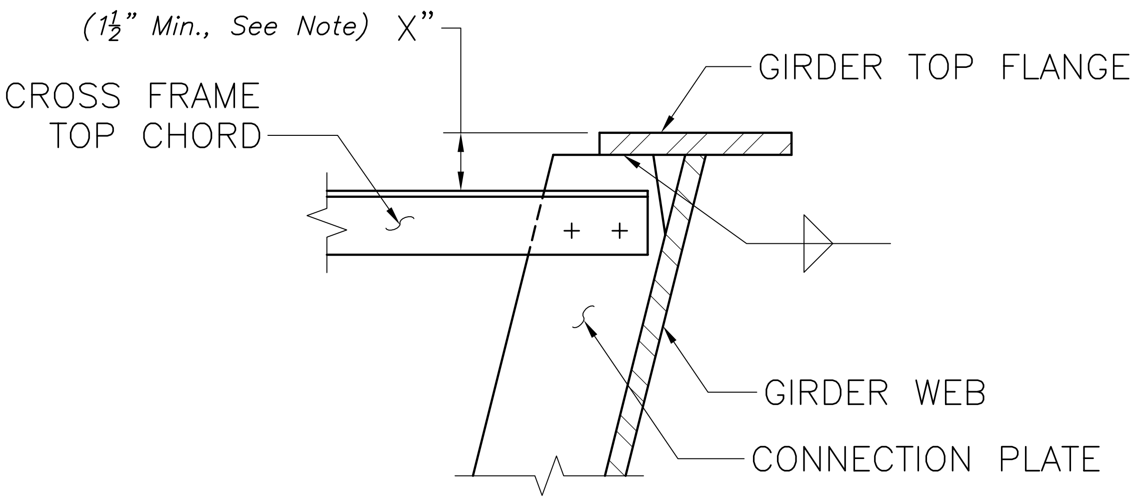
MASS HIGHWAY BRIDGE MANUAL	INTERIOR INTERMEDIATE CROSS FRAME DETAILS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.5**



WITH LATERAL BRACING

DETAIL A

SCALE: 1" = 1'–0"



WITHOUT LATERAL BRACING

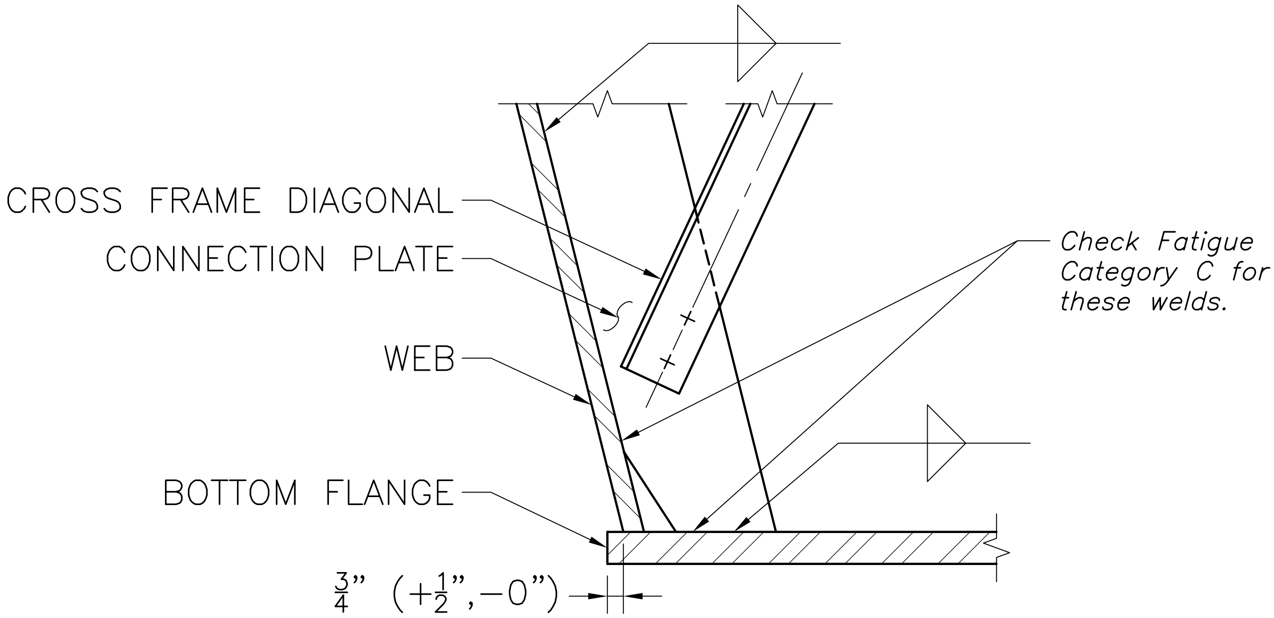
DETAIL B

SCALE: 1" = 1'–0"

NOTE:

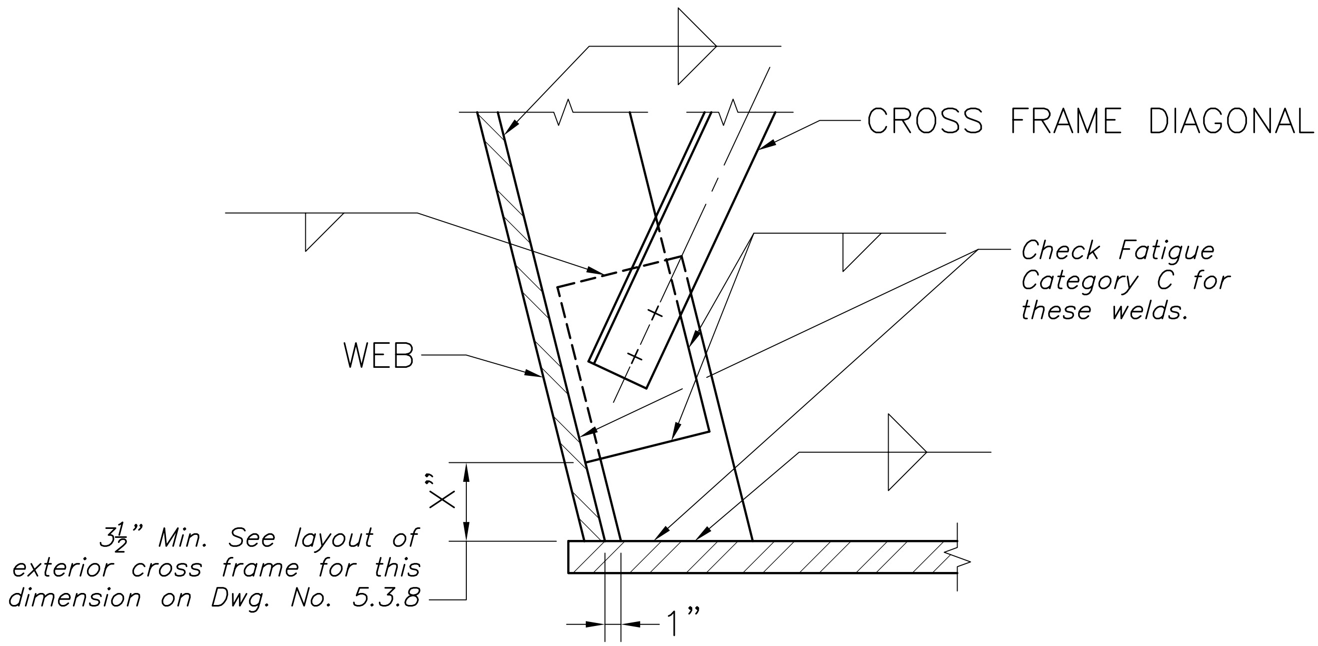
Leave gap to facilitate deck forming. Always keep dimension consistent between cross frames.

MASS HIGHWAY BRIDGE MANUAL	INT. INTERMEDIATE CROSS FRAME CONNECTION DETAILS BOX GIRDERS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **5.3.6**



CONNECTION DETAIL

SCALE: 1" = 1'−0"



NOTES:

1. SEE CLIP DETAIL ON SHEET X. *(See Dwg. No. 5.2.5)*
2. TERMINATE FILLET WELDS $\frac{1}{2}$" SHORT OF ALL PLATE EDGES.

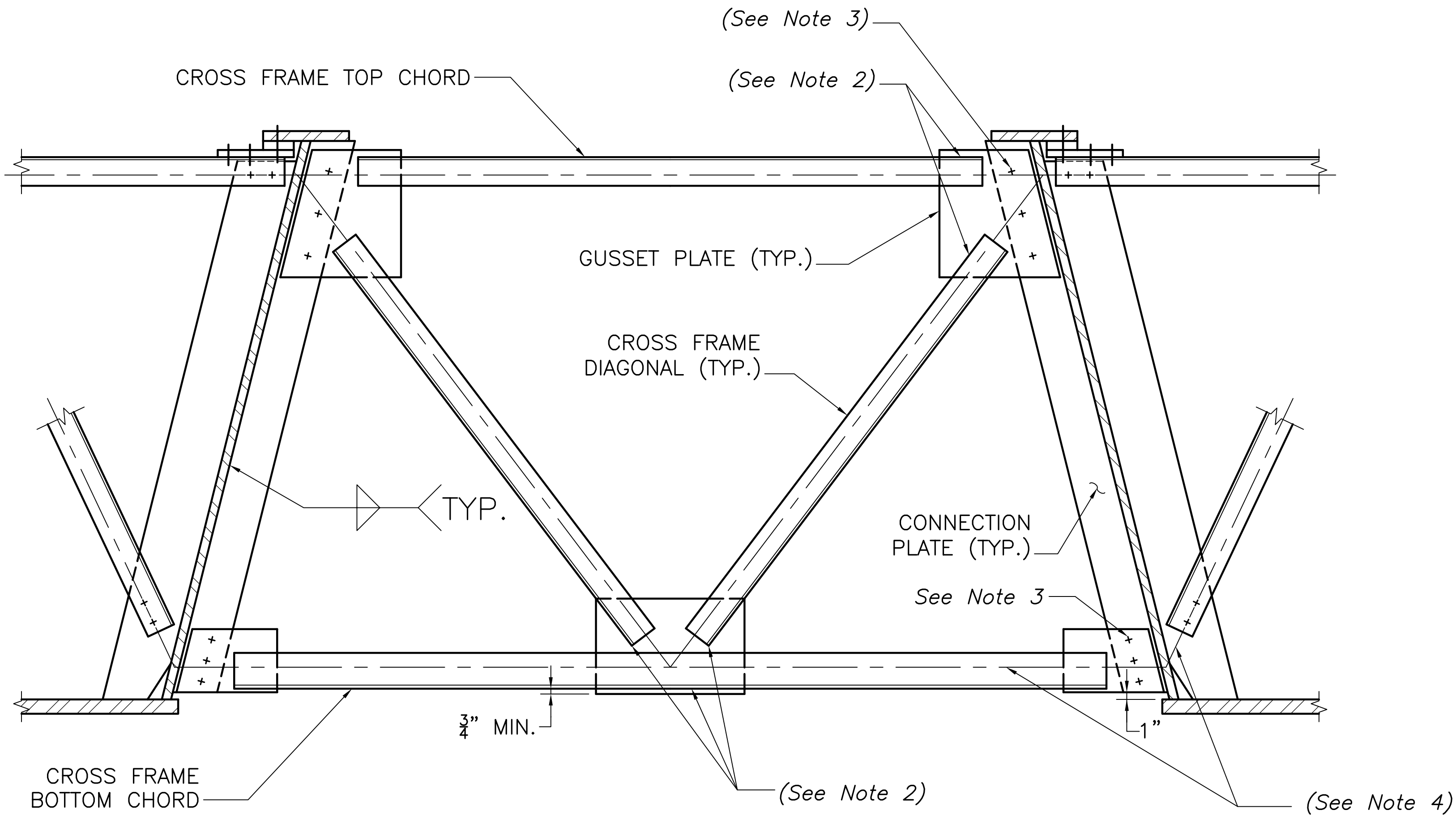
CONNECTION DETAIL (ALTERNATE)

SCALE: 1" = 1'−0"

NOTE:

Both details shall be shown on the Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	INT. INTERMEDIATE CROSS FRAME CONNECTION DETAILS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.7**



EXTERIOR INTERMEDIATE CROSS FRAME

SCALE: ¾" = 1'–0"

NOTES:

1. *The interior cross frame members shall be designed to accommodate the forces from the exterior cross frames.*
2. *Weld all angles to gusset plates with fillet welds on near side only.*
3. *Minimum number of bolts shown. Actual number of bolts shall be determined by design.*
4. *Line of action for interior and exterior cross frame members shall be coincident to the centerline of web.*

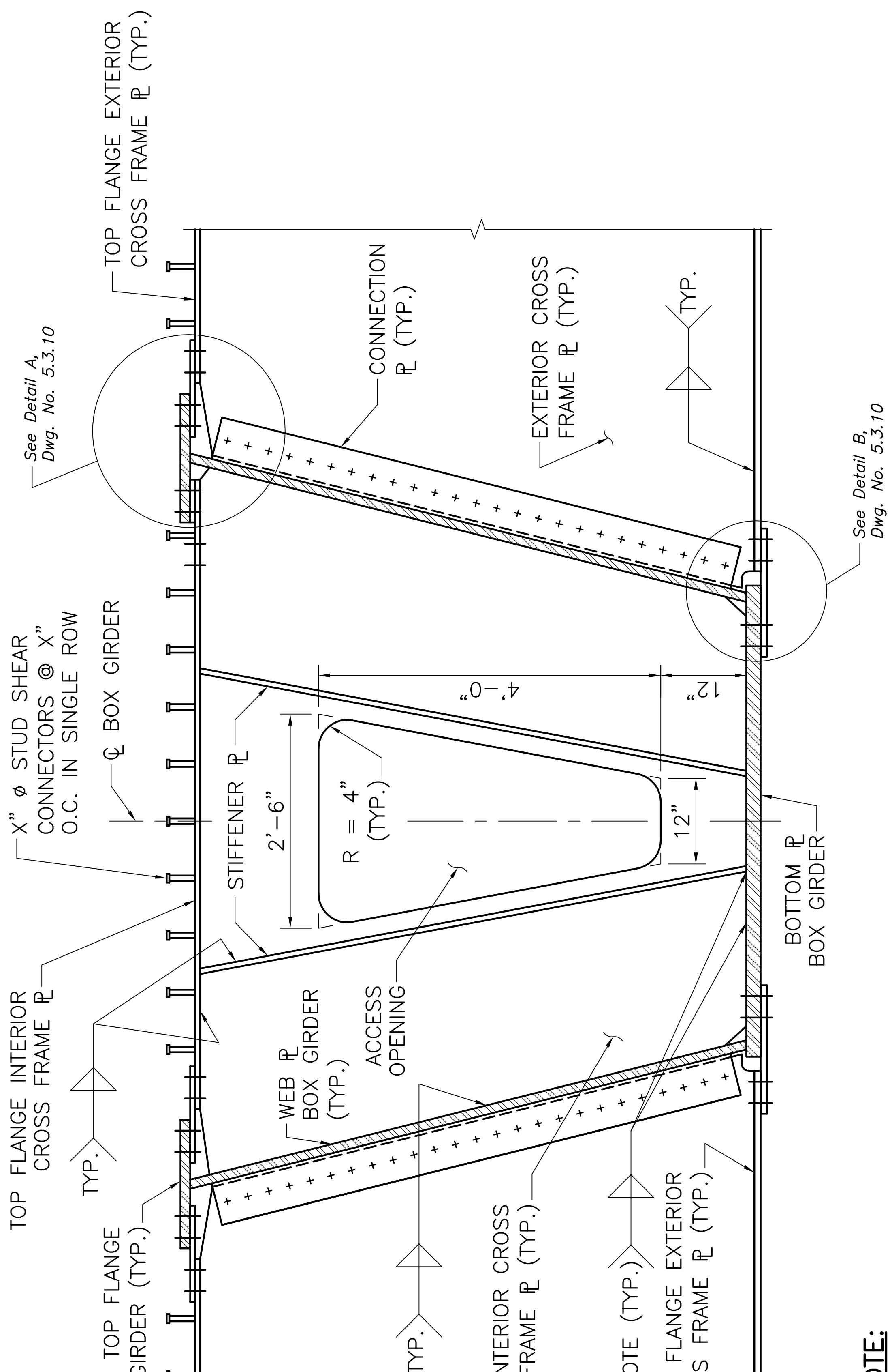
MASS HIGHWAY BRIDGE MANUAL

EXTERIOR INTERMEDIATE CROSS FRAME

STEEL BOX GIRDERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.3.8



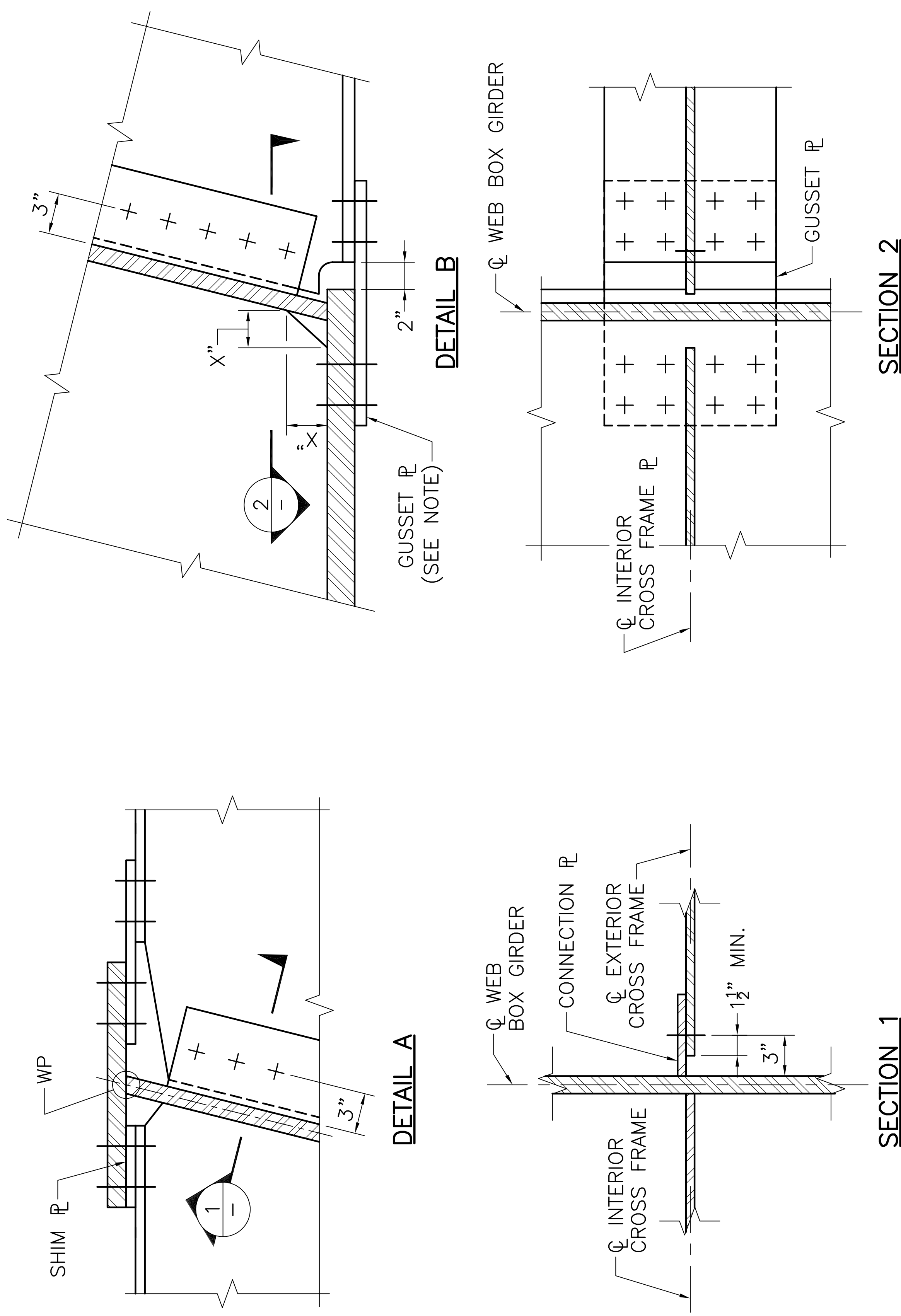
NOTE:

ALL CROSS FRAME AND STIFFENER PLATE CONNECTIONS TO BOX GIRDER BOTTOM FLANGE ARE MILLED TO BEAR.

END CROSS FRAME

SCALE: $\frac{3}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	END CROSS FRAME STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.9**

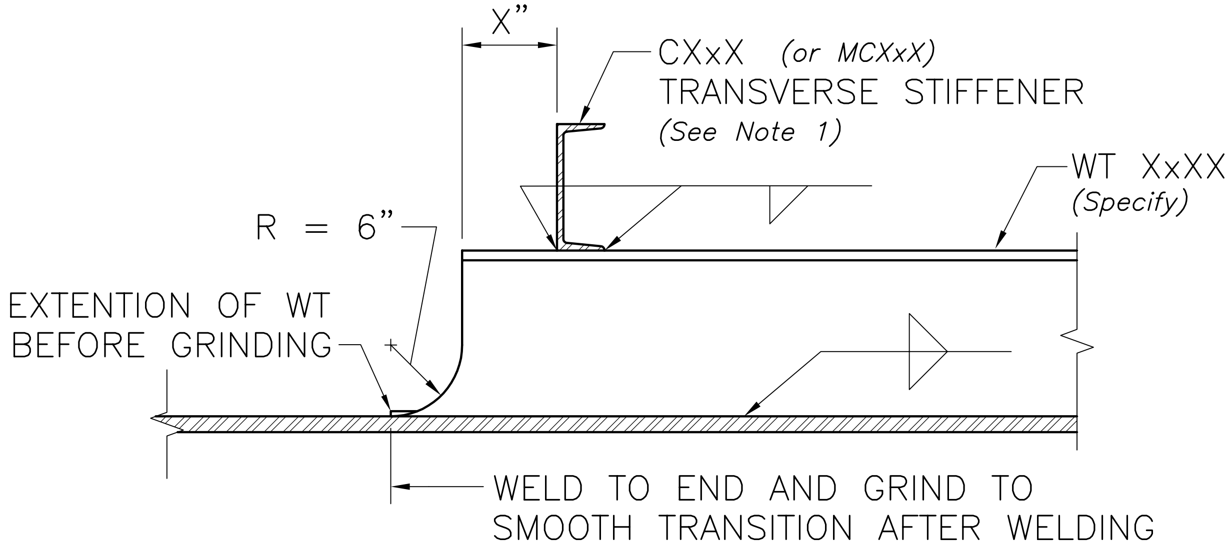


NOTE:
BEND PLATE AS REQUIRED WHEN CONNECTING CROSS FRAME BETWEEN BOXES WITH VARYING CROSS SLOPE.

END CROSS FRAME CONNECTION DETAILS

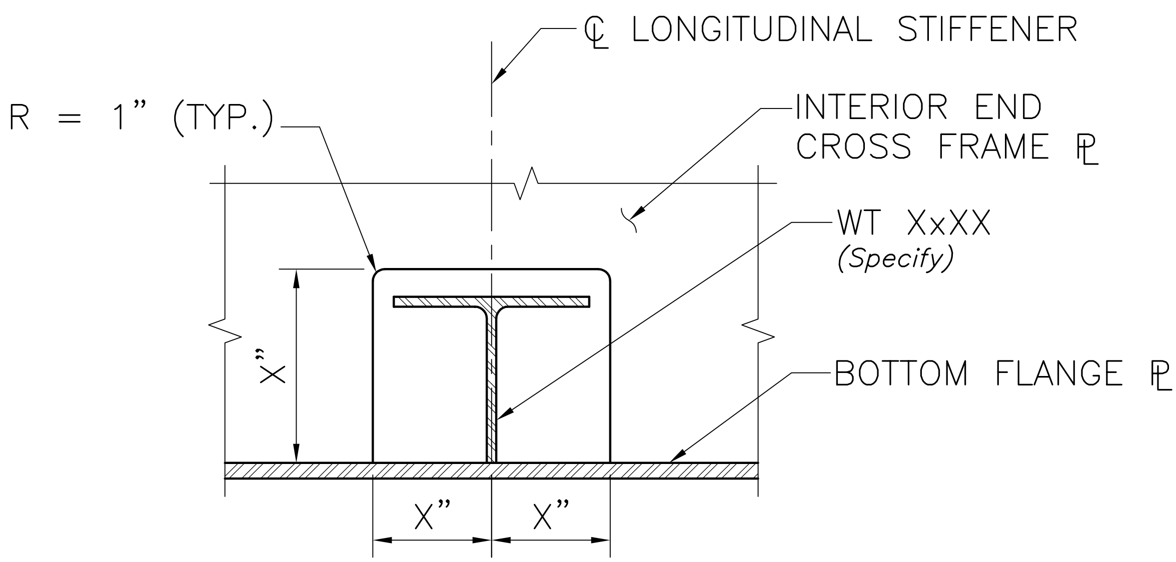
SCALE: $1\frac{1}{2}$" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	END CROSS FRAME CONNECTION DETAILS STEEL BOX GIRDER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.10**



BOTTOM FLANGE STIFFENER TERMINUS DETAIL

NOT TO SCALE



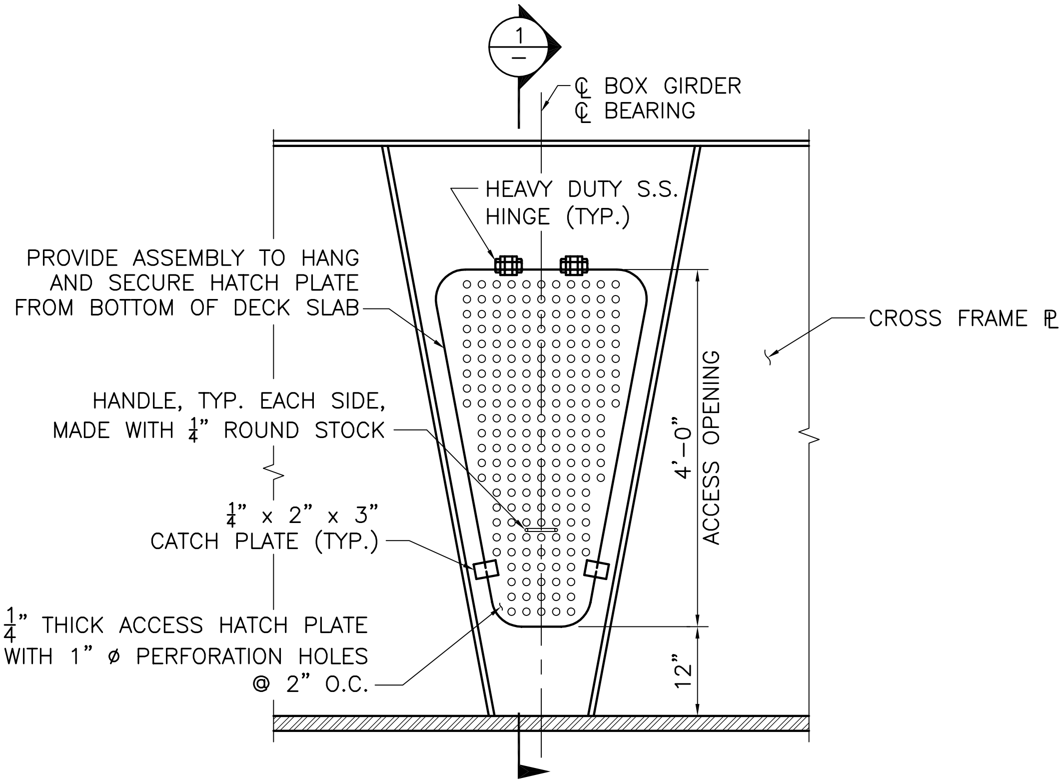
BOTTOM FLANGE STIFFENER/ PIER CROSS FRAME INTERFACE

NOT TO SCALE

NOTES:

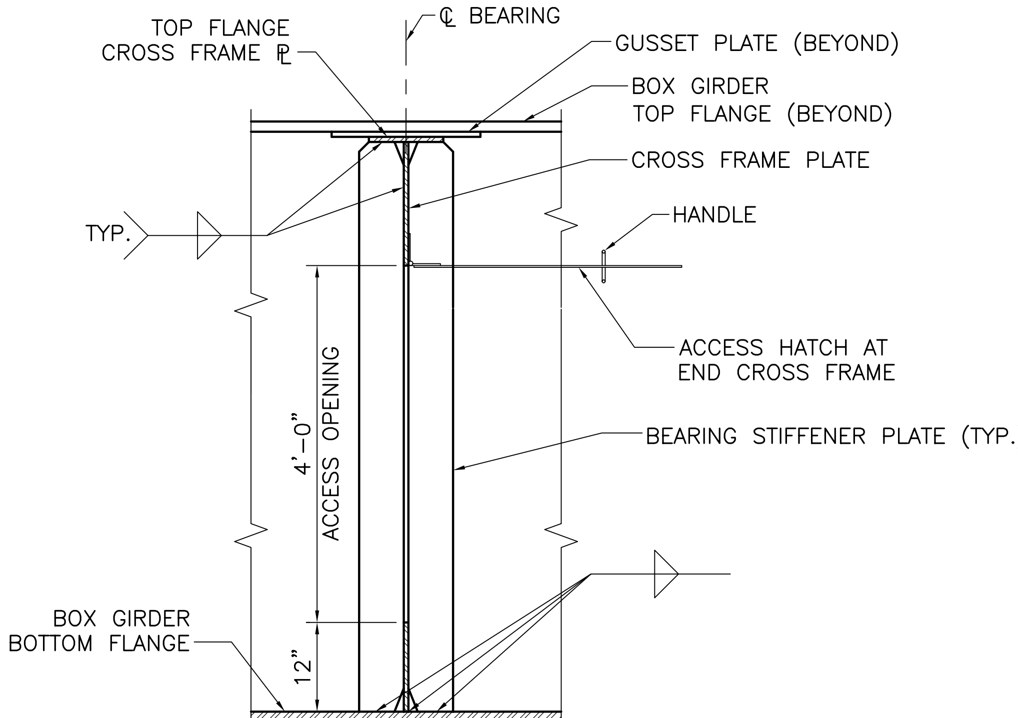
1. *Refer to AASHTO for additional information regarding size and location of stiffener. Show location of transverse stiffener on framing plan.*
2. *Longitudinal stiffeners are typically only required for wider than normal box girders and the bearing stiffener details shown on Dwg. No. 5.3.9 will need to be modified to accommodate this detail.*

MASS HIGHWAY BRIDGE MANUAL	LONGITUDINAL STIFFENER DETAILS STEEL BOX GIRDER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.11**



ACCESS HATCH AT INTERIOR END CROSS FRAME

SCALE: 3/4" = 1'–0"



NOTE:

ABUTMENT END CROSS FRAME SHOWN. PIER END CROSS FRAME SIMILAR.
(Include this note for multiple span bridges)

SECTION 6

SCALE: 3/4" = 1'–0"

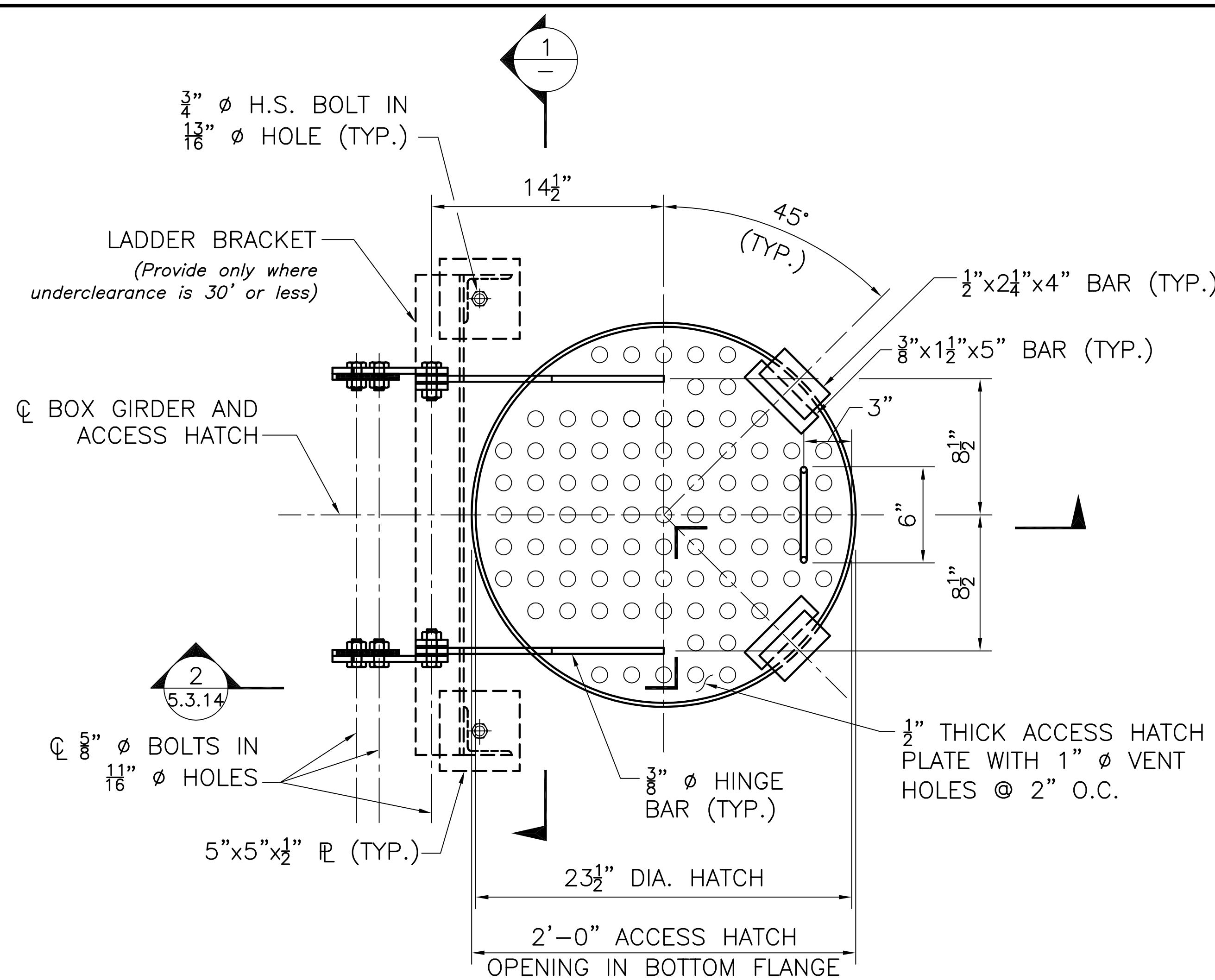
MASS HIGHWAY
BRIDGE MANUAL

END CROSS FRAME ACCESS HATCH DETAILS

STEEL BOX GIRDERS

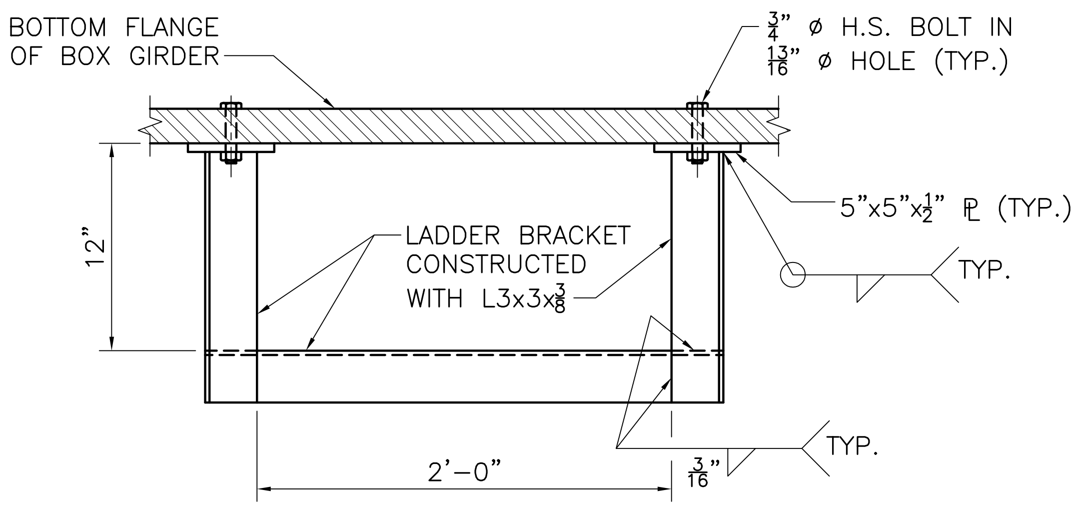
DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.3.12



INSPECTION ACCESS HATCH PLAN

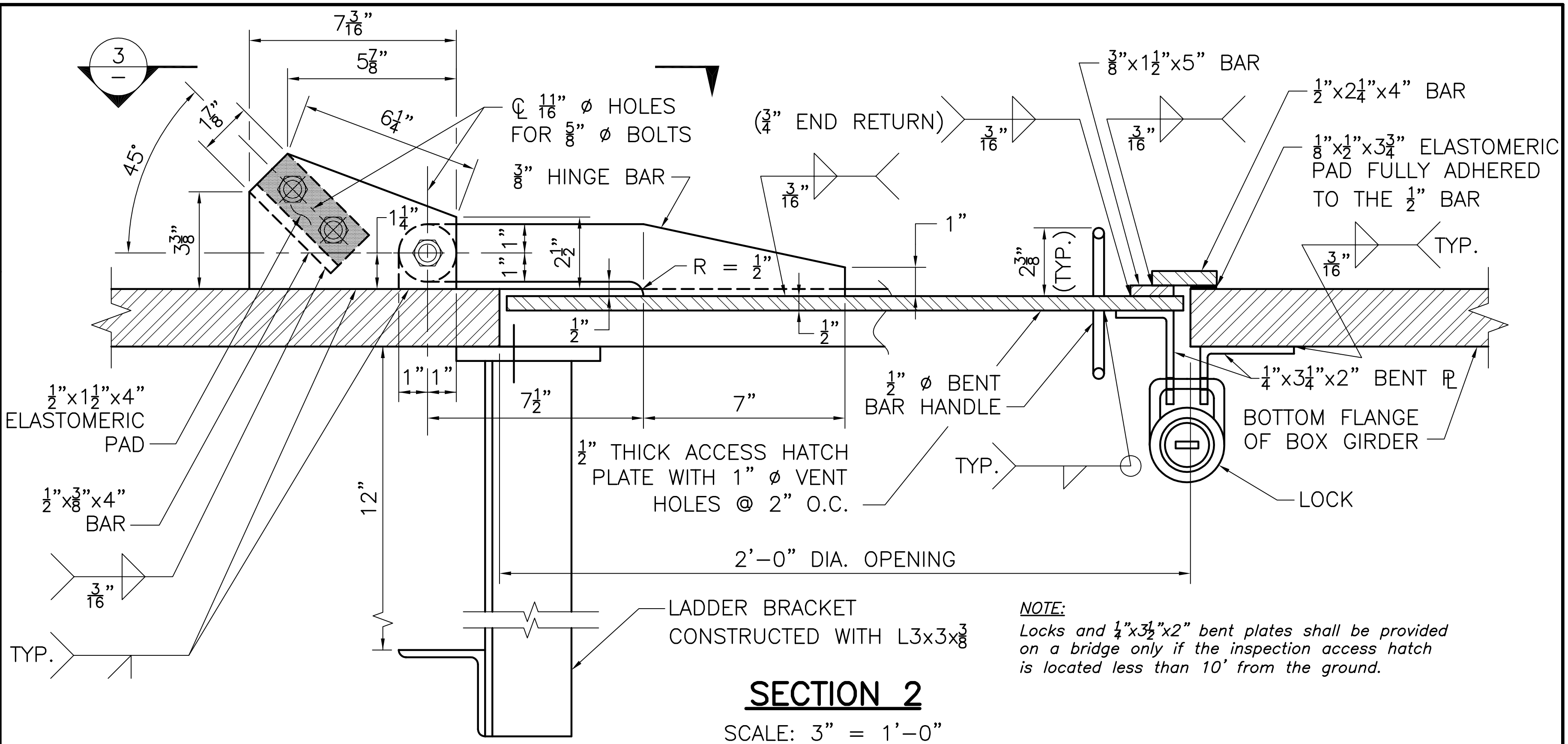
SCALE: 1 1/2" = 1'–0"



SECTION 1

SCALE: 1 1/2" = 1'–0"

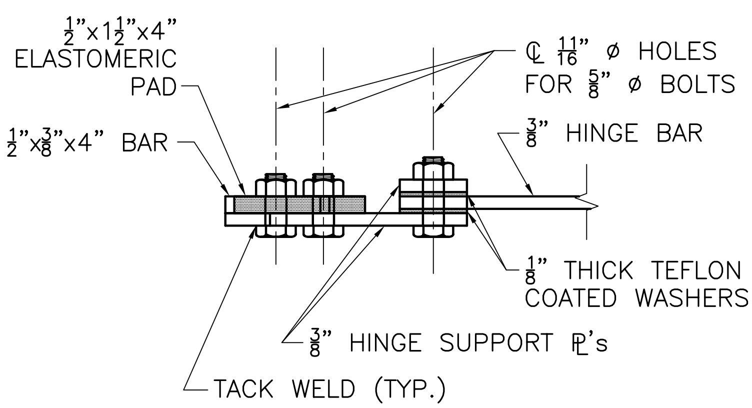
MASS HIGHWAY BRIDGE MANUAL	INSPECTION ACCESS HATCH DETAILS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.13**



NOTE:
Locks and 1/4"x3 1/2"x2" bent plates shall be provided on a bridge only if the inspection access hatch is located less than 10' from the ground.

SECTION 2

SCALE: 3" = 1'-0"



SECTION 3

SCALE: 3" = 1'-0"

INSPECTION ACCESS HATCH NOTES:

1. INTERIOR OF ALL BOX BEAMS SHALL BE LEFT IN A BROOM CLEAN CONDITION, FREE FROM ALL DEBRIS. DISTRICT BRIDGE INSPECTION ENGINEER SHALL BE PROVIDED ACCESS TO BOX INTERIORS FOR CLEAN-OUT ACCEPTANCE.

2. ALL STEEL COMPONENTS SHALL CONFORM TO AASHTO M 270 GRADE 36 AND SHALL BE GALVANIZED AFTER ASSEMBLY IN ACCORDANCE WITH THE REQUIREMENTS OF AASHTO M 111. ALL FASTENERS SHALL BE GALVANIZED IN ACCORDANCE WITH THE REQUIREMENTS OF AASHTO M 232.

3. ACCESS HATCH SHALL BE PAINTED ON BOTH SIDES WITH THE SAME COATING AS USED ON THE OUTSIDE/INSIDE OF THE BOX GIRDER.

4. ALL LOCKS ON A BRIDGE SHALL BE KEYED THE SAME.
(eliminate this note if locks are not needed)

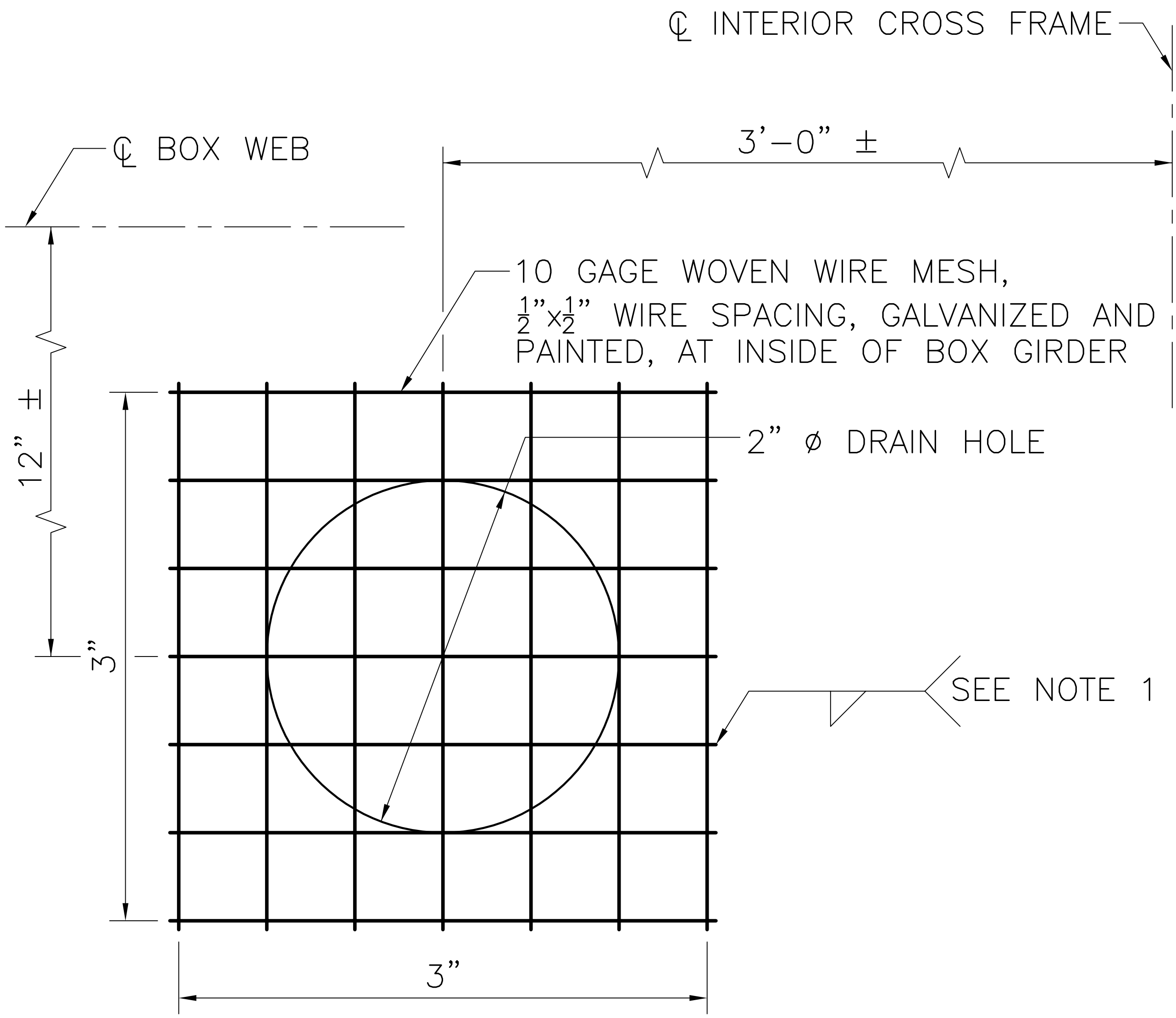
MASS HIGHWAY
BRIDGE MANUAL

INSPECTION ACCESS HATCH DETAILS AND NOTES

STEEL BOX GIRDERS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.3.14



NOTES:

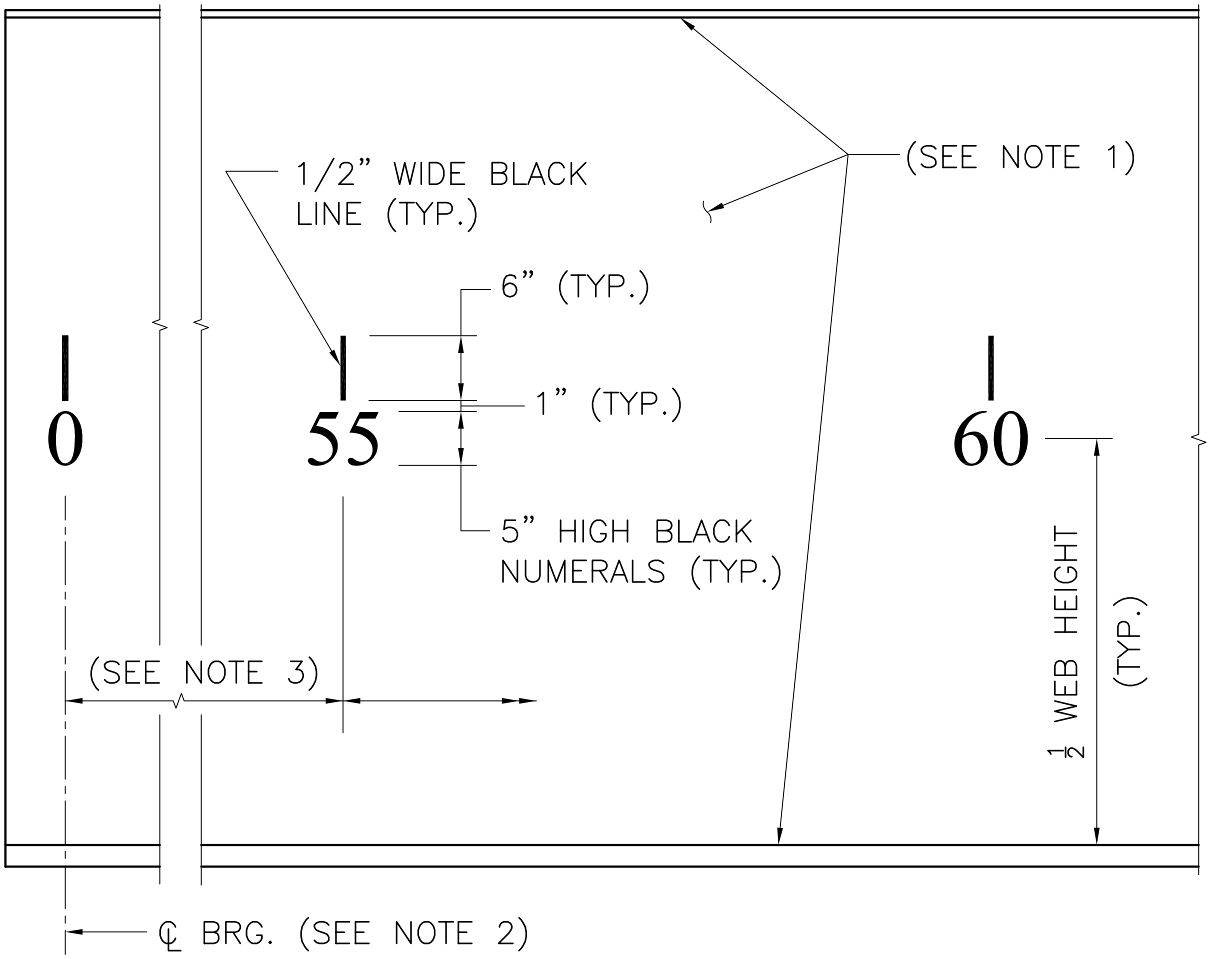
1. TACK WELD ENDS OF WIRE MESH TO BOTTOM FLANGE.

2. DRAIN HOLE SHALL BE LOCATED IN BOTTOM FLANGE OF EACH BOX GIRDER AT THE LOW END OF SPAN AND LOW SIDE OF BOX OF EACH SPAN.

DRAIN HOLE DETAILS

NOT TO SCALE

MASS HIGHWAY BRIDGE MANUAL	DRAIN HOLE DETAILS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.15**



NOTE:

1. THE INTERIOR OF ALL BOX GIRDERS, INCLUDING ALL STRUCTURAL STEEL COMPONENTS WITHIN EACH BOX GIRDER (SUCH AS DIAPHRAGMS, CROSS–FRAMES, CONNECTION PLATES, ETC.) SHALL BE PAINTED GLOSS WHITE (FEDERAL STANDARD 595B, COLOR NO. 17925).

2a. ZERO DISTANCE REFERENCE LINE LOCATED AT WEST CENTERLINE OF BEARING. *(for bridges oriented West to East)*

2b. ZERO DISTANCE REFERENCE LINE LOCATED AT SOUTH CENTERLINE OF BEARING. *(for bridges oriented South to North)*

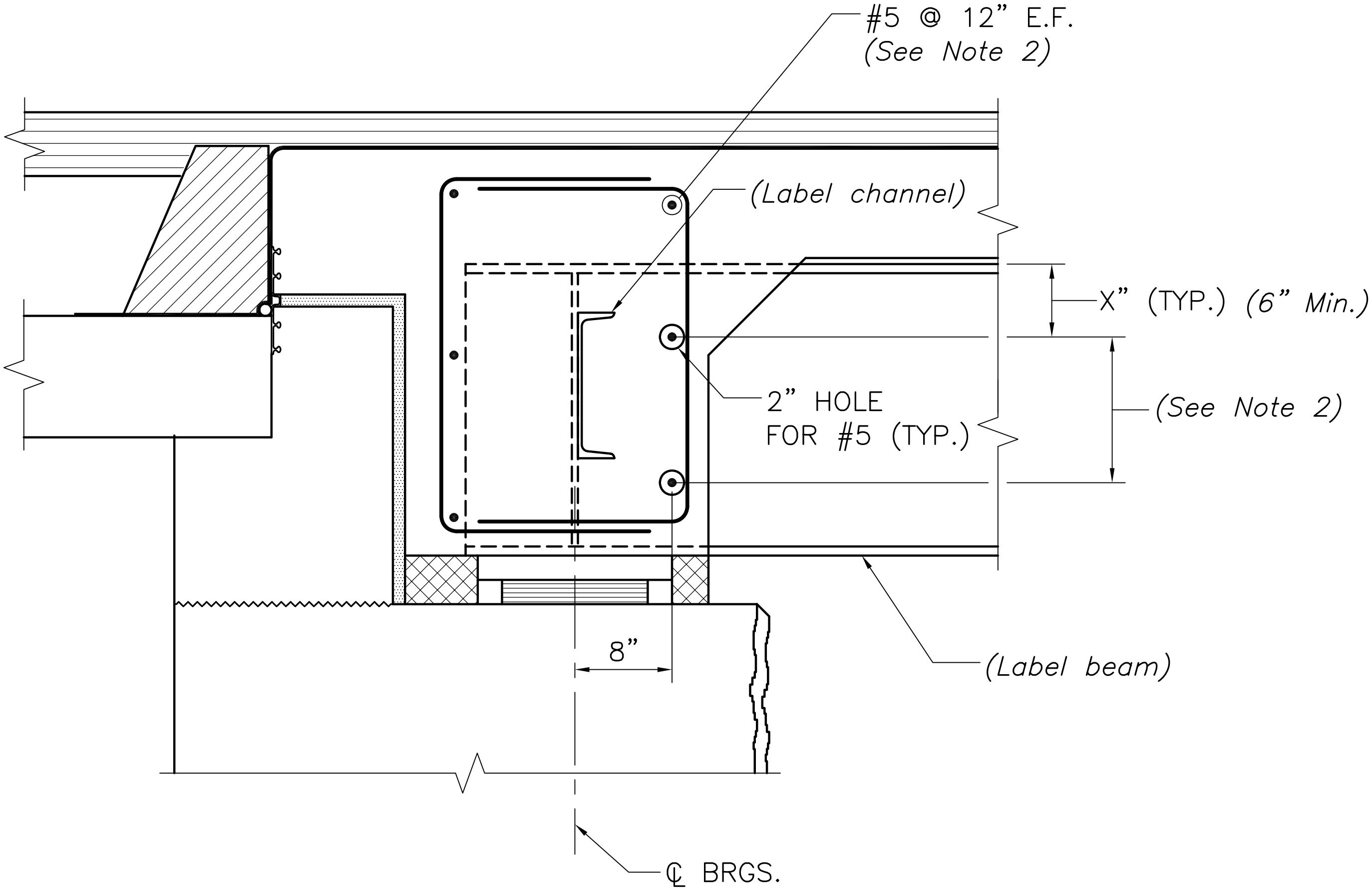
3. INDICATE DISTANCES SEQUENTIALLY AT FIVE (5) FOOT INTERVALS WITHOUT INTERUPTION FULL LENGTH WITHIN EACH BOX GIRDER WITH BLACK LINES AND NUMERALS ON LEFT WEB.

4. DO NOT CARRY OVER THE MEASURED DISTANCE SEQUENCE BETWEEN SEPARATE BOX GIRDERS WITHIN THE SAME GIRDER LINE OVER PIER(S).

INTERIOR PAINTING REQUIREMENTS

SCALE: $\frac{3}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	INTERIOR PAINTING REQUIREMENTS STEEL BOX GIRDERS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.3.16**



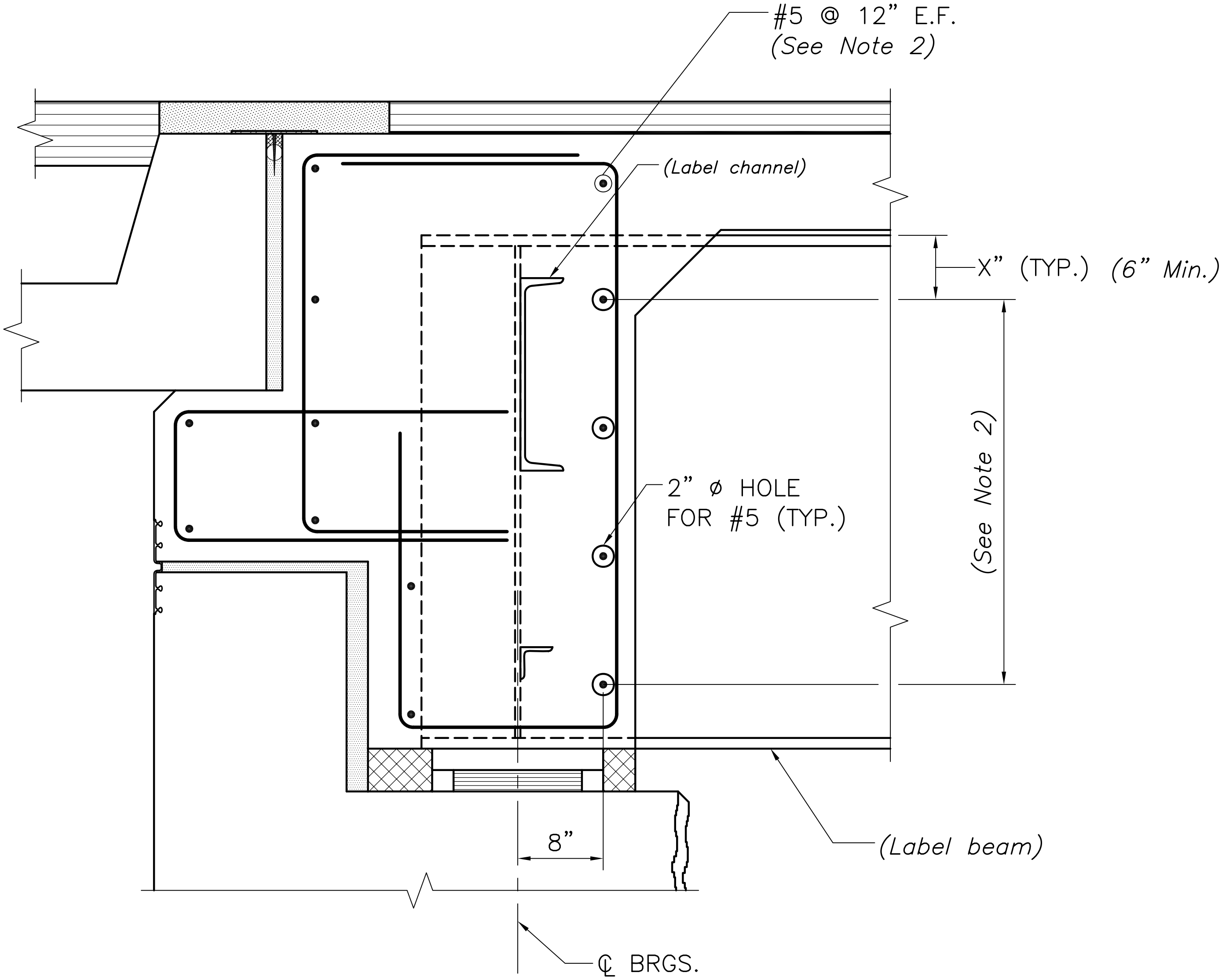
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.9 and 3.7.10 as shown above for steel stringer bridges.*
2. *12" spacing typical. 10" min., if required for proper distribution of reinforcement.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION STRINGER DEPTH ⩽ 3'–6" ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **5.4.1**



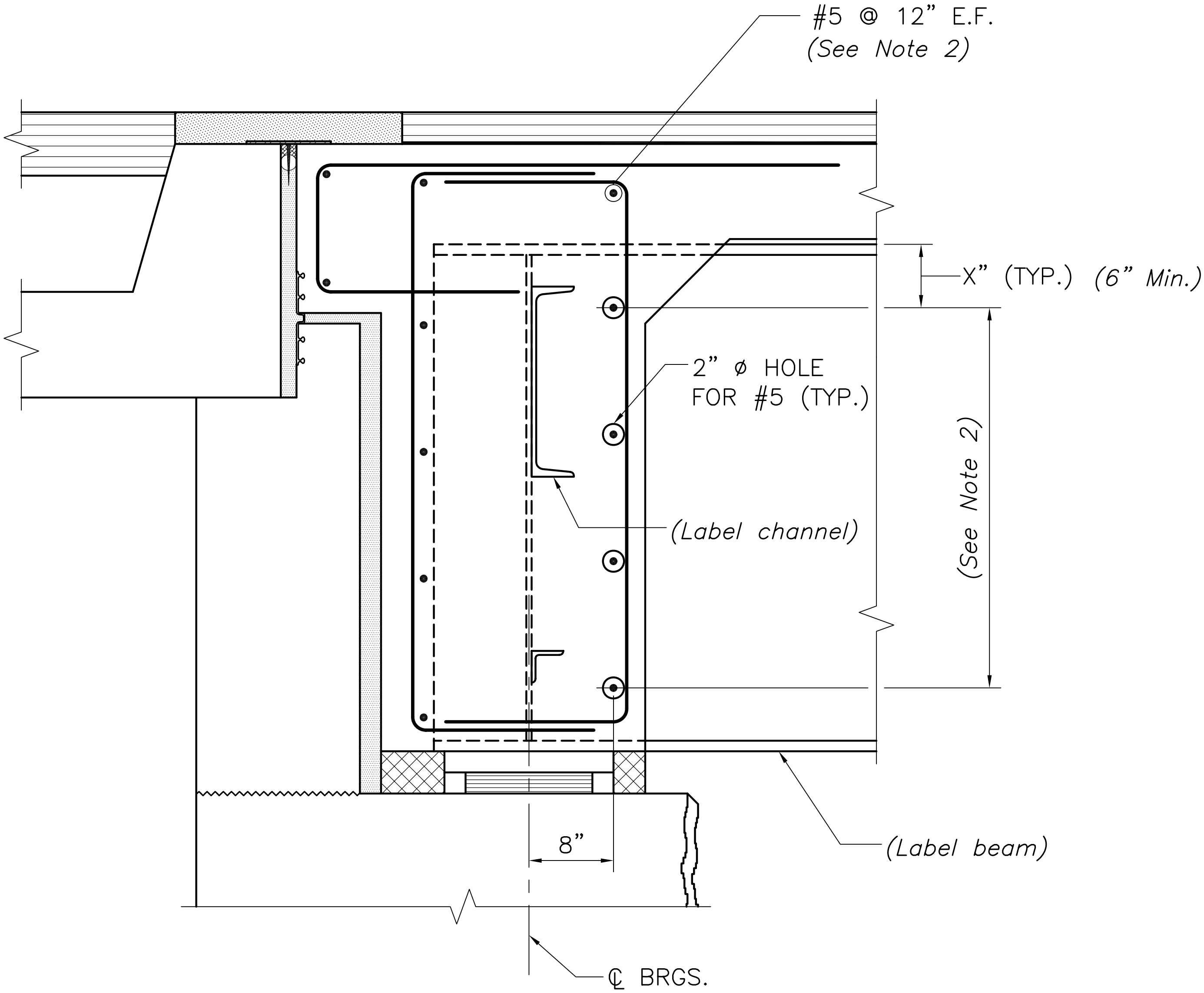
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.14 and 3.7.15 as shown above for steel stringer bridges.
2. 12" spacing typical; 10" Min., if required for proper distribution of reinforcement.

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION STRINGER DEPTH > 3'–6" ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER 5.4.2



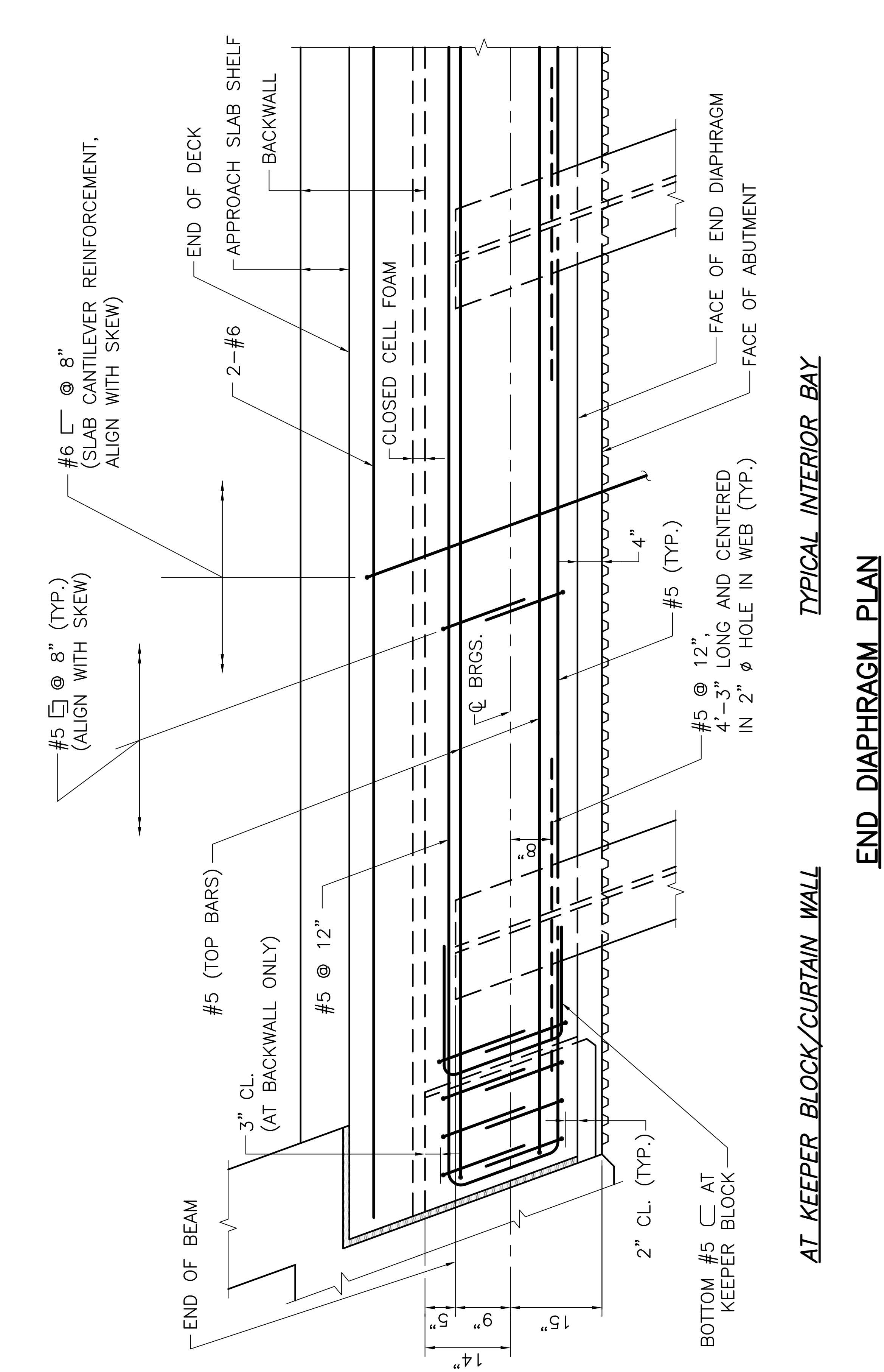
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.19 and 3.7.20 as shown above for steel stringer bridges.*
2. *12" spacing typical; 10" Min., if required for proper distribution of reinforcement.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION WITH ASPHALTIC BRIDGE JOINT ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **5.4.3**



END DIAPHRAGM PLAN

SCALE: $\frac{3}{4}$" = 1'-0"

NOTE:
Detail shown is for stringer depths 3'-6" or less. Modify drawing as needed for the actual stringer depth being used.

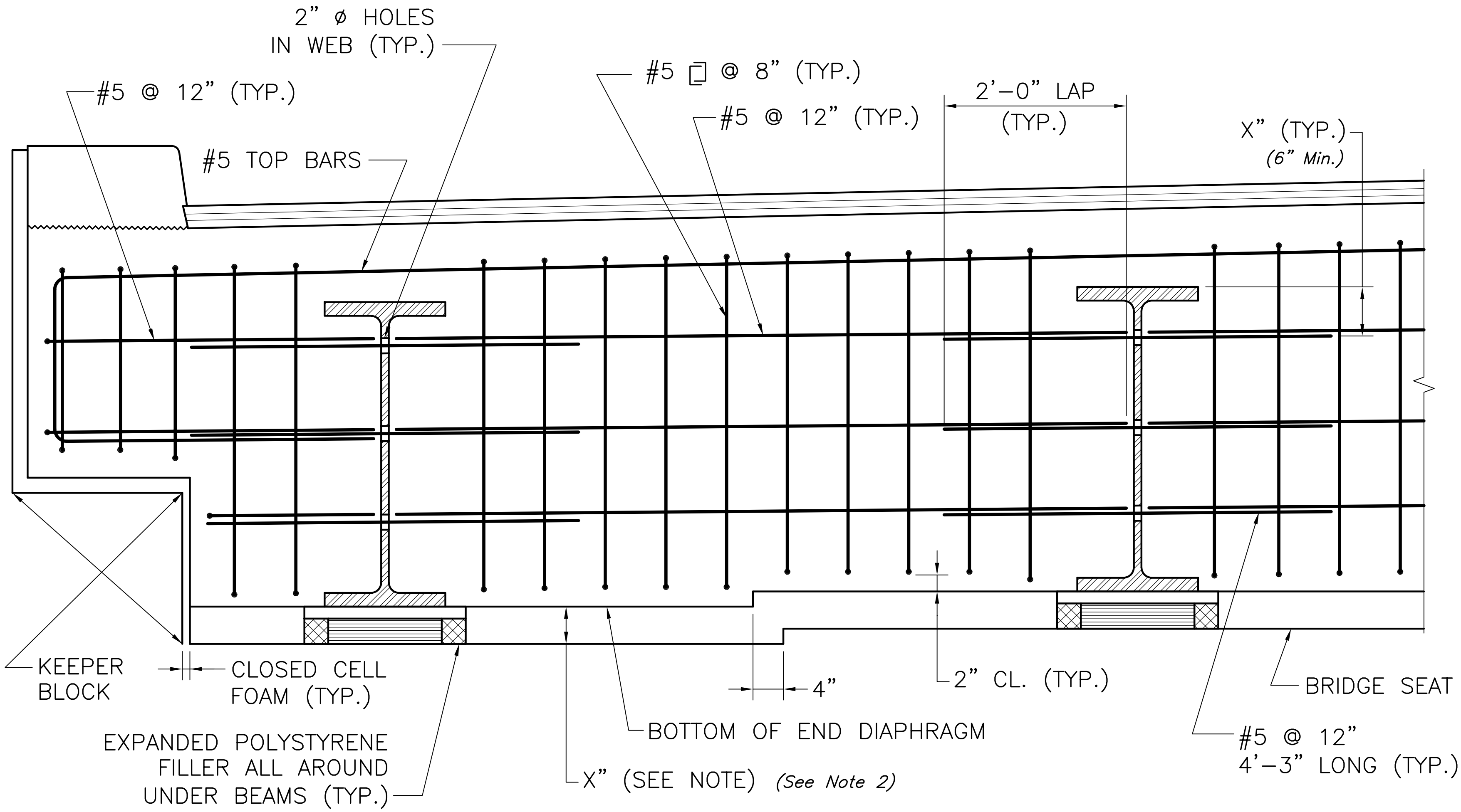
MASS HIGHWAY
BRIDGE MANUAL

END DIAPHRAGM PLAN

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.4.4



AT KEEPER BLOCK/CURTAIN WALL

TYPICAL INTERIOR BAY

NOTE:

CONTRACTOR MAY USE EXPANDED POLYSTYRENE FILLER OR A REMOVABLE FORM TO FORM THE BOTTOM OF THE END DIAPHRAGM.

END DIAPHRAGM ELEVATION

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Detail shown is for stringer depths 3'–6" or less. Modify drawing as needed for the actual stringer depth being used.*
2. *Dimension to be provided is equal to Total Thickness of Bearing + Thickness of Sole Plate.*

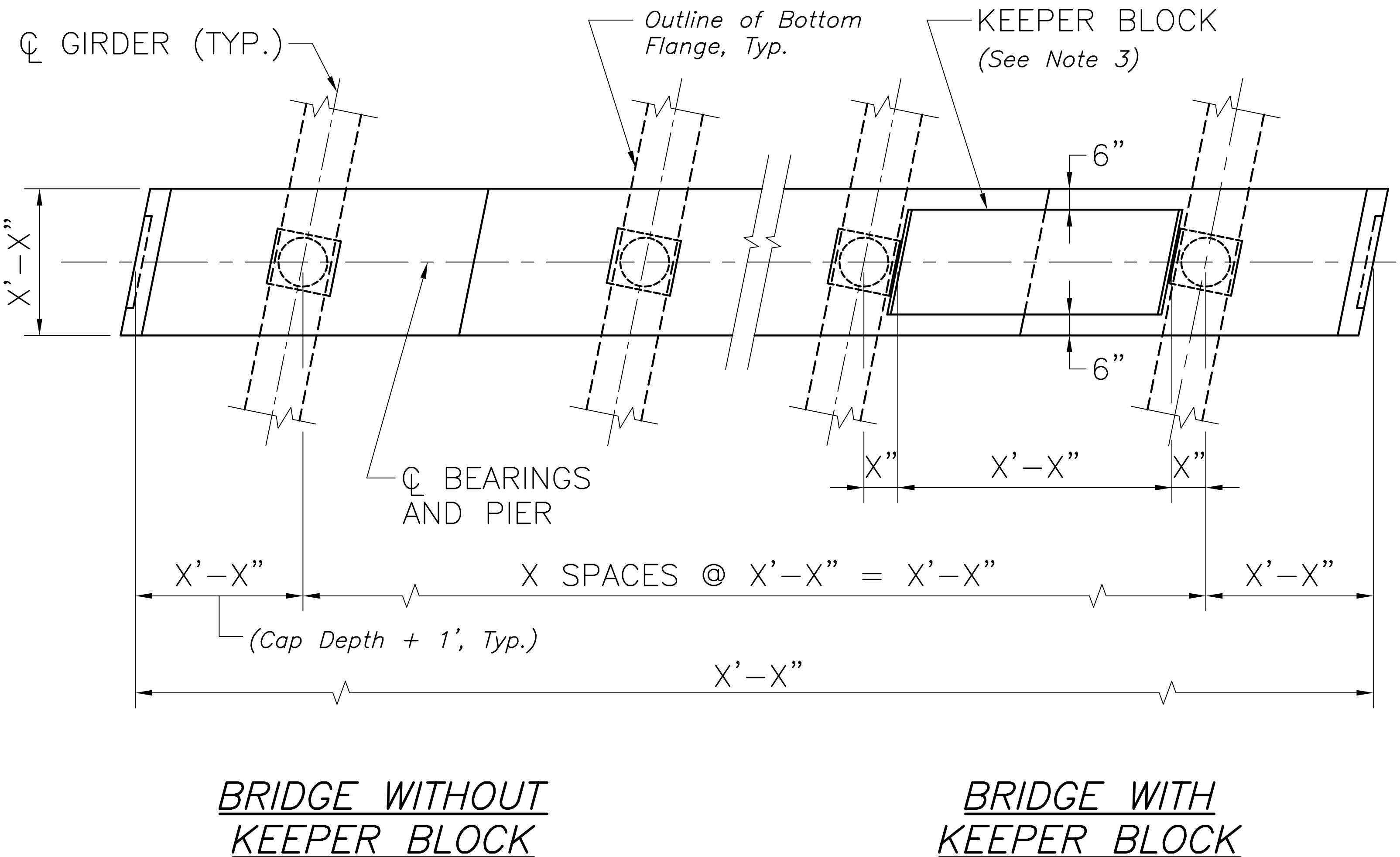
MASS HIGHWAY BRIDGE MANUAL

END DIAPHRAGM ELEVATION

ABUTMENT DETAILS

DATE OF ISSUE MAY 2007

DRAWING NUMBER **5.4.5**

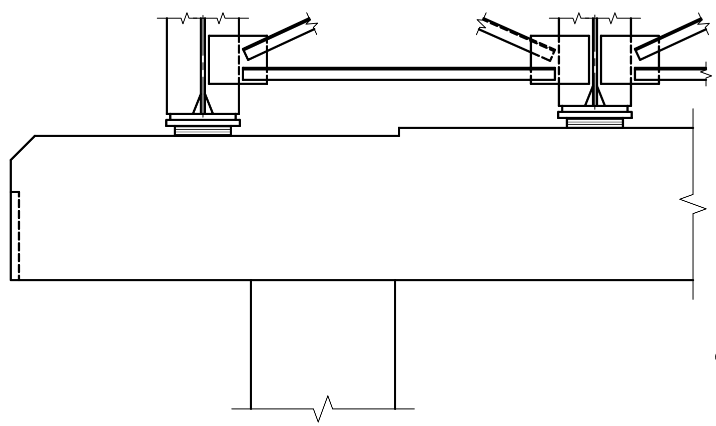


PLAN OF PIER CAP

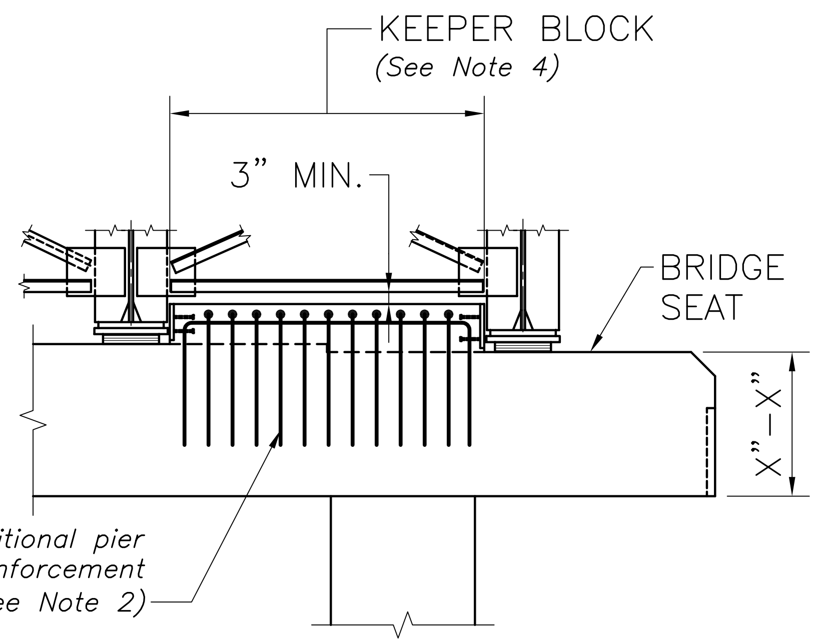
SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Plan of pier shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant dimensions, angles, survey information and North Arrow.*
2. *Plate girders shown, rolled beams are similar.*
3. *The actual number of keeper blocks shall be determined by design.*



BRIDGE WITHOUT KEEPER BLOCK



BRIDGE WITH KEEPER BLOCK

SECTION THRU PIER CAP

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. Remainder of pier and pier reinforcement omitted for clarity.
2. Additional pier cap reinforcement shall be designed as a restraint for transverse seismic loads.
3. Transverse section shall be drawn without breaks and to scale on the Construction Drawings and all reinforcement shall be included.
4. For keeper block details see Dwg. No. 5.5.3 and 5.5.4.
5. For pier details see Chapter 3.

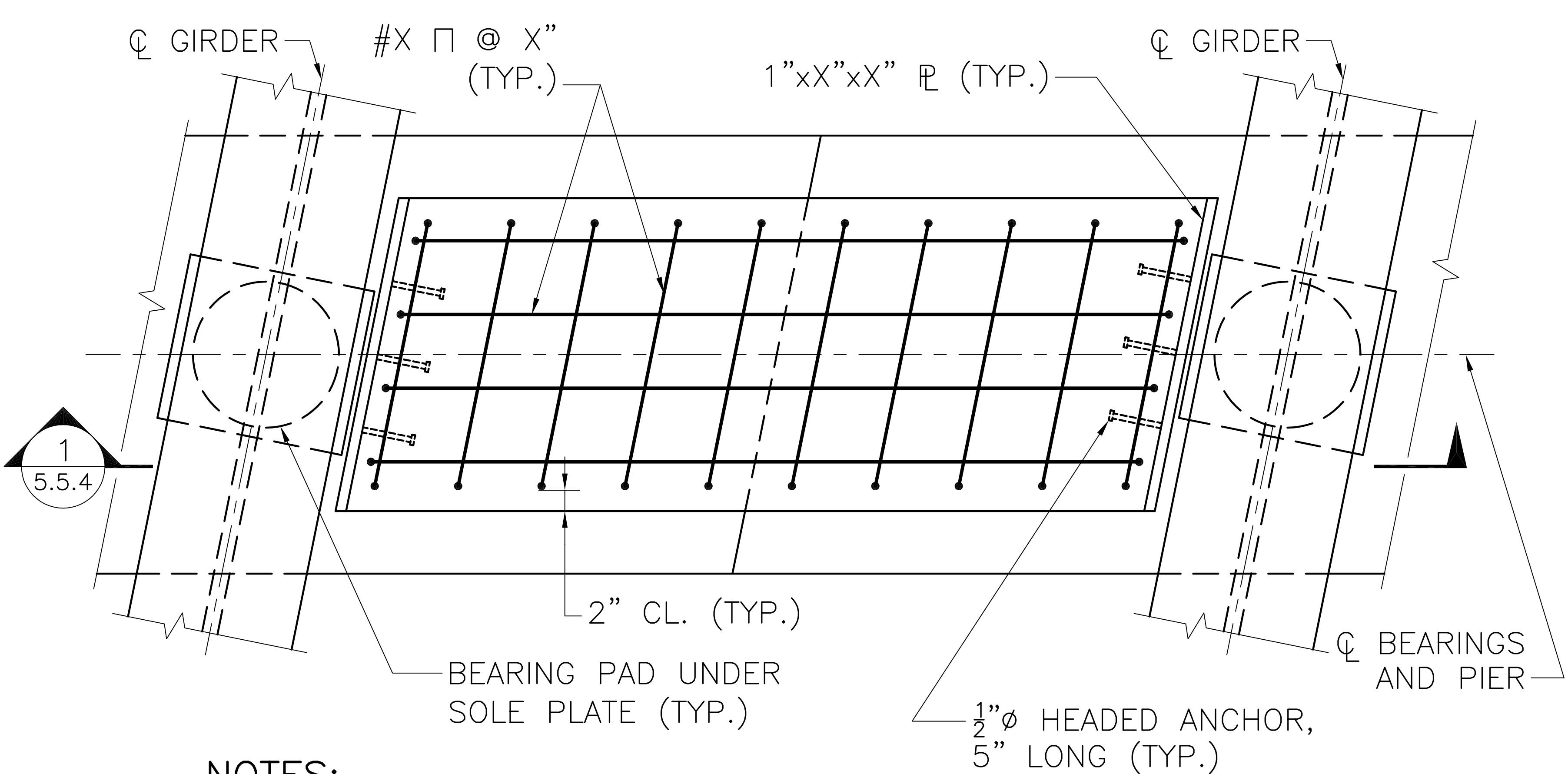
MASS HIGHWAY BRIDGE MANUAL

SECTION THRU PIER CAP

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.5.2



NOTES:

1. KEEPER BLOCKS SHALL BE CAST BEFORE BEAMS ARE SET.
2. STEEL PLATES EMBEDED IN KEEPER BLOCK SHALL BE HOT-DIP GALVANIZED.

PLAN OF KEEPER BLOCK

SCALE: $\frac{3}{4}$" = 1'-0"

NOTE:

Reinforcement configuration shown is conceptual. The Designer shall determine bar size and spacing as required by the actual design.

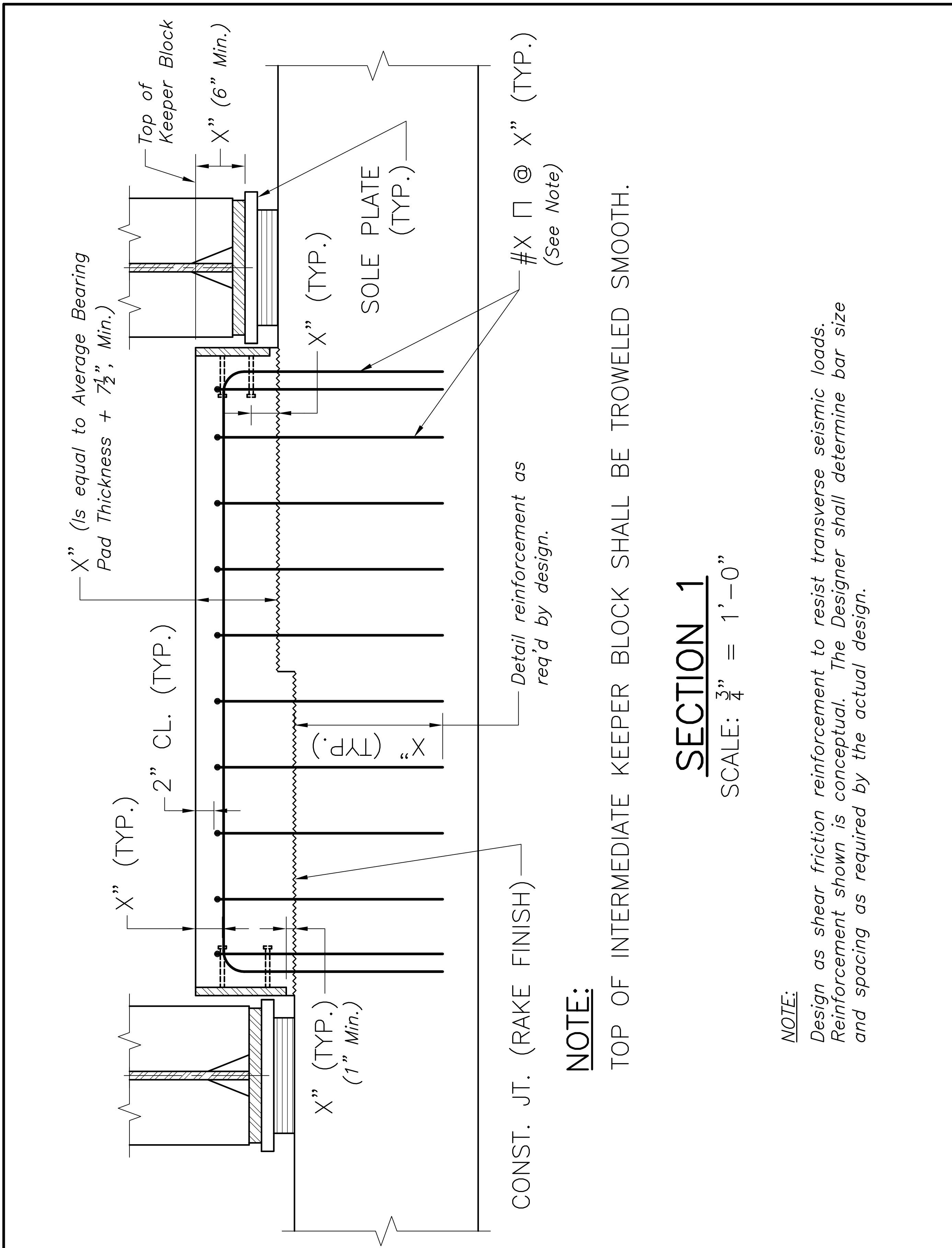
MASS HIGHWAY BRIDGE MANUAL

PLAN OF KEEPER BLOCK

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.5.3



MASS HIGHWAY BRIDGE MANUAL	KEEPER BLOCK VERTICAL SECTION PIER DETAILS	DATE OF ISSUE MAY 2005 / DRAWING NUMBER 5.5.4

MASS HIGHWAY
BRIDGE MANUAL

KEEPER BLOCK VERTICAL SECTION

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
5.5.4

NOTES:

1. The Theoretical Camber shall be shown on the Construction Drawings by either a camber diagram or a table.
2. The Camber shall be specified by equally spaced ordinates at the mid–length of the segment to be curved and by as many additional points as necessary to be defined clearly.
3. In the calculation for the Minimum Theoretical Camber, do not include camber tolerances. Do not show tolerances on the Construction Drawings.
4. The minimum Theoretical Camber shall be a sum of the following values:
   - X = 100% Dead Load Deflection
   - Y = Vertical Curve Camber (See Notes 3 and 4 below)
   - Z = Additional Camber (from the Table below)

ADDITIONAL CAMBER – "Z"

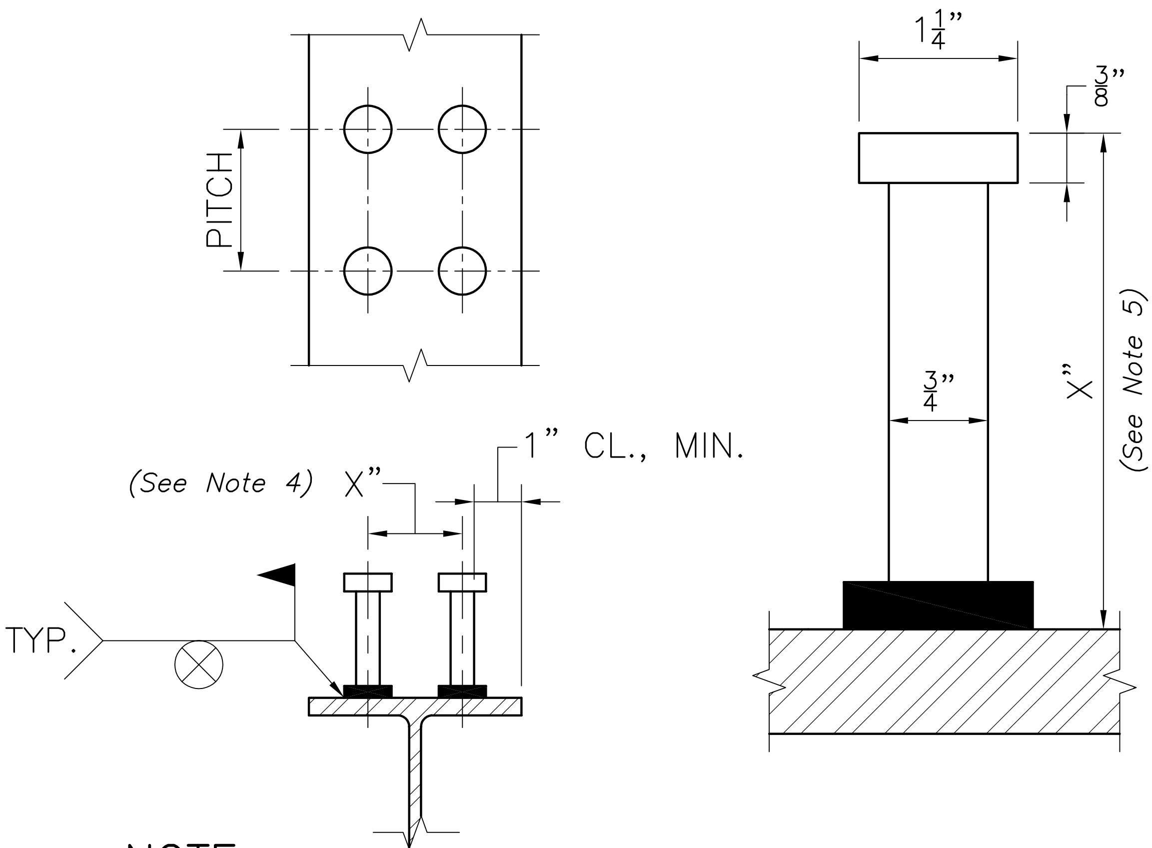
Profile Grade	Simple Span	Multiple Simple Spans	Multiple Spans Continuous
Vertical Curve	$\frac{1}{16}$" per 10' of Span	0	0
Tangent	$\frac{1}{8}$" per 10' of Span	$\frac{1}{16}$" per 10' of Span	$\frac{1}{16}$" per 10' of Span

CAMBER TABLE

BM. NO.		SPAN NO. X										
		℄ BRG. ABUT.	0.1L	0.2L	0.3L	0.4L	0.5L	0.6L	0.7L	0.8L	0.9L	℄ BRG. ABUT./PIER
1	STEEL DL DEFLECTION											
	CONC. DL DEFLECTION											
	S.D.L. DEFLECTION											
	VERT. CURVE CAMBER											
	ADDITIONAL CAMBER											
	TOTAL CAMBER											
2	STEEL DL DEFLECTION											
	CONC. DL DEFLECTION											
	S.D.L. DEFLECTION											
	VERT. CURVE CAMBER											
	ADDITIONAL CAMBER											
	TOTAL CAMBER											

NOTES:

1. Camber values shall be shown in inches.
2. Expand the table, as necessary, for additional beams and spans.
3. Y = B2 – (B1 + B3)/2 where:
   - B1 = Final top of roadway elevation @ ℄ of Bearing @ Support #1
   - B2 = Final top of roadway elevation @ mid span of the beam
   - B3 = Final top of roadway elevation @ ℄ of Bearing @ Support #2
4. Y = 0 for a Negative Vertical Curve.



NOTE:

7/8" ø STUDS MAY BE SUBSTITUTED FOR 3/4" ø STUDS BY ADJUSTING THE PITCH TO PROVIDE AN EQUIVALENT CROSS–SECTIONAL AREA PER FOOT.

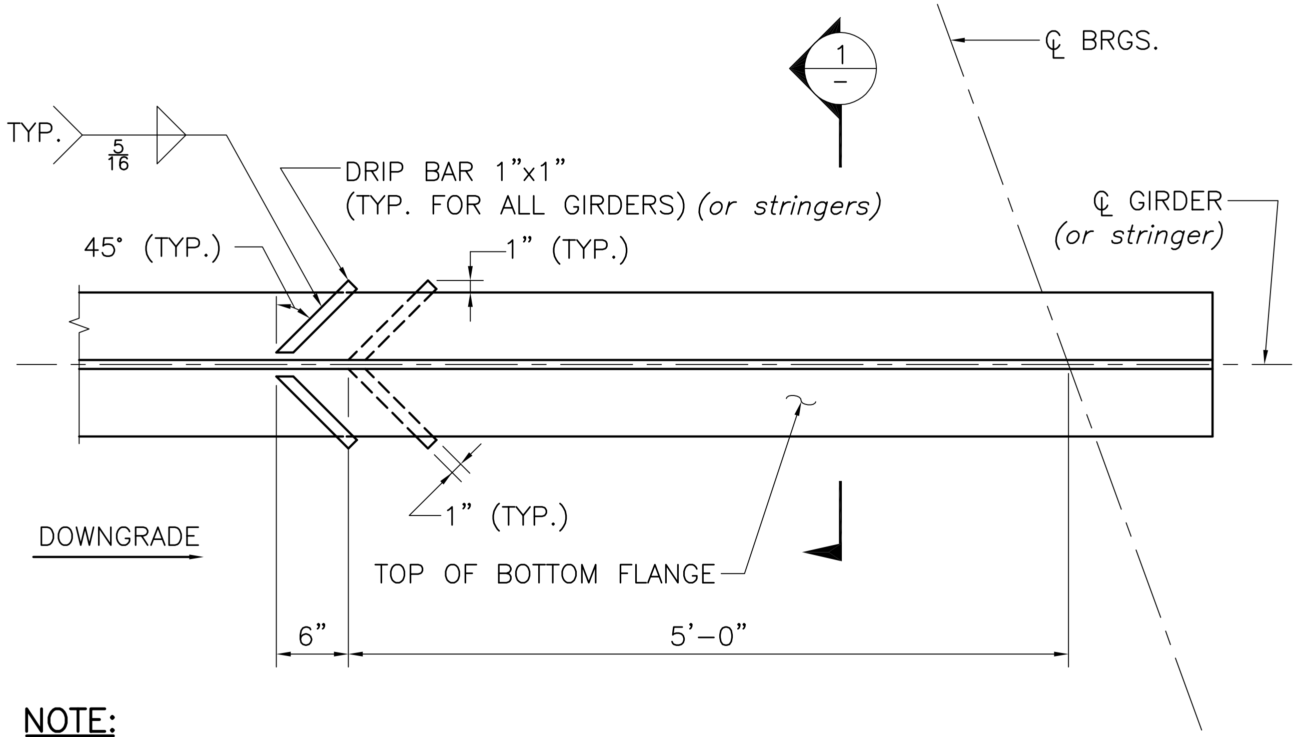
STUD SHEAR CONNECTORS

NOT TO SCALE

NOTES:

1. *All shear connectors shall be designed according to the current edition of the AASHTO Standard Specifications for Highway Bridges.*
2. *In the case where the beam haunch exceeds 6", the AASHTO embedment provisions may not be met. The plane between the deck slab and haunch shall be checked for shear resistance. If additional resistance is required, stirrups shall be designed across the plane rather than lengthening the stud connectors.*
3. *The pitch of the studs need not be made in multiples of the spacing of transverse steel reinforcement in the deck slab, however, the stud's alignment shall be parallel to that of the transverse reinforcement.*
4. *The minimum pitch shall be as specified in AASHTO. The maximum pitch shall be 2'–0". Indicate the stud spacing and orientation on the Construction Drawings in the beam elevation views.*
5. *Studs available from 4" Min. in 1" increments.*

MASS HIGHWAY BRIDGE MANUAL	STUD SHEAR CONNECTORS MISCELLANEOUS DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.6.2**

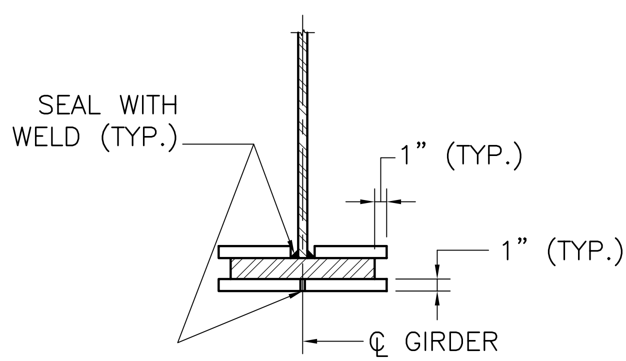


NOTE:

DRIP BARS SHALL BE LOCATED ON THE LOW END OF EACH SPAN FOR ALL GIRDERS *(or stringers)*.

DRIP BAR DETAIL

SCALE: 1" = 1'–0"



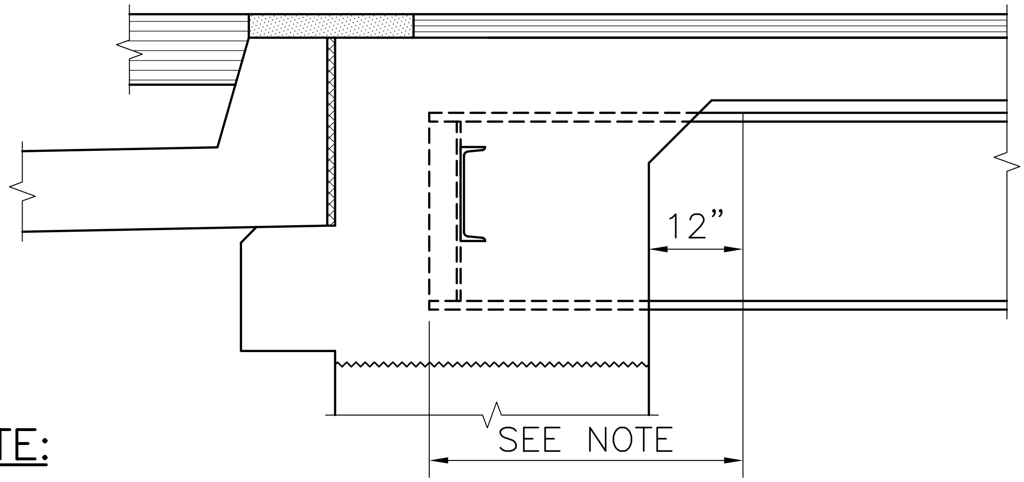
SECTION 1

SCALE: 1" = 1'–0"

NOTE:

This detail shall only be used with unpainted weathering steel stringers and girders.

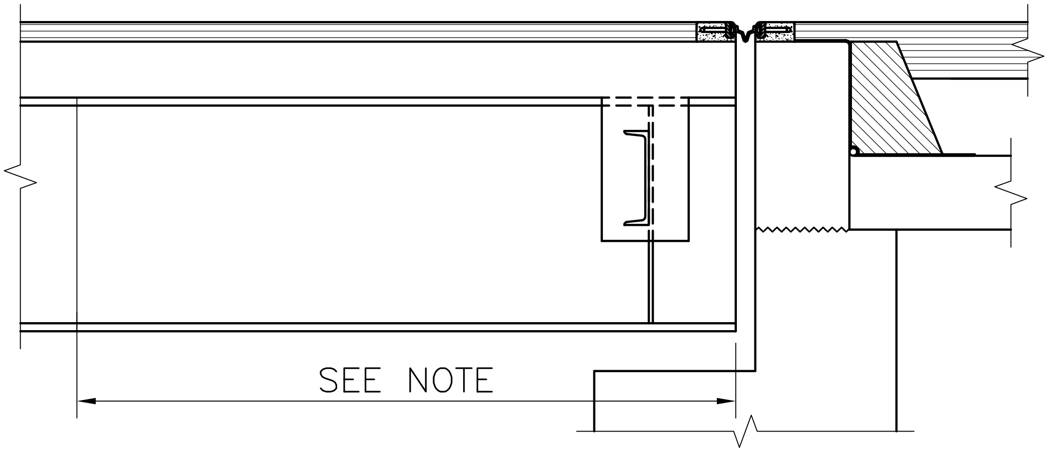
MASS HIGHWAY BRIDGE MANUAL	DRIP BAR DETAIL WEATHERING STEEL ONLY MISCELLANEOUS DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **5.6.3**



NOTE:

THE UNPAINTED WEATHERING STEEL STRINGER *(or girder)* AND ATTACHED PLATES EMBEDDED IN THE ABUTMENT *(or end diaphragm)* AND WITHIN 12" OF THE ABUTMENT FACE *(or face of end diaphragm)* SHALL BE PAINTED IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE FINISH COAT COLOR SHALL MATCH COLOR CHIP NO. 30045 OF FEDERAL STANDARD 595B. THE STEEL DIAPHRAGM SHALL NOT BE PAINTED.

AT INTEGRAL AND SEMI-INTEGRAL ABUTMENTS



NOTE:

ALL UNPAINTED WEATHERING STEEL INCLUDING STEEL DIAPHRAGMS WITHIN 1.5 TIMES THE GIRDER DEPTH (7'-0" MIN.) OF BRIDGE EXPANSION JOINTS SHALL BE PAINTED IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS. THE FINISH COAT COLOR SHALL MATCH COLOR CHIP NO. 30045 OF FEDERAL STANDARD 595B.

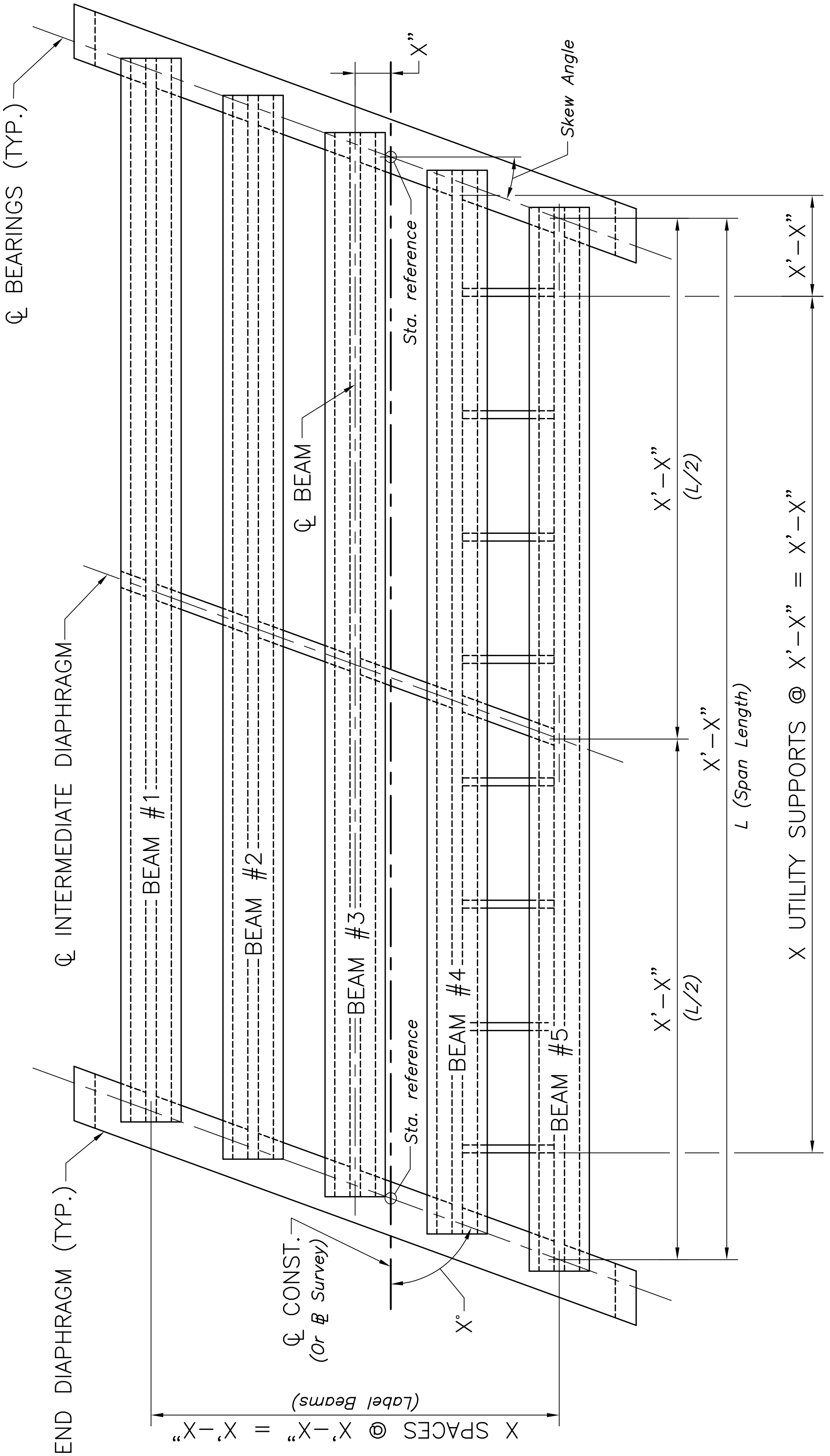
AT DECK JOINTS

LIMITS OF PAINTED WEATHERING STEEL

SCALE: $\frac{1}{2}$" = 1'-0"

NOTES:

1. *Modify Integral Abutment detail shown for Semi-Integral Abutment Bridges.*
2. *Include applicable detail on Construction Drawings for unpainted weathering steel beam bridges.*



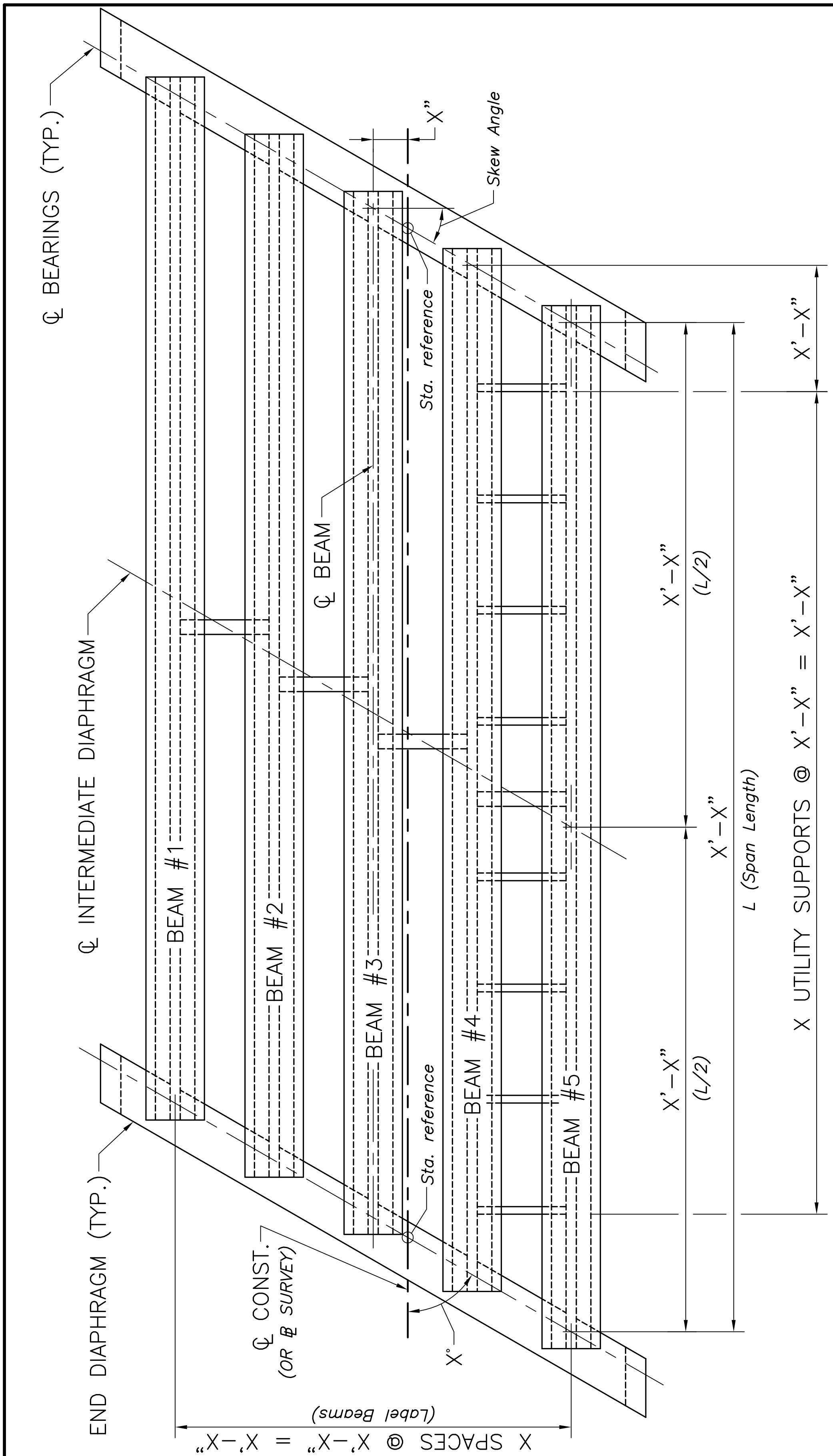
FRAMING PLAN

SCALE: (1/8" = 1'–0" Min.)

NOTES:

1. Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Label beam types and include North Arrow.
2. No intermediate diaphragms required for spans of 80' or less.
3. Ends of NEBT's shall be square, but end diaphragms shall follow skew of bridge.
4. For utility support spacing requirements, see Dwg. No. 6.1.17.
5. The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.

MASS HIGHWAY BRIDGE MANUAL	FRAMING PLAN (SKEW ≤ 30°) PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE: MAY 2005 / DRAWING NUMBER: 6.1.1



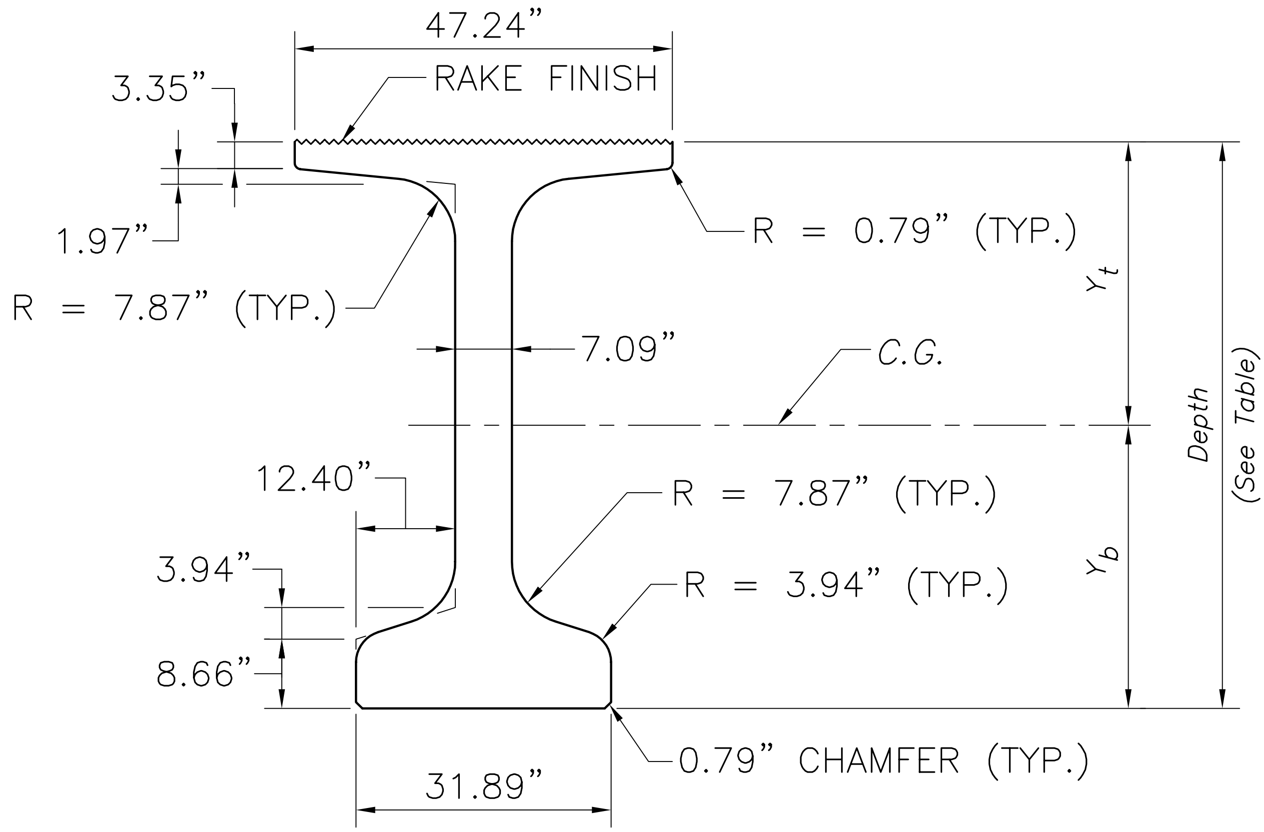
FRAMING PLAN

SCALE: (1/8" = 1'–0" Min.)

NOTES:

1. Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Label beam types and include North Arrow.
2. No intermediate diaphragms required for spans of 80' or less.
3. Ends of NEBT's shall be square, but end diaphragms shall follow skew of bridge.
4. For utility support spacing requirements, see Dwg. No. 6.1.17.
5. The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.

MASS HIGHWAY BRIDGE MANUAL	FRAMING PLAN (SKEW > 30°) PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE: MAY 2005
		DRAWING NUMBER: 6.1.2



BEAM PROPERTIES

Beam Type	*Depth (in)*	*Weight (Lbs./Ft)*	*Area (in^2)*	*Ix c.g. (in^4)*	*Iy c.g. (in^4)*	*Yt (in)*	*Yb (in)*	*St (in^3)*	*Sb (in^3)*	*Max. Span (Ft.)*
NEBT 1000	*39.37*	*778*	*746*	*149196*	*61745*	*20.35*	*19.02*	*7332*	*7844*	*70*
NEBT 1200	*47.24*	*835*	*801*	*238089*	*61985*	*24.61*	*22.63*	*9675*	*10516*	*81*
NEBT 1400	*55.12*	*894*	*857*	*353169*	*62225*	*28.86*	*26.26*	*12237*	*13449*	*94*
NEBT 1600	*62.99*	*952*	*913*	*492515*	*62465*	*33.03*	*29.96*	*14911*	*16439*	*105*
NEBT 1800	*70.87*	*1010*	*969*	*660691*	*62706*	*37.2*	*33.66*	*17761*	*19663*	*115*

NOTES:

1. *Maximum Span lengths are approximate and are based on the following assumptions:*
   f'c = 6500 psi (Precast)
   f'ci = 4500 psi (Precast)
   f'c = 4000 psi (Deck)
   Beam spacing = 6'–6"
   Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   HS25 Truck loading
2. *Above drawing is not to scale.*

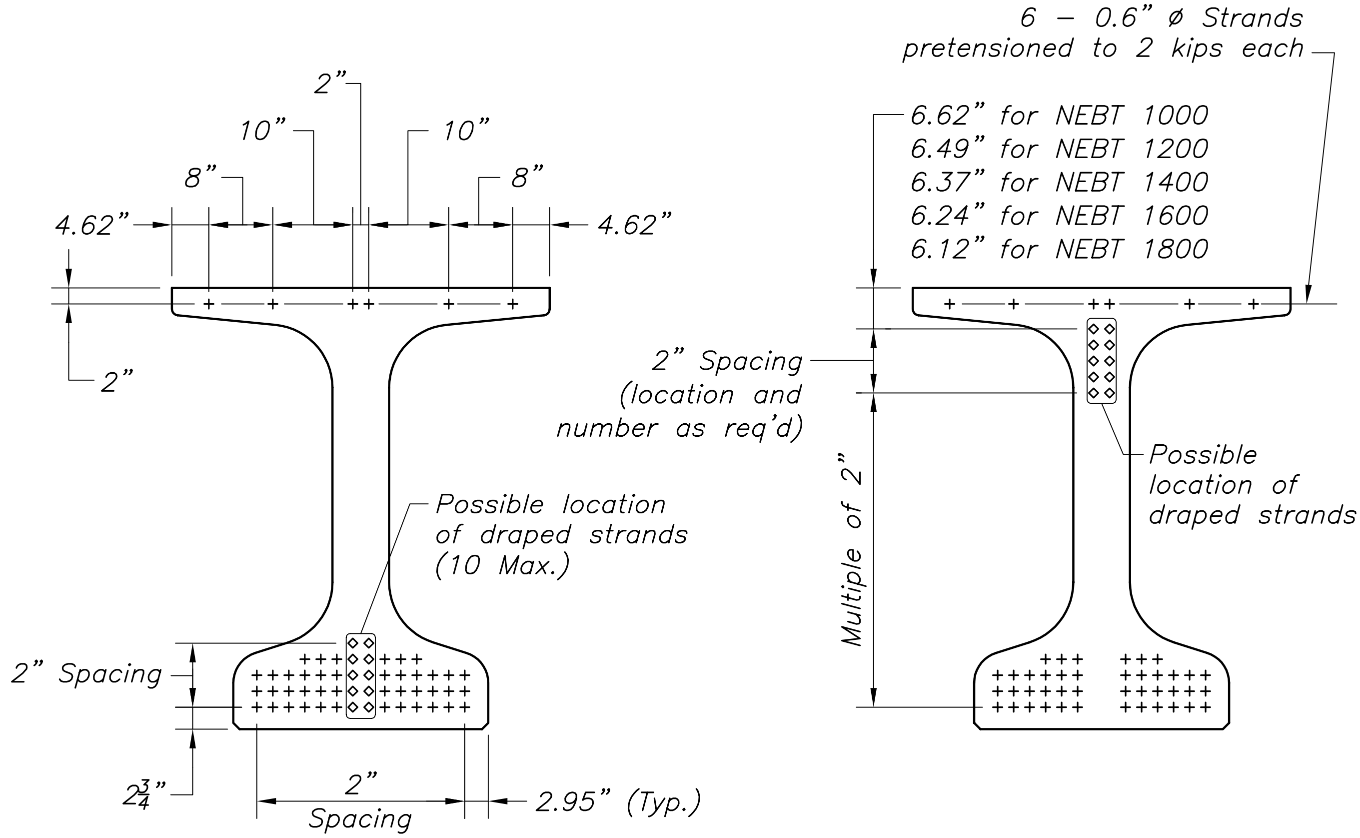
MASS HIGHWAY BRIDGE MANUAL

STANDARD NEBT SERIES TYPICAL DIMENSIONS

PRECAST CONCRETE NEBT BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.1.3



STRAND LOCATION MIDSPAN

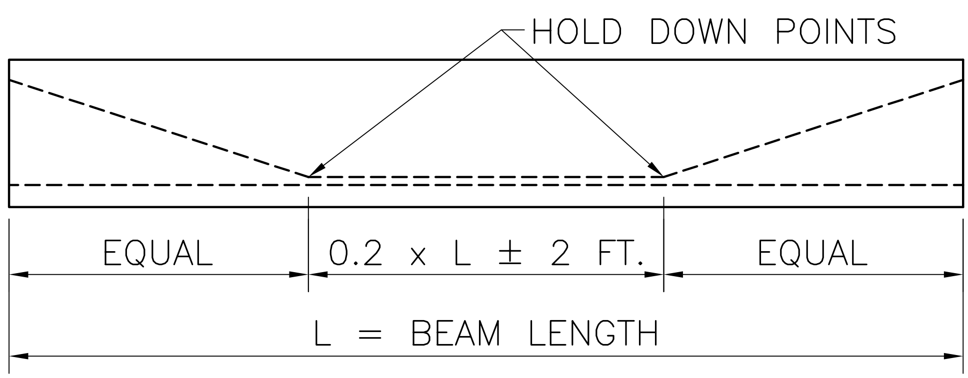
NOT TO SCALE

STRAND LOCATION END OF BEAM

NOT TO SCALE

NOTES:

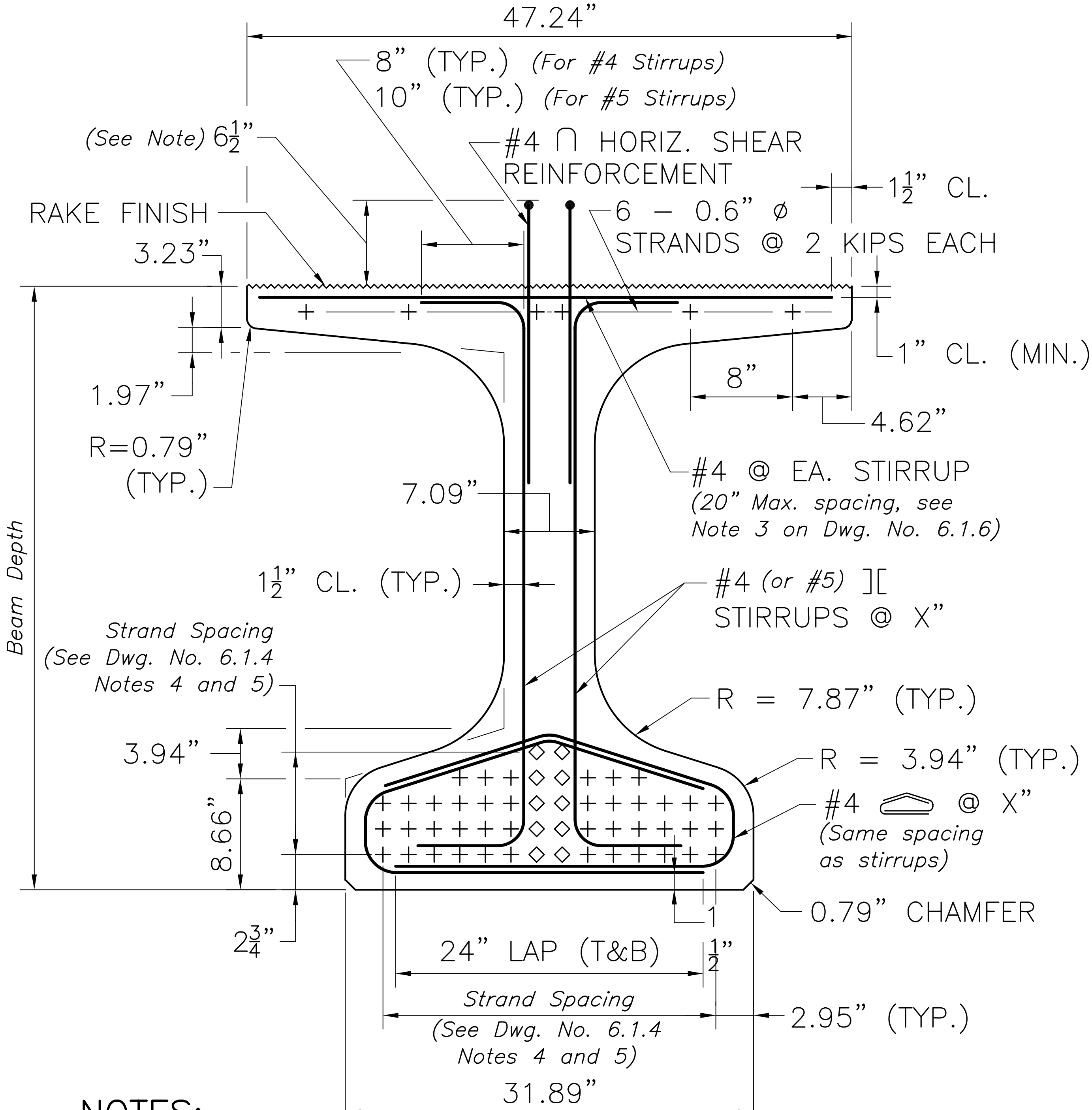
1. \+ Denotes straight strands.
2. ◇ Denotes draped strands.
3. ⊕ Denotes debonded strands. (None shown above.)
   No more than 25% of the total number of strands shall be debonded.
   The spacing between debonded strands shall be at least 4" apart, both vertically and horizontally. Outer most strands in each layer shall not be debonded.
4. Strands shall be placed within 2" x 2" grid. The number and location of the strands shall be as required by design.
5. The Designer shall provide the midspan and end of beam strand pattern on the Construction Drawings.



HOLD DOWN POINTS FOR DRAPED STRANDS

NOT TO SCALE

MASS HIGHWAY BRIDGE MANUAL	STRAND LOCATIONS AND HOLD DOWN DETAILS PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.1.4**



NOTES:

1. + DENOTES STRAIGHT STRANDS.
2. ◇ DENOTES DRAPED STRANDS.
3. ⊕ DENOTES DEBONDED STRANDS. *(None shown above.)*

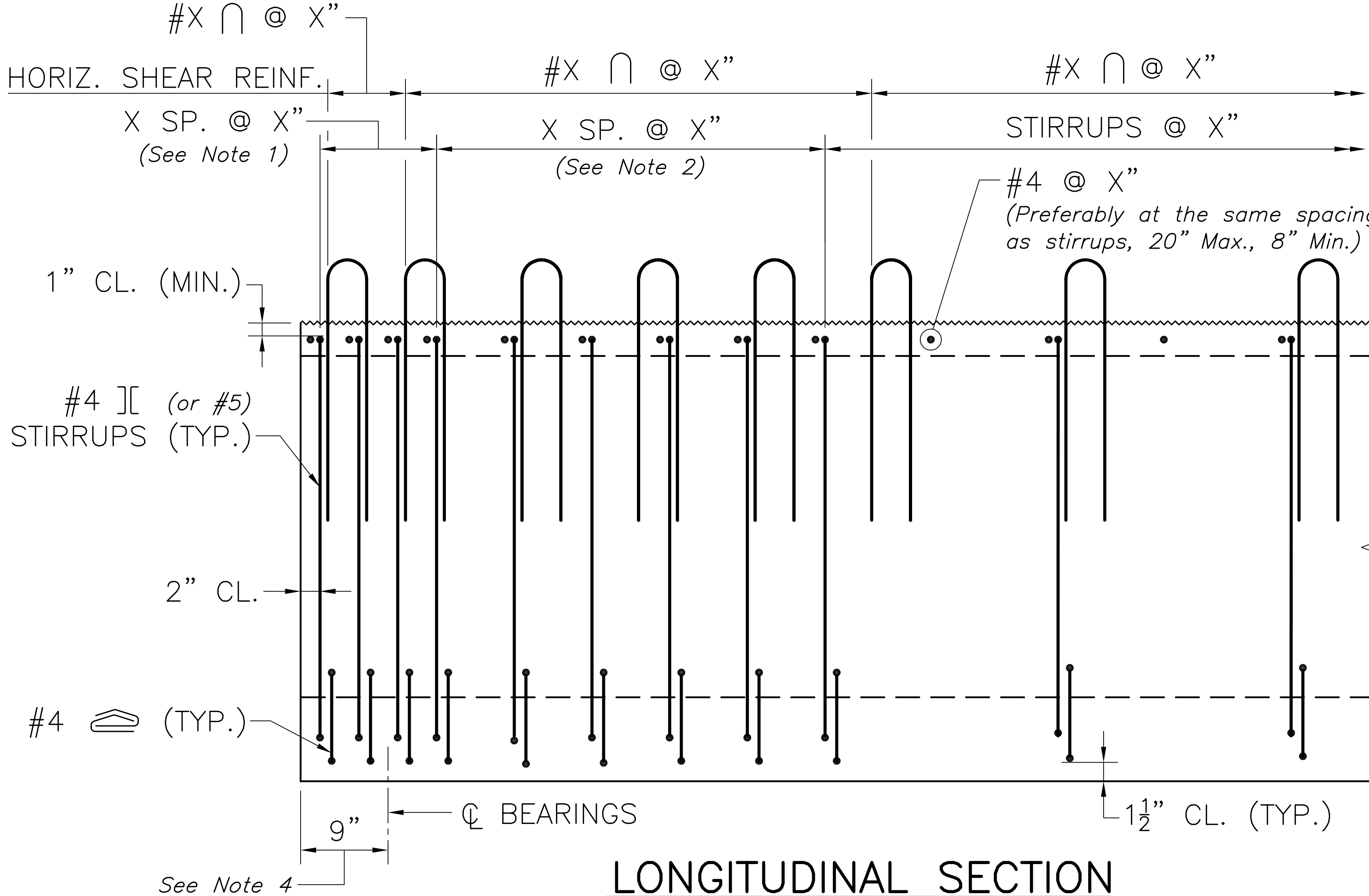
TYPICAL SECTION

SCALE: 1" = 1'–0"

NOTE:

Embedment Length of the Horizontal Shear Reinforcement into the deck may need to be increased in cases with large blocking depths. The Designer shall ensure that at least 2" clear cover is maintained to the top of the deck at all locations. The embedment length shown does not produce full development.

MASS HIGHWAY BRIDGE MANUAL	TYPICAL SECTION	DATE OF ISSUE NOVEMBER 2010
	PRECAST CONCRETE NEBT BEAMS	DRAWING NUMBER **6.1.5**



LONGITUDINAL SECTION

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *The vertical stirrups within h/4 of the end of the beam shall satisfy the requirements of AASHTO 9.22.*
2. *See Part I of the Bridge Manual for guidelines for the design of stirrups near the support.*
3. *The 20" maximum spacing for #4 bars in the NEBT top flange is based on a 10 feet beam spacing, 10" deck thickness, and a 50 psf construction live load. If any of these conditions are exceeded, the designer shall verify the required reinforcement spacing.*
4. *If the bearing exceeds 16" in diameter, set this dimension equal to (Bearing Diameter/2 + 1")*

MASS HIGHWAY
BRIDGE MANUAL

LONGITUDINAL SECTION

PRECAST CONCRETE NEBT BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.1.6

PRESTRESS NOTES:

1. ALL PRETENSIONING ELEMENTS SHALL BE 0.6" Ø, UNCOATED, SEVEN–WIRE, LOW RELAXATION STEEL STRANDS AND SHALL CONFORM TO AASHTO M 203.

2. THE MINIMUM ULTIMATE TENSILE STRENGTH OF THE PRETENSIONING STRANDS SHALL BE 270 KSI.

3. THE INITIAL TENSION PER 0.6" Ø STRAND SHALL BE 44 KIPS, EXCEPT THE SIX STRANDS IN THE TOP FLANGE WHICH SHALL BE TENSIONED TO 2 KIPS.

4. THE MINIMUM 28 DAY COMPRESSIVE STRENGTH SHALL BE 6500 PSI. *(See Note)*

5. NO PRESTRESS SHALL BE TRANSFERRED TO THE CONCRETE UNTIL IT HAS ATTAINED A COMPRESSIVE STRENGTH, AS SHOWN BY A CYLINDER TEST, OF AT LEAST 4000 PSI. *(See Note 1)*

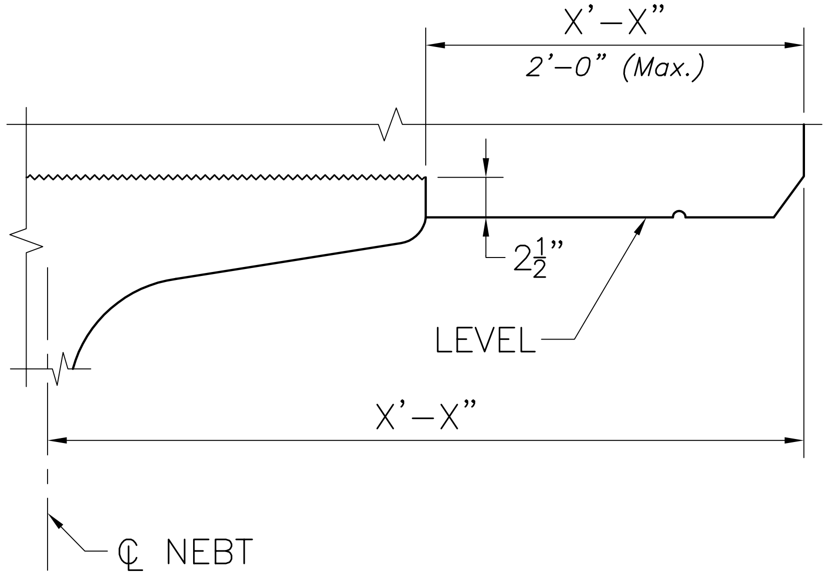
6. THE TOP OF ALL BEAMS SHALL BE GIVEN A RAKED FINISH ($\frac{1}{4}$" AMPLITUDE) ACROSS THE WIDTH (PERPENDICULAR TO THE BEAM'S AXIS).

7. THE FABRICATOR IS FULLY RESPONSIBLE FOR THE DESIGN OF THE LIFTING DEVICES WHICH SHALL BE ADEQUATE FOR THE SAFETY FACTORS REQUIRED BY THE ERECTION PROCEDURE.

NOTE:

If required by design, HP concrete with a compressive strength of 8000 psi may be used with the permission of the Bridge Engineer. A Special Provision will be required in this case. See the prestressed concrete section of Part I of the Bridge Manual.

THIS DRAWING HAS BEEN DELETED

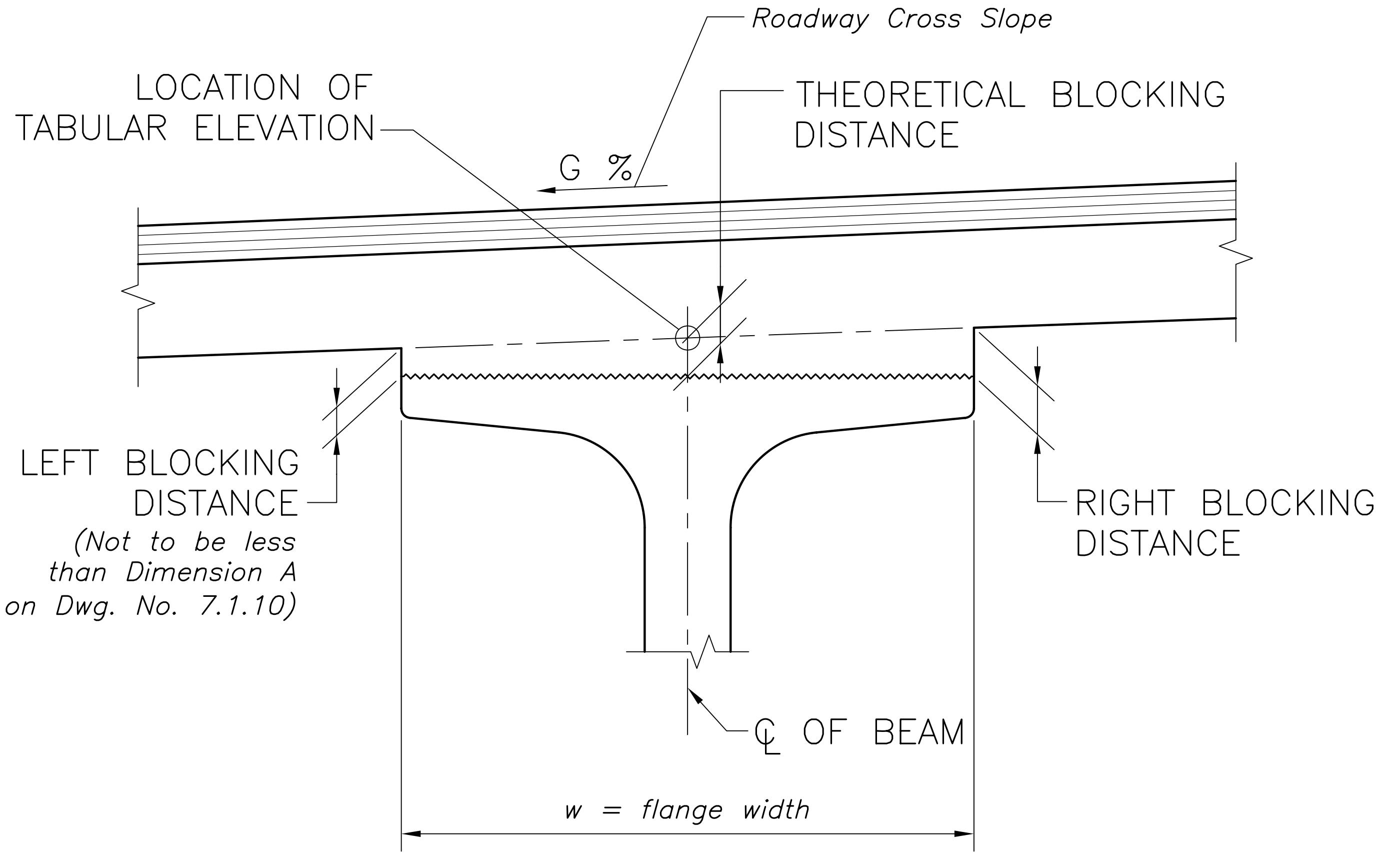


SLAB OVERHANG AT FASCIA BEAM

SCALE: 1" = 1'–0"

NOTE:

Modify the deck slab overhang details as depicted for steel stringer bridges in the relevant Chapter 9 drawings as shown above, when using NEBT beams.



NOTES:

1. THE RIGHT AND LEFT ORIENTATION IS TAKEN LOOKING UPSTATION ALONG THE BEAM.

2. RIGHT BLOCKING DISTANCE = THEORETICAL BLOCKING DISTANCE + "R"
   LEFT BLOCKING DISTANCE = THEORETICAL BLOCKING DISTANCE + "L"

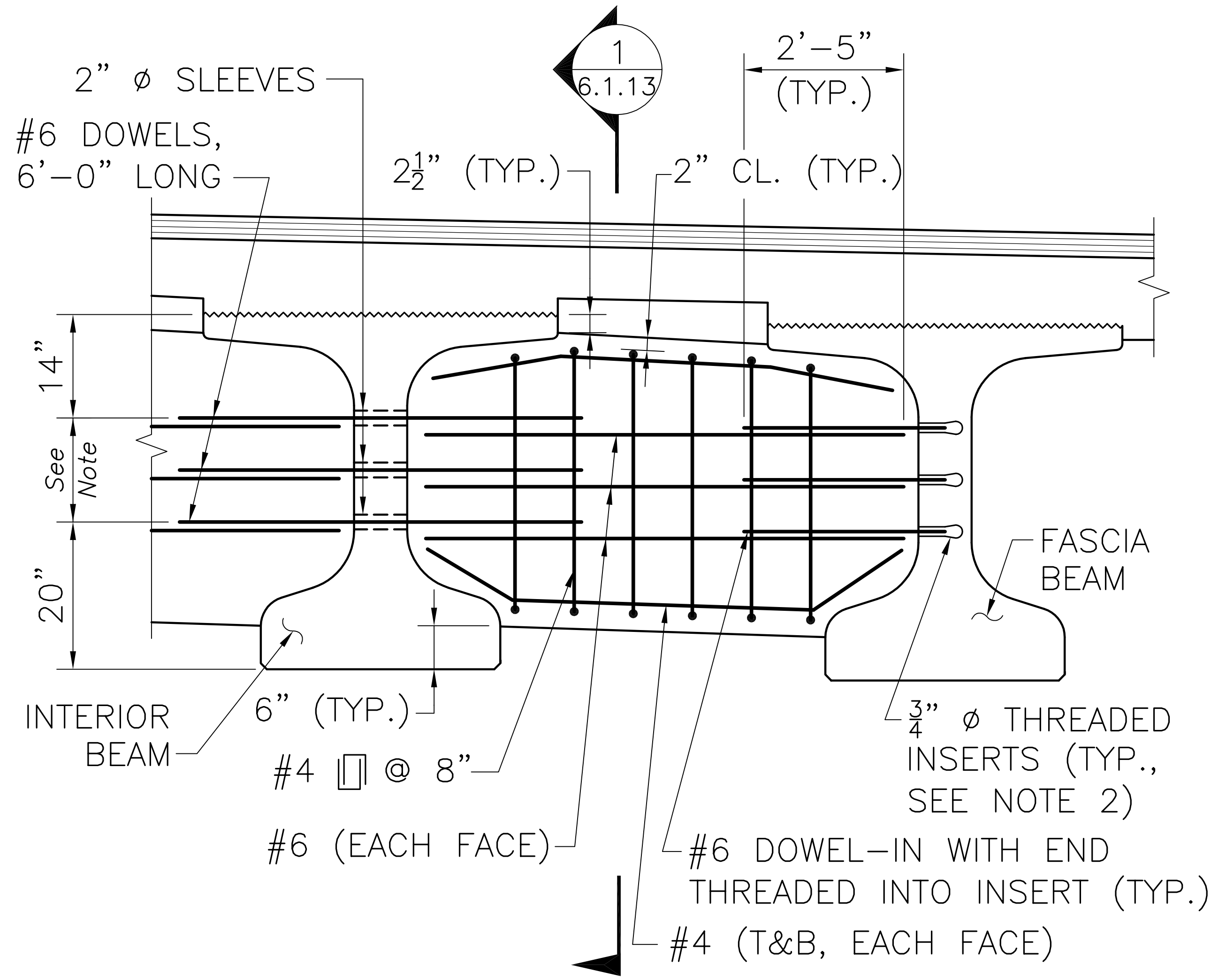
HAUNCH DETAIL

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *For bridges with NEBT beams, use the above Haunch Detail in place of the one on Dwg. No. 7.1.10. Also, modify the note on Dwg. No. 7.1.10 to say "Theoretical" instead of "Actual" blocking distance.*
2. *For the above detail:*
   "R" = G/100 x w/2
   "L" = –G/100 x w/2
   Since "R" and "L" vary with changes in the roadway cross slope, it is advisable to provide a table of "R" and "L" values for each beam or group of beams for each roadway cross slope situation. Always show "R" and "L" with their correct algebraic sign.

MASS HIGHWAY BRIDGE MANUAL	HAUNCH DETAIL	DATE OF ISSUE NOVEMBER 2010
	PRECAST CONCRETE NEBT BEAMS	DRAWING NUMBER 6.1.10



NOTES:

1. SLEEVES AND INSERTS SHALL BE ALIGNED WITH DIAPHRAGM SKEWS AS SHOWN ON THE FRAMING PLAN.

2. #6 REINFORCEMENT BAR INSERTS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THE #6 REINFORCEMENT BAR INSERTS SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 17.4 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 15.3 KIPS IN 3000 PSI CONCRETE.

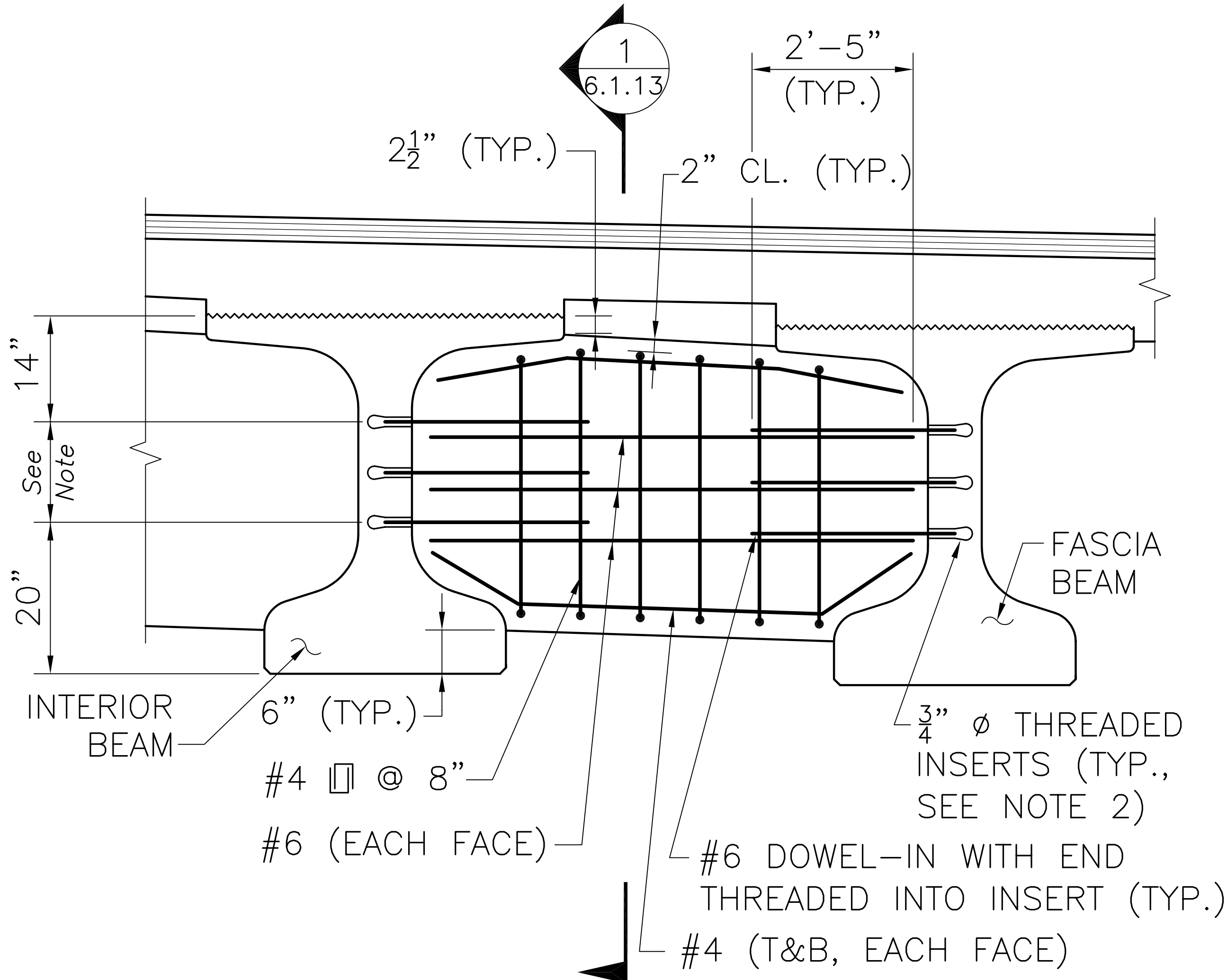
TYPICAL INTERMEDIATE DIAPHRAGM

SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

For NEBT 1000 use 1 dowel at midbeam.
For NEBT 1200 and NEBT 1400, use 2 dowels.
For NEBT 1600 and NEBT 1800, use 3 dowels equally spaced.

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM DETAIL (SKEW ⩽ 30°) PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.1.11**



NOTES:

1. INSERTS SHALL BE SET PERPENDICULAR TO THE NEBT WEB.

2. #6 REINFORCEMENT BAR INSERTS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THE #6 REINFORCEMENT BAR INSERTS SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 17.4 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 15.3 KIPS IN 3000 PSI CONCRETE.

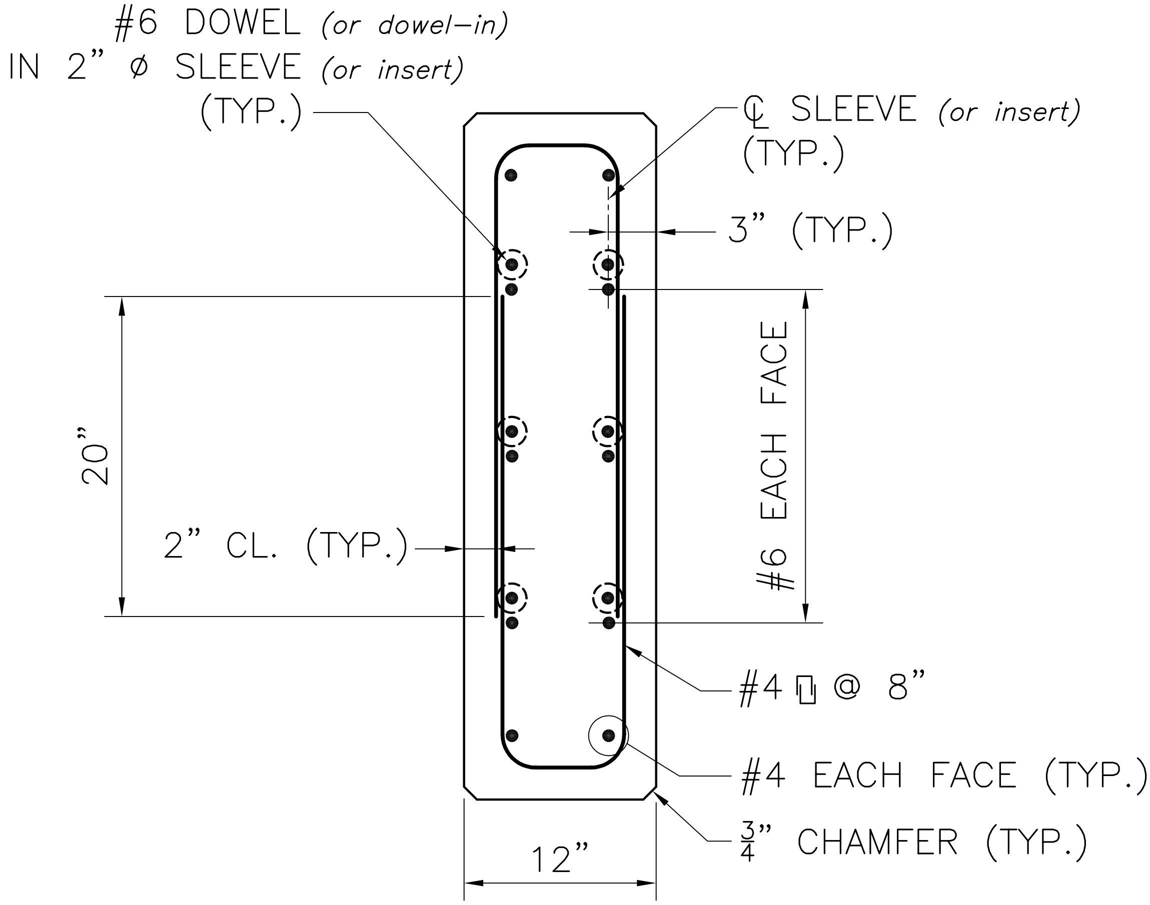
TYPICAL INTERMEDIATE DIAPHRAGM

SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

For NEBT 1000 use 1 insert at midbeam.
For NEBT 1200 and NEBT 1400, use 2 inserts.
For NEBT 1600 and NEBT 1800, use 3 inserts equally spaced.

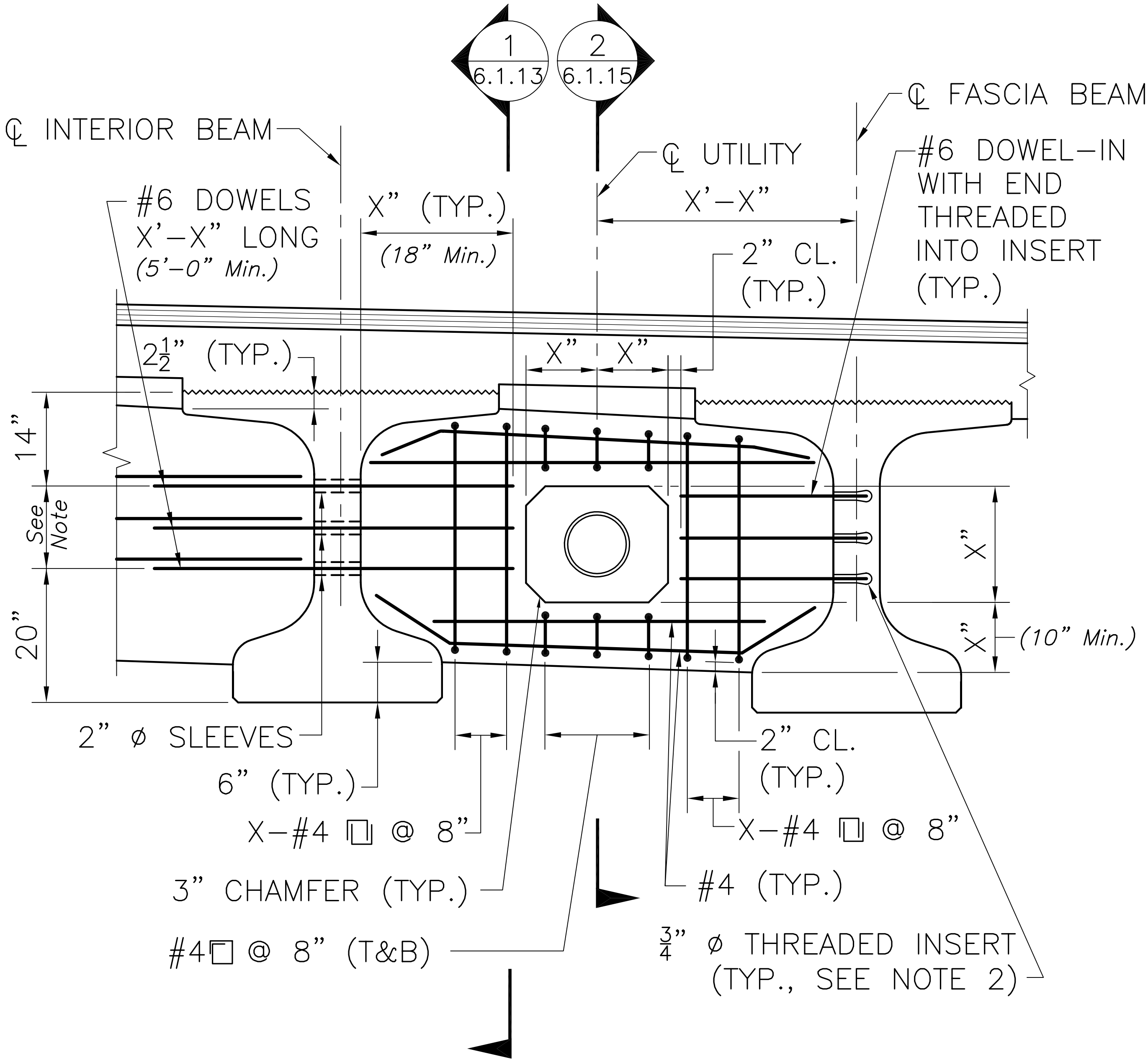
MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM DETAIL (SKEW > 30°) PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER 6.1.12



SECTION 1

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM TYPICAL SECTION PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.1.13**



(For Construction Notes see Dwg. No. 6.1.11)

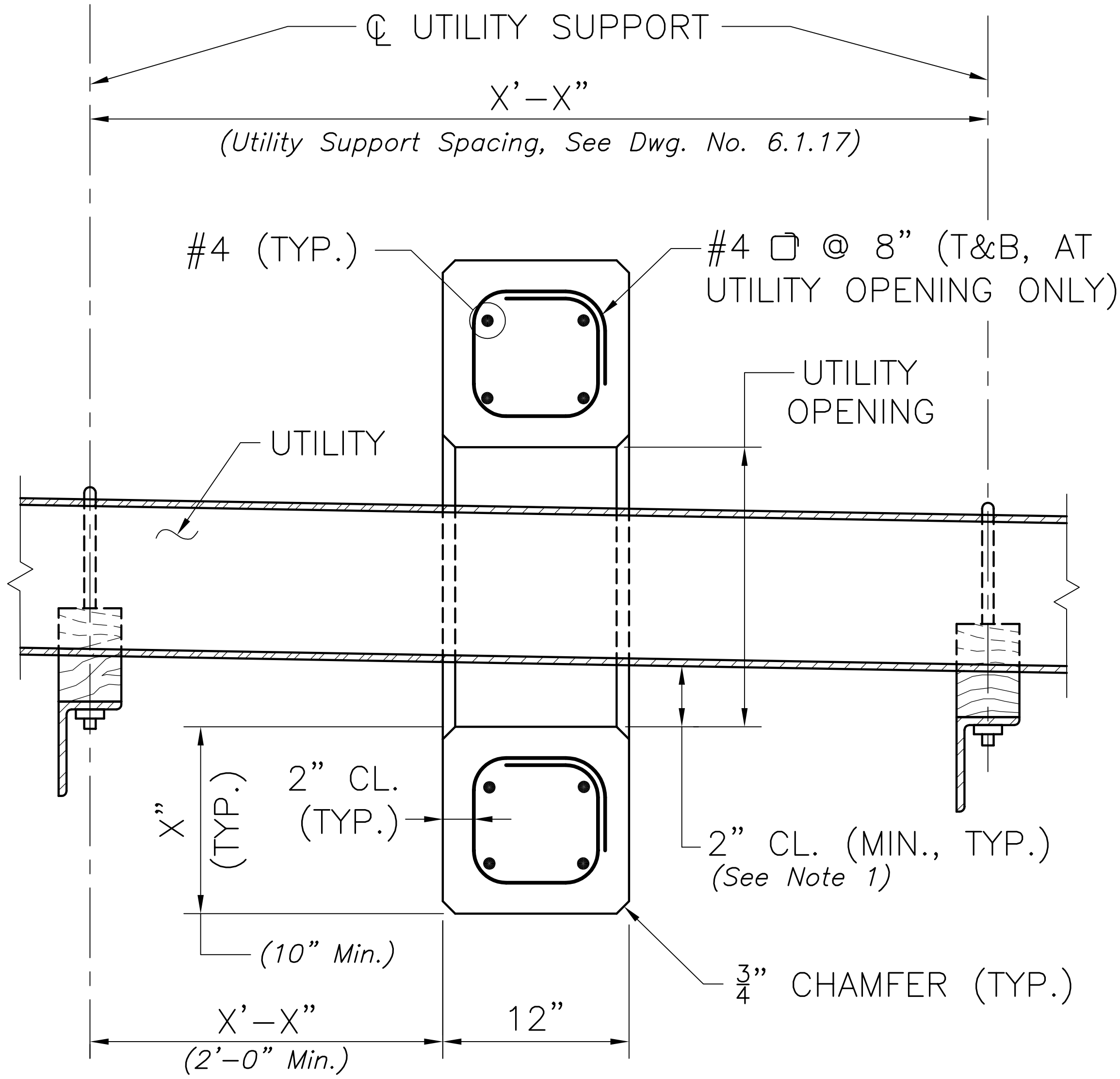
TYPICAL INTERMEDIATE DIAPHRAGM WITH UTILITY

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *For NEBT 1000, use 1 dowel at mid–beam.*
   For NEBT 1200 and NEBT 1400, use 2 dowels.
   For NEBT 1600 and NEBT 1800, use 3 dowels equally spaced.
2. *Detail shown is for skews ⩽ 30°. For skews > 30°, modify this detail for interior beam using inserts as shown on Dwg. No. 6.1.12 and use Construction Notes on that drawing.*
3. *The type of utility shown is conceptual and shall be modified to accommodate the actual type.*

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM DETAIL WITH UTILITY PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.1.14**

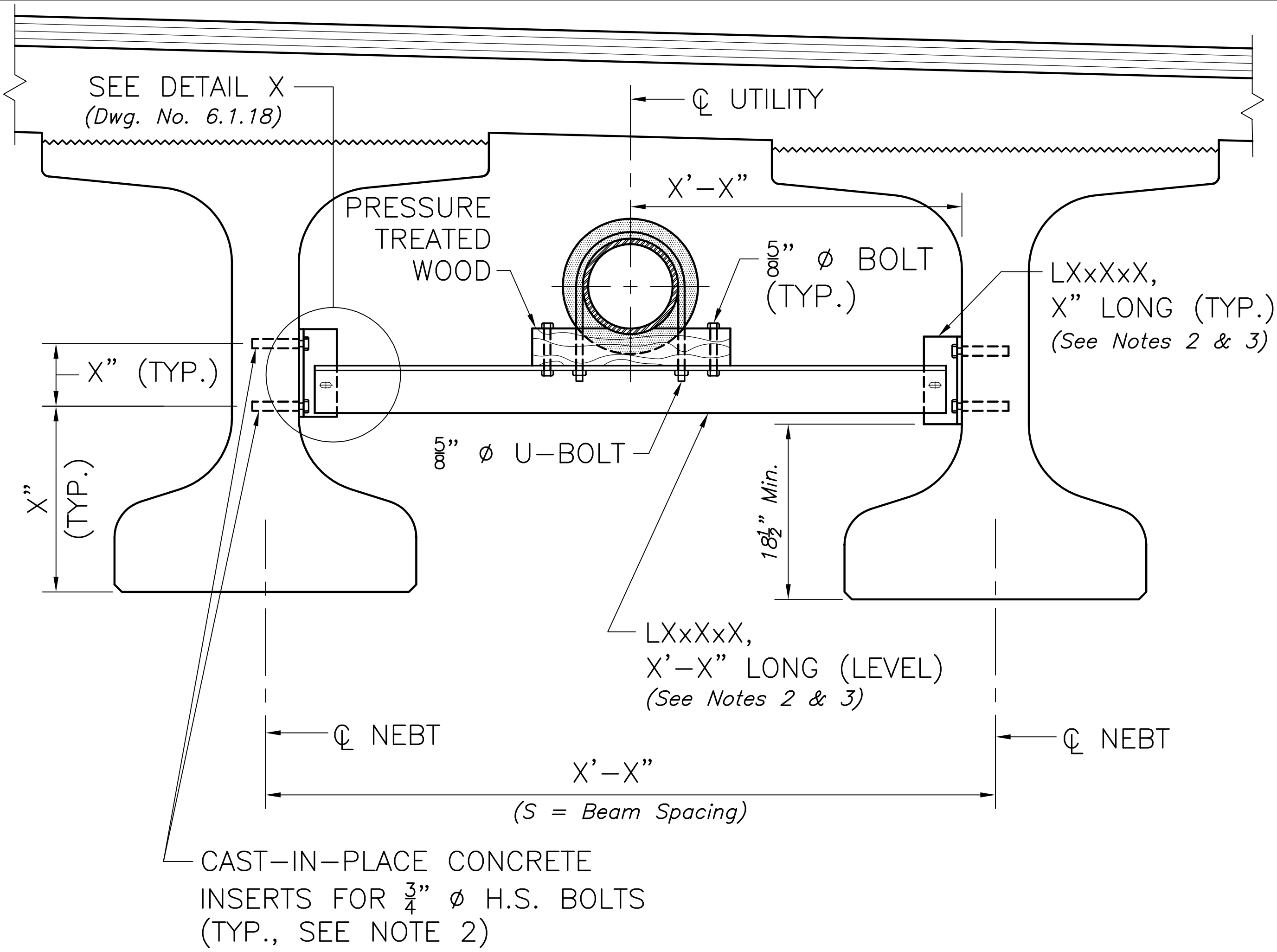


SECTION 2

SCALE: 1" = 1'–0"

NOTES:

1. *The Designer shall verify that the clearances required by utilities are maintained.*
2. *The type of utility is conceptual, and shall be modified to accommodate the actual type.*



NOTES:

1. ALL STRUCTURAL STEEL FOR UTILITY SUPPORTS SHALL CONFORM TO AASHTO M 270 GRADE 36. ALL STRUCTURAL STEEL AND FASTENERS SHALL BE HOT–DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 111 AND M 232.

2. INSERTS FOR 3/4" ø H.S. BOLTS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THE 3/4" ø H.S. BOLT INSERTS SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 1.1 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 4.1 KIPS IN 3000 PSI CONCRETE. *(The Designer shall determine the required insert capacities if S > 12 feet).*
3. THE UTILITY SUPPORT ANGLE SHALL BE ERECTED WITH THE LONG LEG VERTICAL.

4. INSERTS SHALL BE POSITIONED TO AVOID INTERFERENCE WITH PRESTRESSING STRANDS.

UTILITY BAY DETAILS

SCALE: 3/4" = 1'–0"

NOTE:
See Dwg. No. 6.1.17 For Designer Notes.

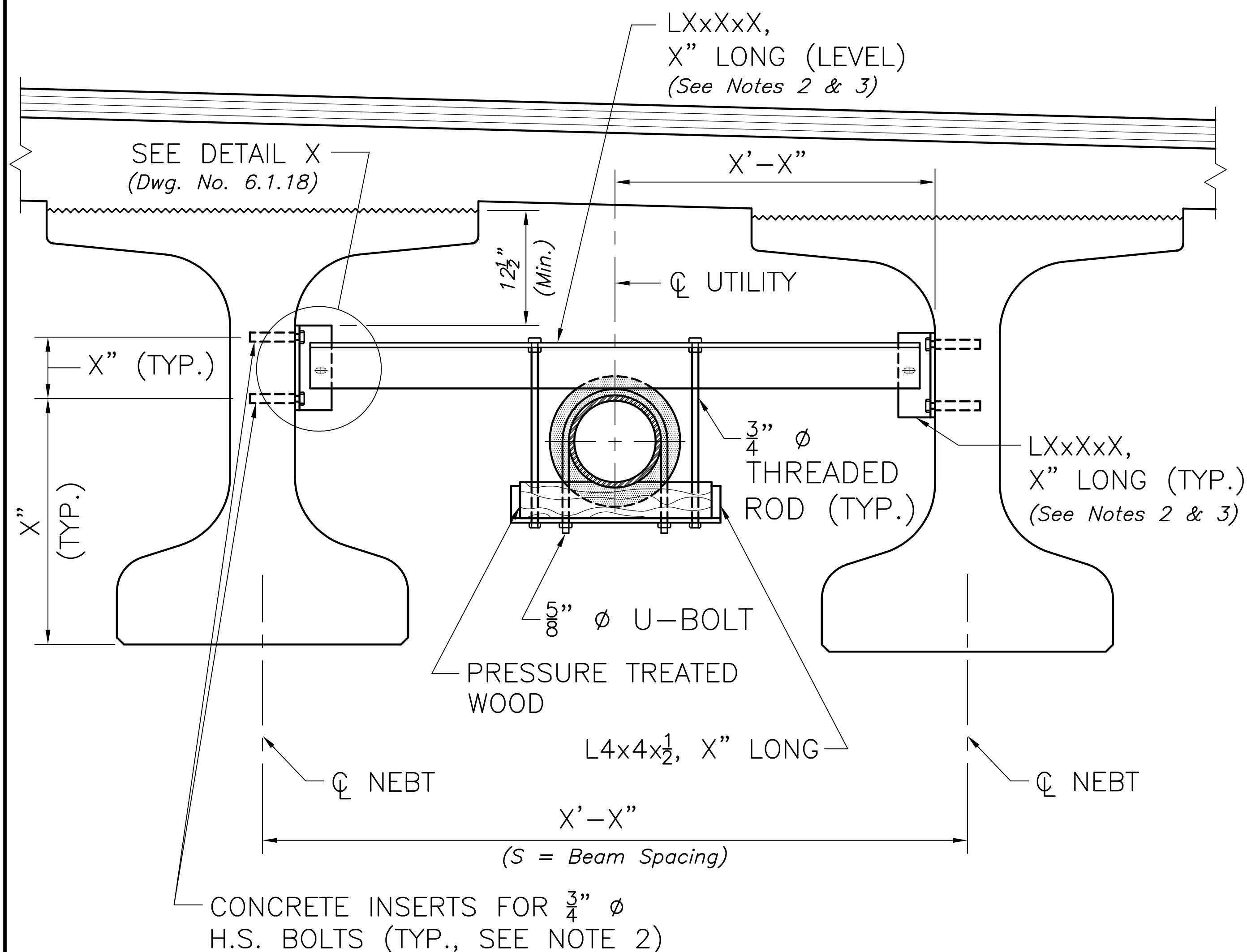
MASS HIGHWAY BRIDGE MANUAL

UTILITY BAY DETAILS (PREFERRED)

PRECAST CONCRETE NEBT BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.1.16



NOTES:

(See Dwg. No. 6.1.16 for Constructions Notes)

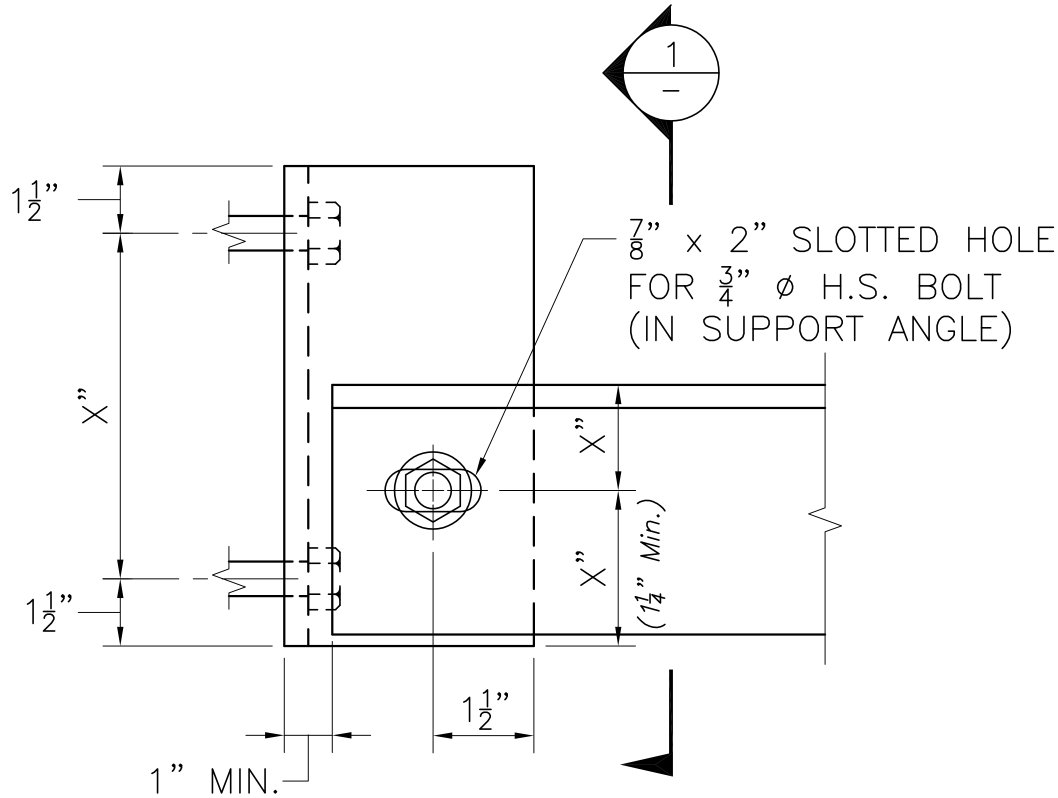
UTILITY BAY DETAILS

SCALE: ¾" = 1'–0"

NOTES:

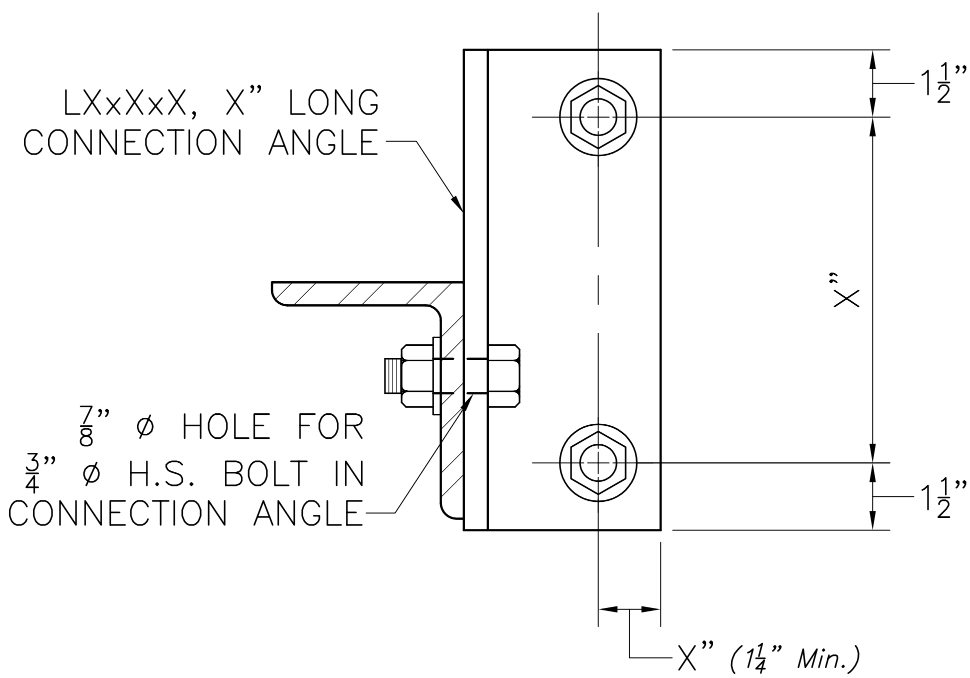
1. *The type of utility shown is conceptual and shall be modified to accommodate the actual type.*
2. *For S < 6'–6" use L5x3½x½*
   For 6'–6" ⩽ S ⩽ 12'–0" use L6x4x⅝
   For S > 12'–0" to be designed by Designer
3. *Maximum utility support spacing = 11'–6" and the maximum total utility weight is 250 lbs/ft. If either of these limits are exceeded, the Designer shall design the support angle.*
4. *The connection angles attached to the NEBT web are positioned to clear the NEBT curvature.*
5. *The alternate utility support detail shown above shall be used where the size of utility precludes the use of the preferred detail of Dwg. No. 6.1.16. The Designer may need to modify the interior diaphragm when using this detail as well.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY BAY DETAILS (ALTERNATE) PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.1.17**



DETAIL X

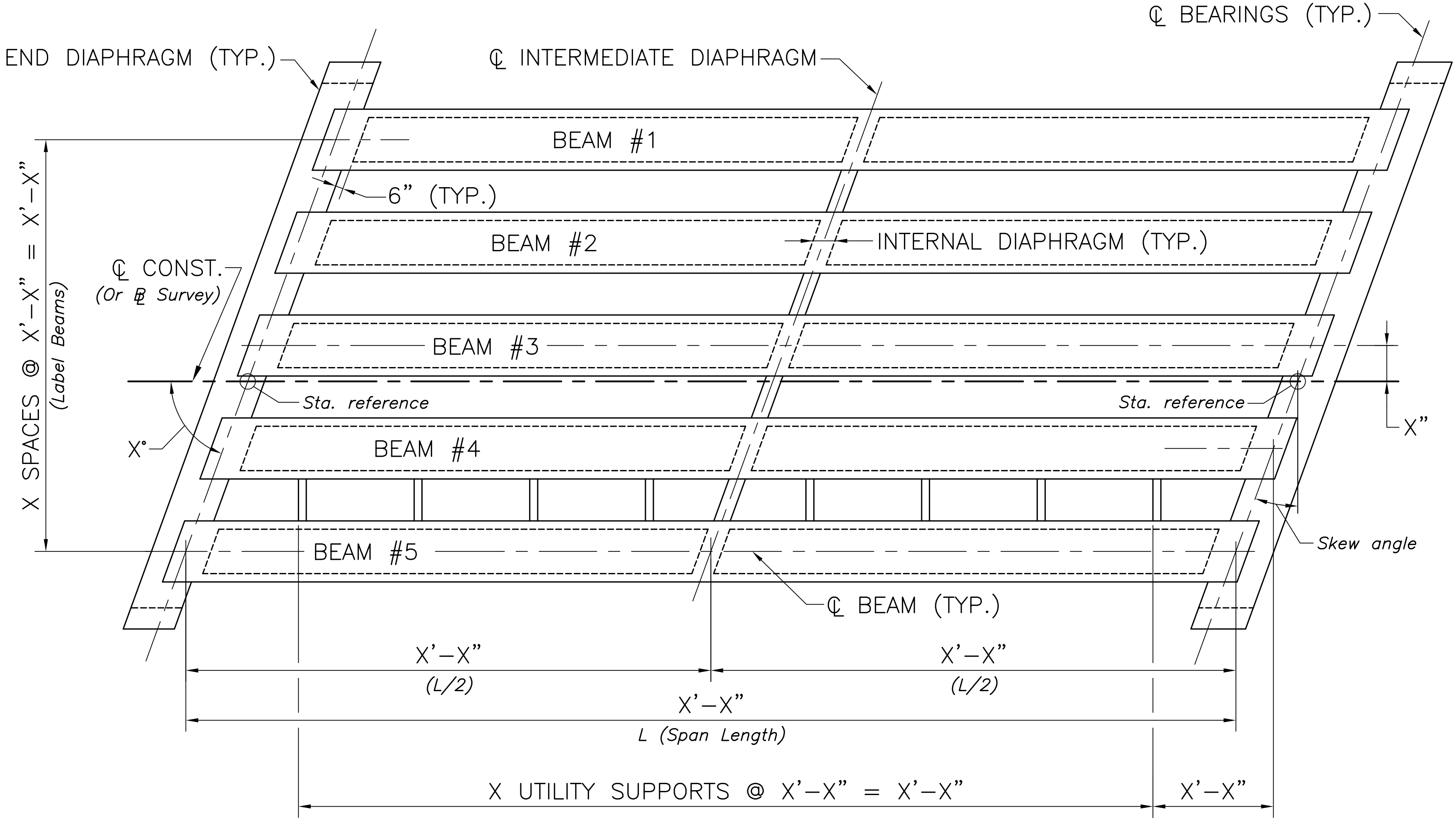
SCALE: 3" = 1'–0"



SECTION 1

SCALE: 3" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	UTILITY SUPPORT DETAILS PRECAST CONCRETE NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.1.18**



FRAMING PLAN

SCALE: ($\frac{1}{8}$" = 1'–0" Min.)

NOTES:

1. *Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Label beam types and include North Arrow.*
2. *No intermediate diaphragms required for spans of 80' or less.*
3. *End diaphragms, ends of beams and ends of voids shall follow skew of bridge.*
4. *For utility support spacing requirements, see Dwg. No. 6.2.20.*
5. *The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.*

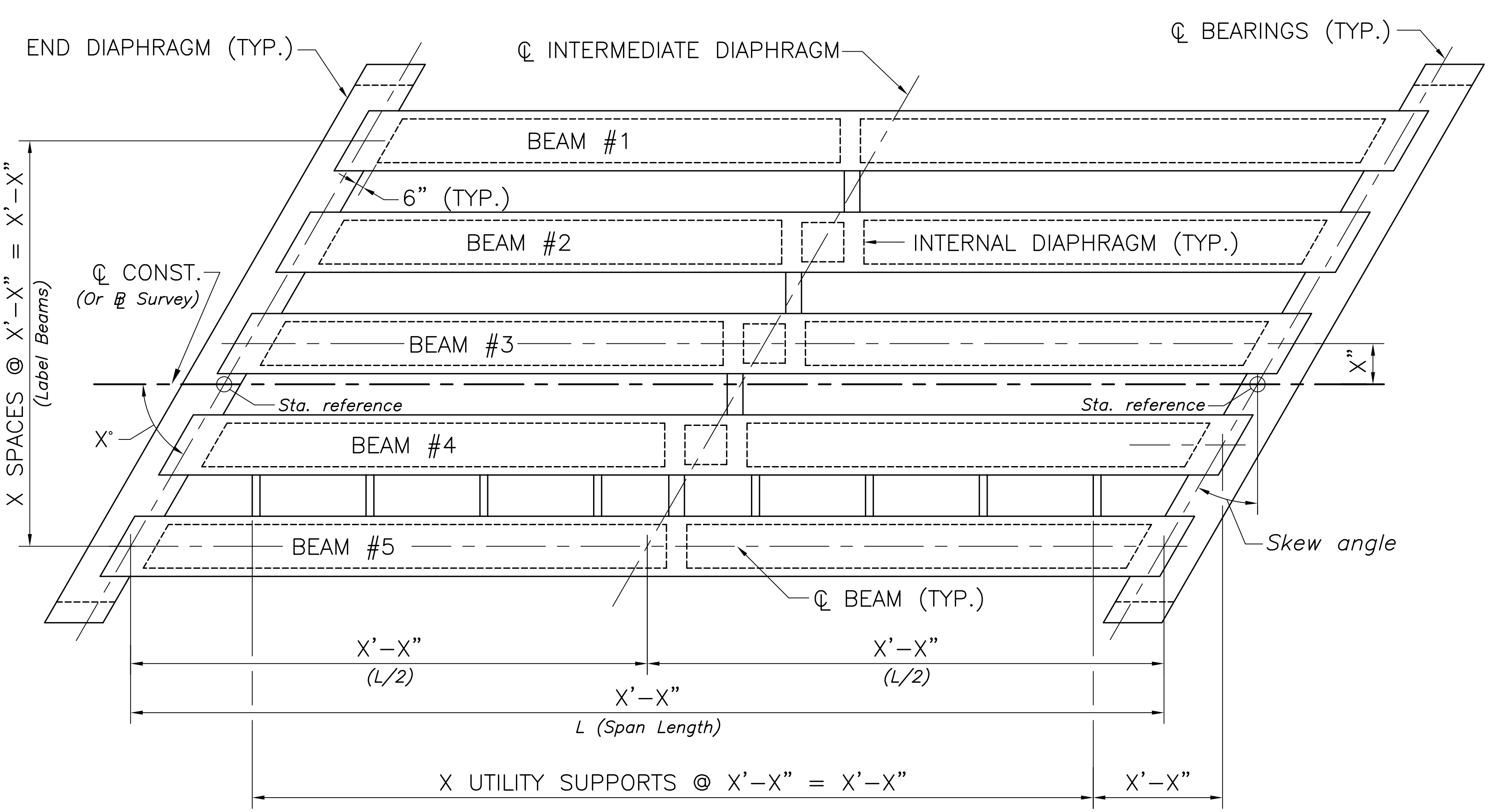
MASS HIGHWAY BRIDGE MANUAL

FRAMING PLAN (SKEW ⩽ 30°)

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **6.2.1**



FRAMING PLAN

SCALE: (1/8" = 1'–0" Min.)

NOTES:

1. *Framing plan shall be drawn full length without breaks and to scale on the Construction Drawings. Label beam types and include North Arrow.*
2. *No intermediate diaphragms required for spans of 80' or less.*
3. *End diaphragms, ends of beams and ends of voids shall follow skew of bridge.*
4. *For utility support spacing requirements, see Dwg. No. 6.2.20.*
5. *The beams shall be consecutively numbered from South to North for bridges oriented generally East–West and from West to East for bridges oriented generally North–South. Spans shall be consecutively numbered from West to East for bridges generally oriented East–West and from South to North for bridges generally oriented North–South.*

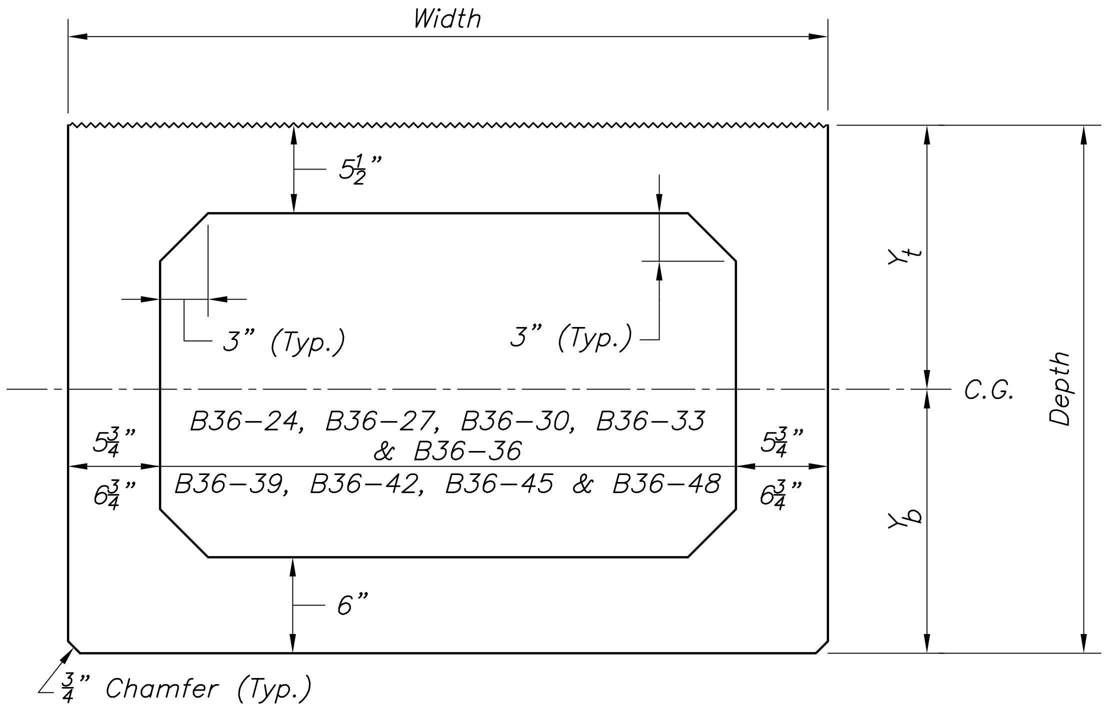
MASS HIGHWAY BRIDGE MANUAL

FRAMING PLAN (SKEW > 30°)

PRECAST CONCRETE BOX BEAMS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.2.2



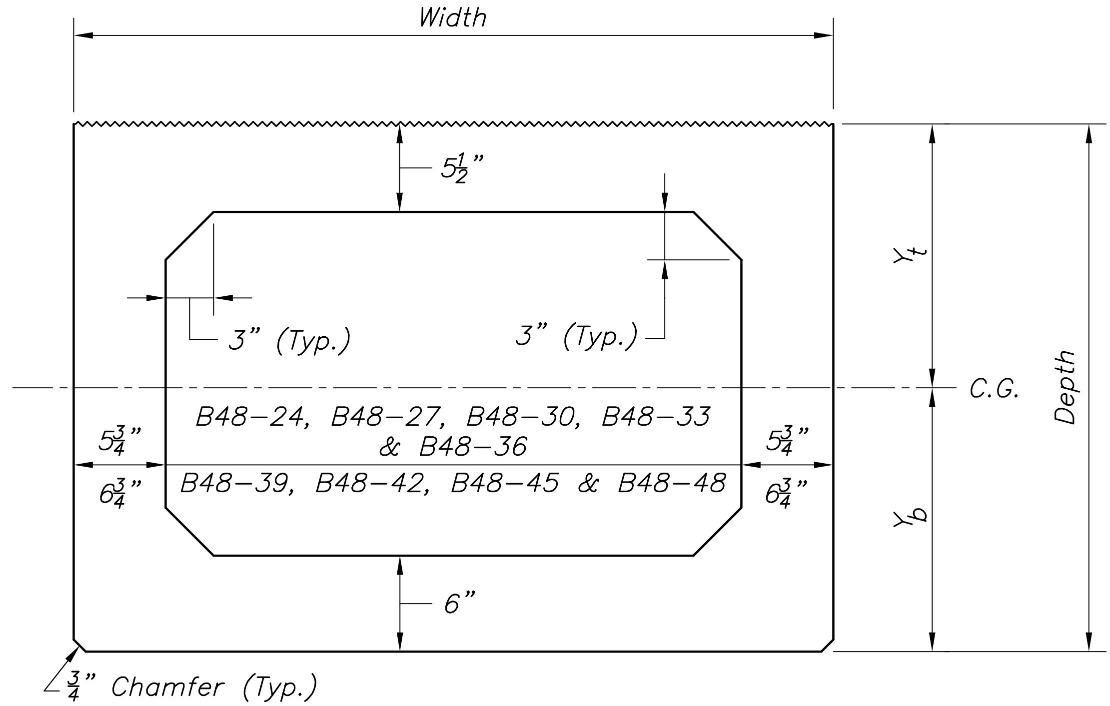
BEAM PROPERTIES

BEAM TYPE	WIDTH (in)	DEPTH (in)	AREA (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
B36–24	35.5	24	569	37392	11.89	12.11	3145	3088	593	50
B36–27	35.5	27	604	51478	13.37	13.63	3850	3777	629	56
B36–30	35.5	30	638	68281	14.85	15.15	4598	4507	665	62
B36–33	35.5	33	673	87958	16.33	16.67	5386	5276	701	67
B36–36	35.5	36	707	110661	17.81	18.19	6213	6084	736	72
B36–39	35.5	39	797	140025	19.33	19.67	7244	7119	830	80
B36–42	35.5	42	837	170514	20.82	21.18	8190	8051	872	85
B36–45	35.5	45	878	204772	22.31	22.69	9178	9025	915	90
B36–48	35.5	48	918	242981	23.80	24.20	10209	10041	956	97

NOTES:

1. Above drawing is not to scale.
2. Maximum Span lengths are approximate and are based on the following assumptions:
   f'c = 6500 psi
   f'ci = 4500 psi
   f'c = 4000 psi for 8" Composite Deck
   Beam Spacing = 5'–0"
   Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi
   HS25 Truck loading.
3. Weight of beams does not include the weight of the solid sections. Include the weight of the solid sections for design.

MASS HIGHWAY BRIDGE MANUAL	STANDARD 36" WIDE BEAMS	DATE OF ISSUE MAY 2005
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER **6.2.3**



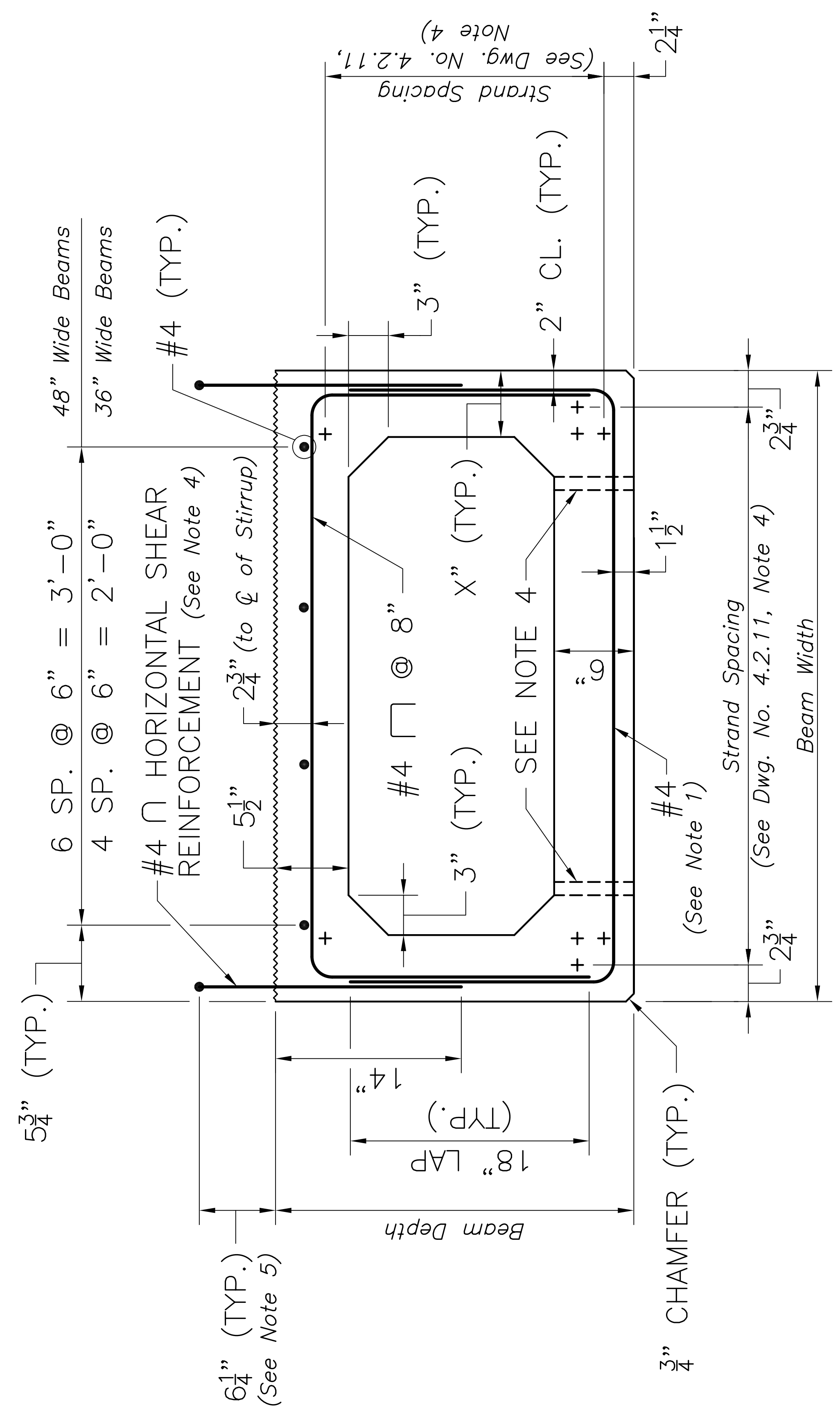
BEAM PROPERTIES

BEAM TYPE	WIDTH (in)	DEPTH (in)	AREA (in^2)	I (in^4)	Y_b (in)	Y_t (in)	S_b (in^3)	S_t (in^3)	WEIGHT (lbs/ft)	MAX. SPAN (ft)
B48–24	47.5	24	707	49247	11.86	12.14	4152	4057	736	55
B48–27	47.5	27	742	67415	13.33	13.67	5057	4932	773	60
B48–30	47.5	30	776	88921	14.80	15.20	6008	5850	808	67
B48–33	47.5	33	811	113920	16.28	16.72	6998	6813	845	73
B48–36	47.5	36	845	142567	17.76	18.24	8027	7816	880	78
B48–39	47.5	39	935	178498	19.27	19.73	9263	9047	974	84
B48–42	47.5	42	975	216174	20.75	21.25	10418	10173	1016	90
B48–45	47.5	45	1016	258238	22.24	22.76	11611	11346	1058	94
B48–48	47.5	48	1056	304874	23.72	24.28	12853	12557	1100	100

NOTES:

1. Above drawing is not to scale.
2. Maximum Span lengths are approximate and are based on the following assumptions:
   - f'c = 6500 psi
   - f'ci = 4500 psi
   - f'c = 4000 psi for 8" Composite Deck
   - Beam Spacing = 6'–10"
   - Final Allowable Tension at bottom of beam is equal to $3\sqrt{f'c}$ psi.
   - HS25 Truck loading.
3. Weight of beams does not include the weight of the solid sections. Include the weight of the solid sections for design.

MASS HIGHWAY BRIDGE MANUAL	STANDARD 48" WIDE BEAMS PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **6.2.4**

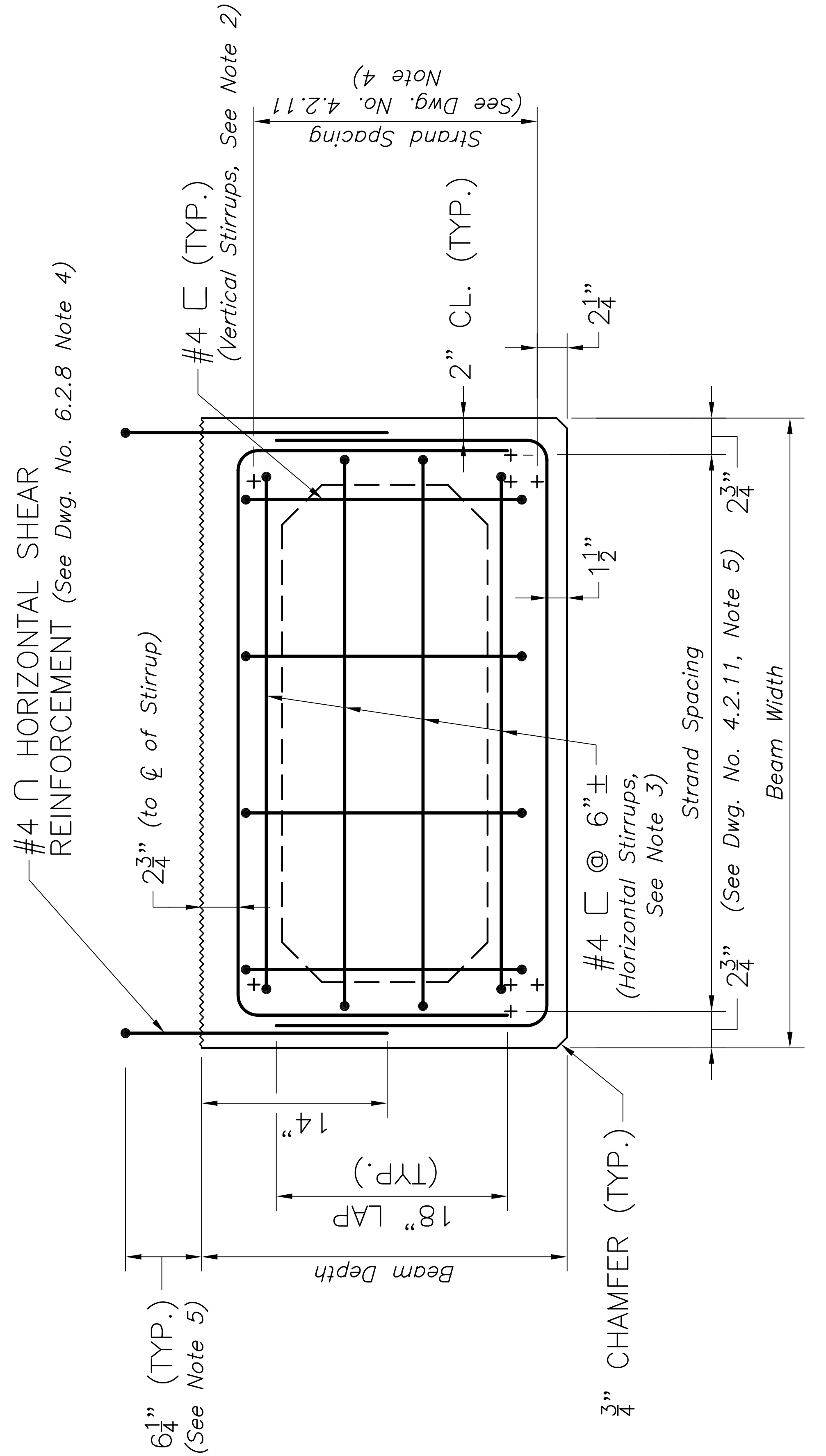


NOTES:

See Dwg. No. 6.2.8 for notes to be included on Construction Drawings.

NOTE: See Dwg. No. 6.2.8 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	MIDSPAN SECTION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **6.2.5**



NOTES:

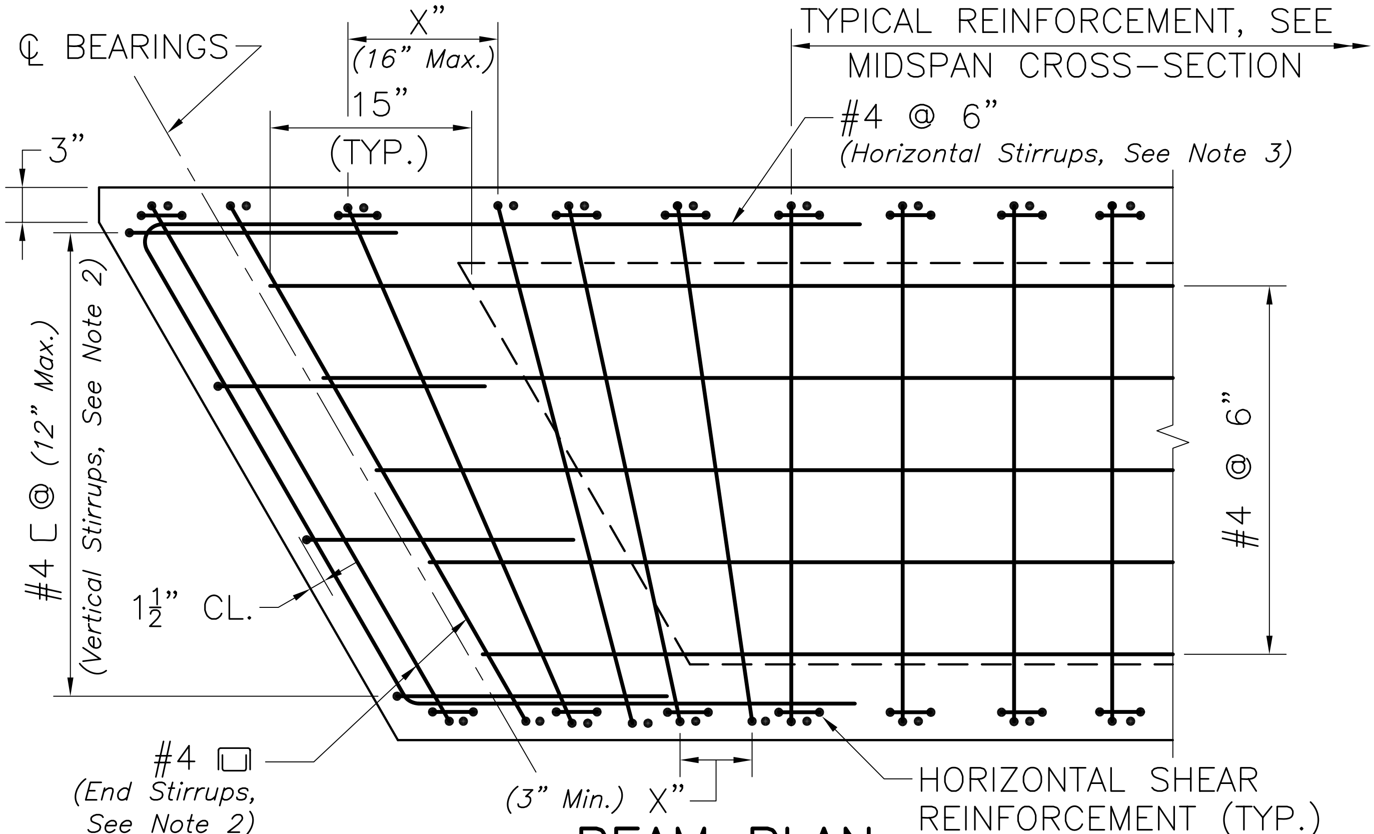
(See Dwg. No. 6.2.8 for notes to be included on Construction Drawings.)

END OF BEAM SECTION

SCALE: 1" = 1'-0"

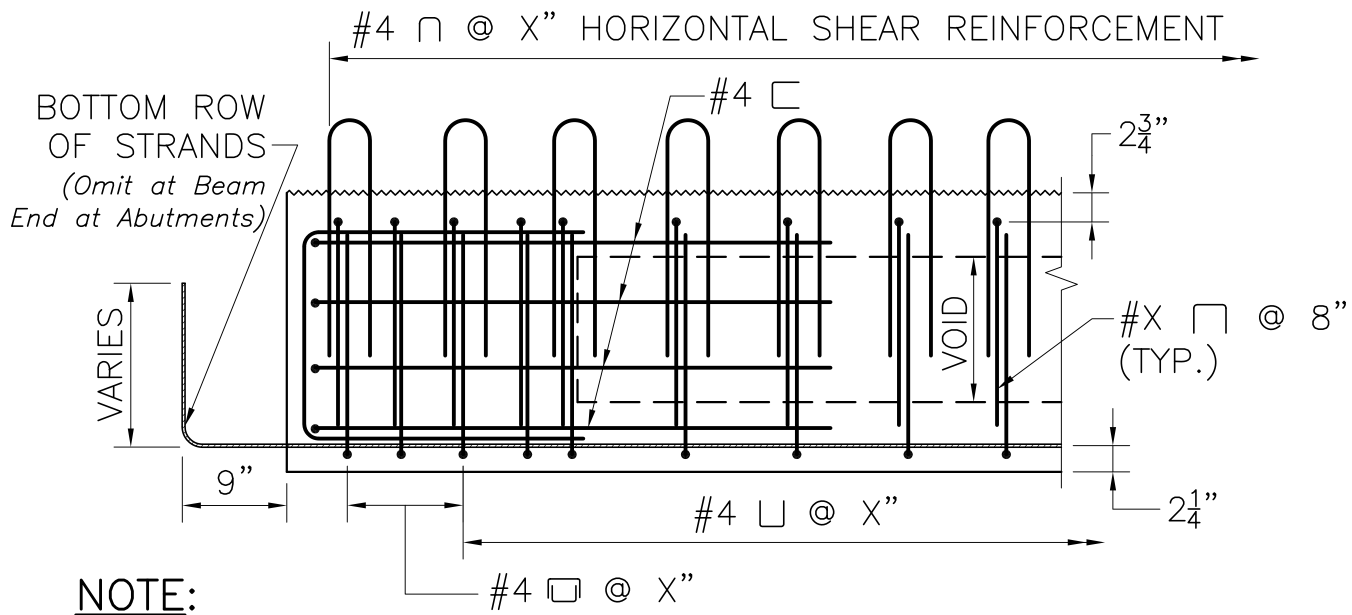
NOTE:
See Dwg. No. 6.2.8 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	END OF BEAM SECTION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER 6.2.6



BEAM PLAN

SCALE: ¾" = 1'–0"



NOTE:
THE REMAINDER OF THE STRANDS IS NOT SHOWN FOR CLARITY.

BEAM ELEVATION

SCALE: ¾" = 1'–0"

NOTES:

1. *The extent of these details should be long enough to indicate typical stirrup spacing throughout the beam.*
2. *See Dwg. 6.2.8 for Designer Notes.*

MASS HIGHWAY BRIDGE MANUAL	BEAM PLAN AND ELEVATION	DATE OF ISSUE: FEBRUARY 2007
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER: **6.2.7**

NOTES: *(Include these notes with details shown on Dwg. No's. 6.2.5 and 6.2.6)*

1. + DENOTES STRAIGHT STRANDS.
2. ◇ DENOTES DRAPED STRANDS. *(Include only if needed)*
3. ⊕ DENOTES DEBONDED STRANDS. *(Include only if needed)*
4. 1" ø DRAIN, PLACED AT BOTH ENDS OF VOIDS.
5. SEE BEAM ELEVATION FOR STIRRUP SPACING.

NOTES: (These notes are for details shown on Dwg. No's. 6.2.5, 6.2.6 and 6.2.7)

1. *Bottom transverse stirrups shall be placed at a multiple of the top transverse stirrup spacing with a maximum spacing of 16". See prestressed section of Part I of the Bridge Manual for the design of the transverse stirrups.*
2. *See the prestressed section of Part I of the Bridge Manual for the design of the end transverse stirrups and vertical stirrups. The horizontal legs of the vertical stirrups are equal to the depth of the beam and shall be dimensioned on the plan view.*
3. *Horizontal stirrups shall be embedded a minimum distance equal to the depth of the beam or 12" into the web of the voided section, whichever is longer. Length of embedment shall be noted on the plan view.*
4. *Horizontal shear reinforcement for composite action shall be designed in accordance with AASHTO.*
5. *Embedment of horizontal shear reinforcement into the deck slab may need to be increased in cases with large blocking depths. However, the Designer shall ensure that at least 2" clear cover is maintained to the top of deck at all locations. The embedment length shown does not produce full development.*

PRESTRESS NOTES:

1. ALL PRETENSIONING ELEMENTS SHALL BE 0.6" ⌀, UNCOATED, SEVEN–WIRE, LOW RELAXATION STEEL STRANDS AND SHALL CONFORM TO AASHTO M 203.

2. THE MINIMUM ULTIMATE TENSILE STRENGTH OF THE PRETENSIONING STRANDS SHALL BE 270 KSI.

3. THE INITIAL TENSION PER 0.6" ⌀ STRAND SHALL BE 44 KIPS.

4. THE MINIMUM 28 DAY COMPRESSIVE STRENGTH SHALL BE 6500 PSI. *(See Note)*

5. NO PRESTRESS SHALL BE TRANSFERRED TO THE CONCRETE UNTIL IT HAS ATTAINED A COMPRESSIVE STRENGTH, AS SHOWN BY A CYLINDER TEST, OF AT LEAST 4000 PSI. *(See Note)*

6. THE TOP OF ALL BEAMS SHALL BE GIVEN A RAKED FINISH ($\frac{1}{4}$" AMPLITUDE) ACROSS THE WIDTH (PERPENDICULAR TO THE BEAM'S AXIS).

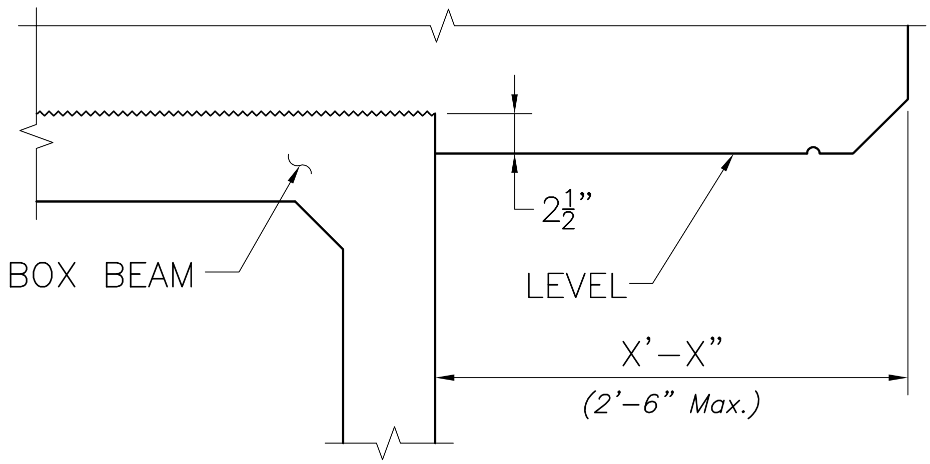
7. THE FABRICATOR IS FULLY RESPONSIBLE FOR THE DESIGN OF THE LIFTING DEVICES WHICH SHALL BE ADEQUATE FOR THE SAFETY FACTORS REQUIRED BY THE ERECTION PROCEDURE.

NOTE:

If required by design, HP concrete with a compressive strength of 8000 psi may be used with the permission of the Bridge Engineer. A Special Provision will be required in this case.

THIS DRAWING HAS BEEN DELETED

MASS HIGHWAY BRIDGE MANUAL	STAY-IN-PLACE FORM ATTACHMENT DETAIL PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.2.10**

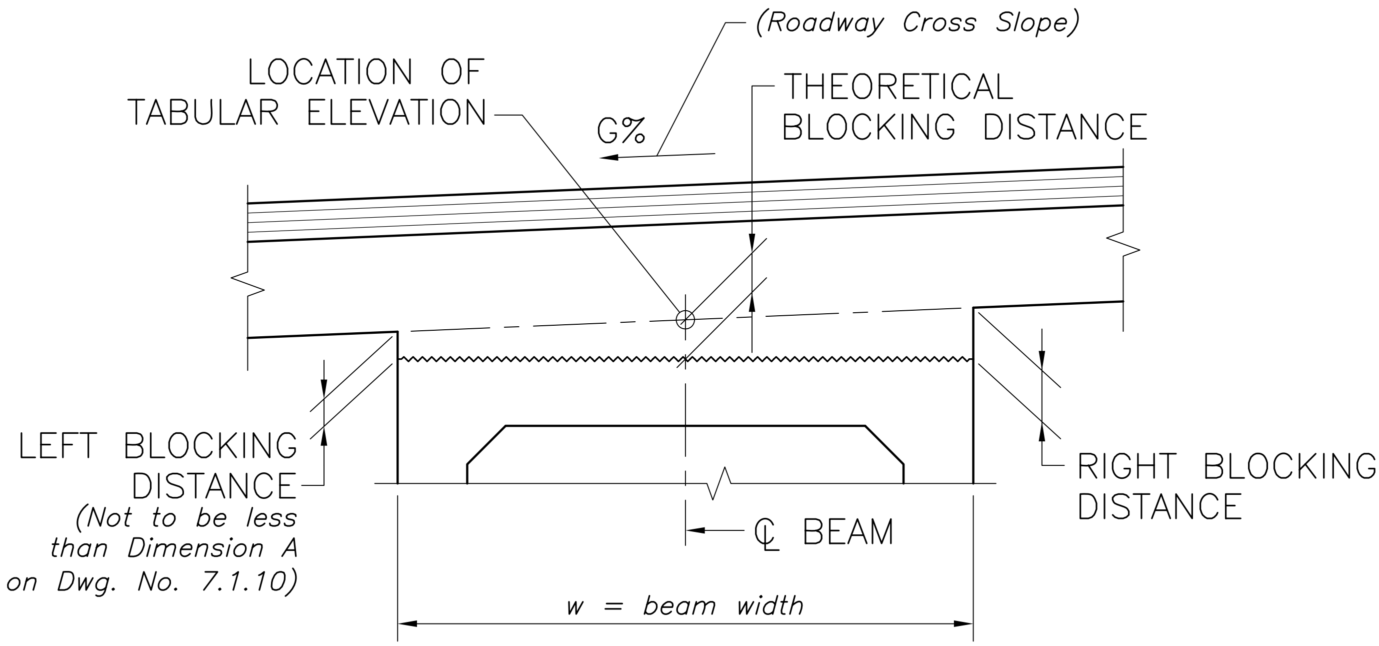


SLAB OVERHANG AT FASCIA BEAM

SCALE: 1" = 1'–0"

NOTE:

Modify the deck slab overhang details as depicted for Steel Stringer Bridges in the relevant Chapter 9 drawings as shown above, when using Spread Box Beams.



NOTES:

1. THE RIGHT AND LEFT ORIENTATION IS TAKEN LOOKING UPSTATION ALONG THE BEAM.

2. RIGHT BLOCKING DISTANCE = THEORETICAL BLOCKING DISTANCE + "R"
   LEFT BLOCKING DISTANCE = THEORETICAL BLOCKING DISTANCE + "L"

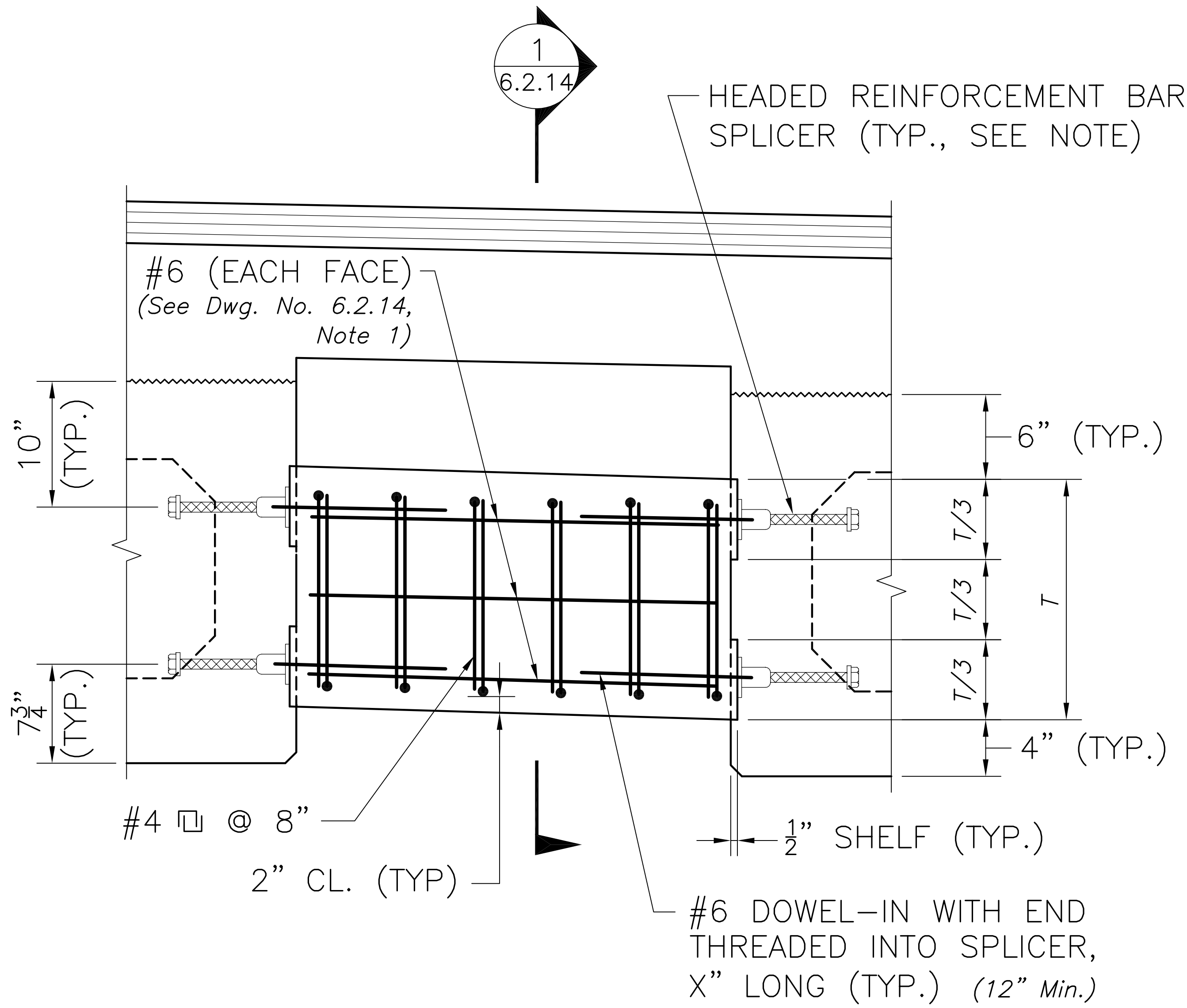
HAUNCH DETAIL

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

1. *For Spread Box Beam bridges, use the above Haunch Detail in place of the one on Dwg. No. 7.1.10. Also modify the note on Dwg. No. 7.1.10 to say "Theoretical" instead of "Actual" blocking distance.*
2. *For the above detail:*
   "R" = G/100 x w/2
   "L" = −G/100 x w/2
   Since "R" and "L" vary with changes in the roadway cross slope, it is advisable to provide a table of "R" and "L" values for each beam or group of beams for each roadway cross slope situation. Always show "R" and "L" with their correct algebraic sign.

MASS HIGHWAY BRIDGE MANUAL	HAUNCH DETAIL	DATE OF ISSUE NOVEMBER 2010
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER **6.2.12**



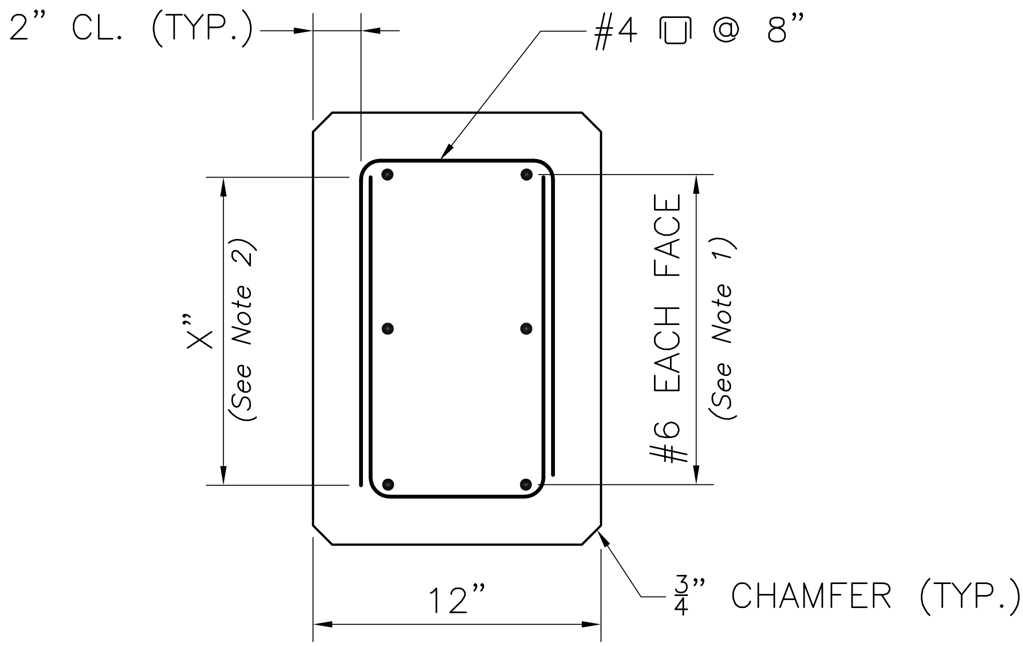
NOTE:

HEADED REINFORCEMENT BAR SPLICERS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THEY SHALL BE EMBEDDED AS REQUIRED TO PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 27.9 KIPS AS SPECIFIED BY THE MANUFACTURER.

INTERMEDIATE DIAPHRAGM

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM	DATE OF ISSUE MAY 2005
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER **6.2.13**



SECTION 1

SCALE: $1\frac{1}{2}$" = 1'–0"

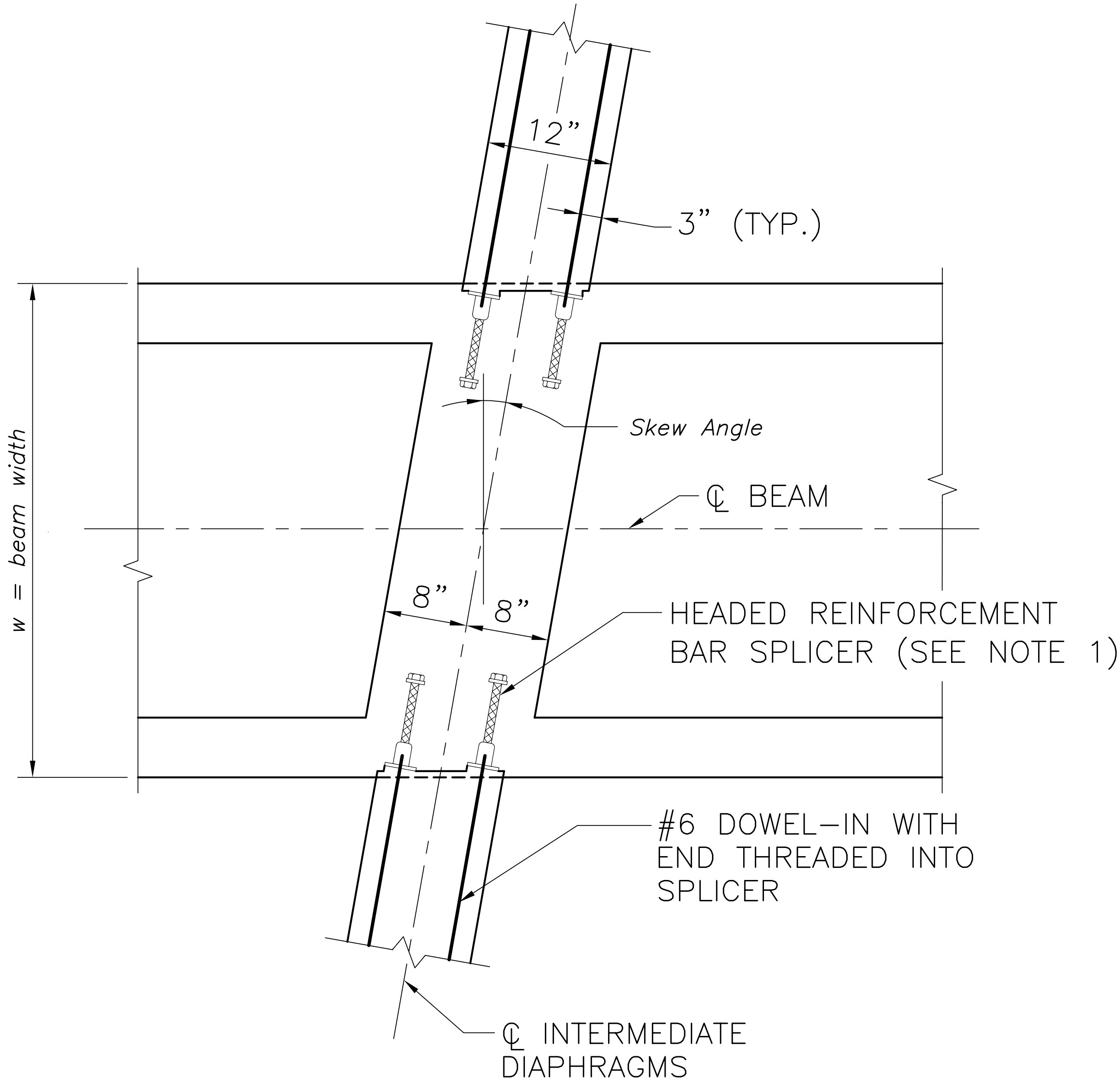
NOTES:

1. *Provide #6 bars by beam designation as follows:*

B–24 and B–27 beams:	*3 bars each face*
B–30, B–33, B–36 and B–39 beams:	*4 bars each face*
B–42, B–45 and B–48 beams:	*5 bars each face*

2. *Lap shall be either 20" or full height of diaphragm minus 4", whichever is smaller. The Designer shall specify the lap length on the plans.*

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM SECTION PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.2.14**



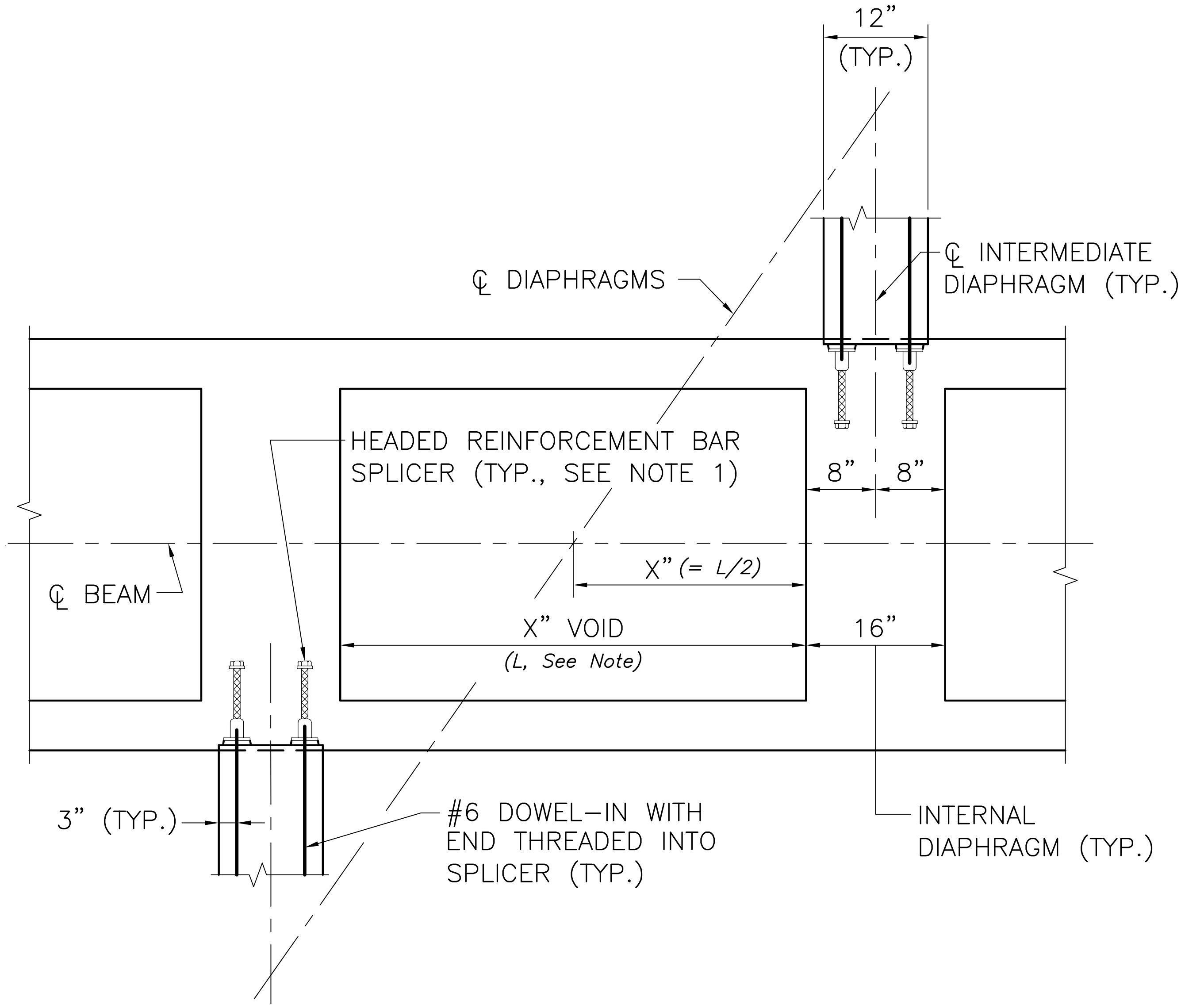
NOTES:

1. HEADED REINFORCEMENT BAR SPLICERS SHALL BE ALIGNED WITH THE SKEW OF THE INTERMEDIATE DIAPHRAGMS.
2. NOT ALL DIAPHRAGM REINFORCEMENT IS SHOWN FOR CLARITY.

INTERNAL DIAPHRAGM

SCALE: $\frac{3}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	INTERNAL DIAPHRAGM (SKEW $\leqslant$ 30°) PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.2.15**



NOTES:

1. HEADED REINFORCEMENT BAR SPLICERS SHALL BE SET PERPENDICULAR TO THE FACE OF THE BEAM.

2. NOT ALL INTERMEDIATE DIAPHRAGM REINFORCEMENT IS SHOWN FOR CLARITY.

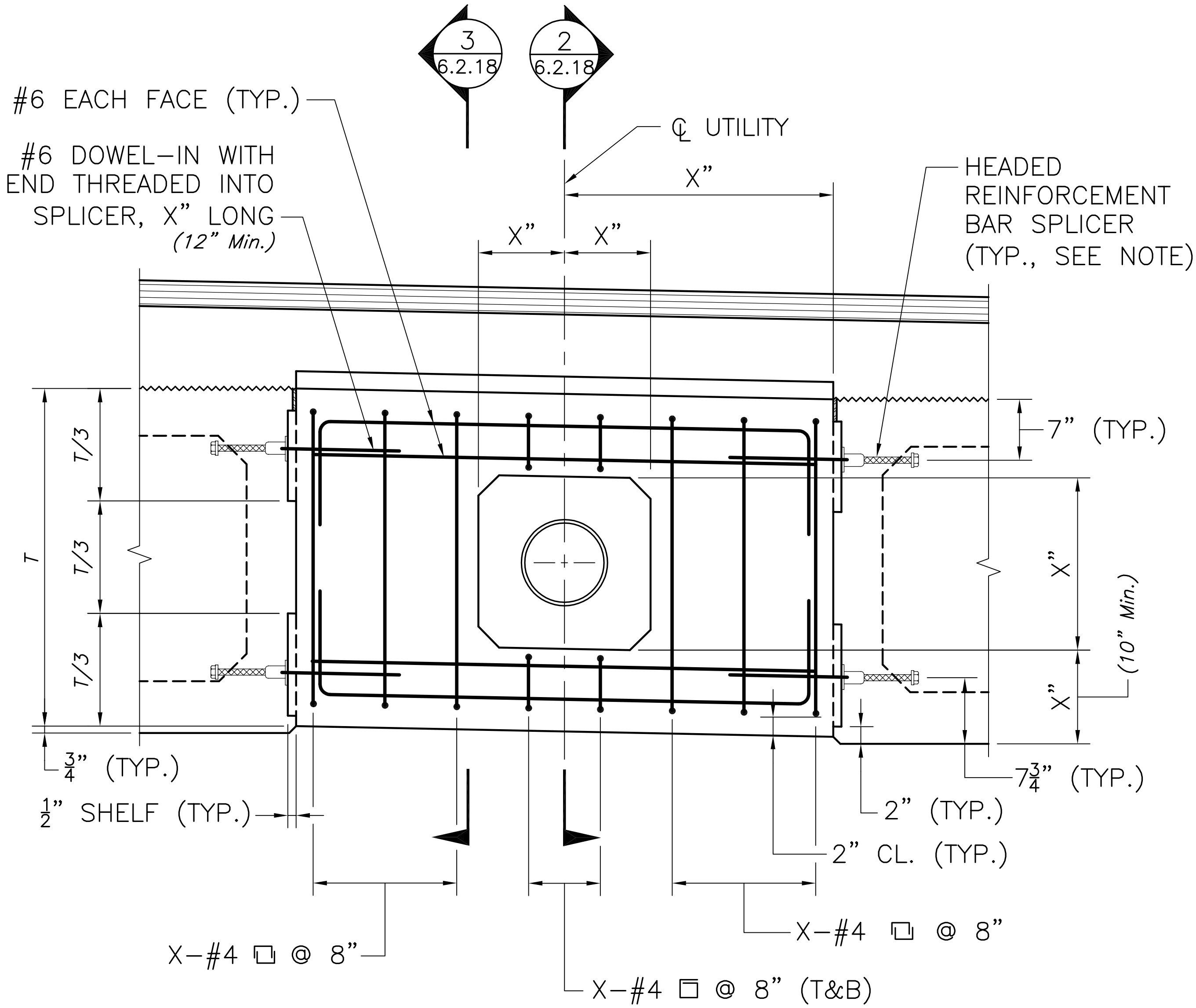
INTERNAL DIAPHRAGM

SCALE: $\frac{3}{4}$" = 1'–0"

NOTE:

Minimum length of void is equal to 2'. If this minimum dimension cannot be met, omit void and combine the internal diaphragms into one solid block. Include weight of this block in design calculations.

MASS HIGHWAY BRIDGE MANUAL	INTERNAL DIAPHRAGM (SKEW > 30°) PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.2.16**



NOTE:

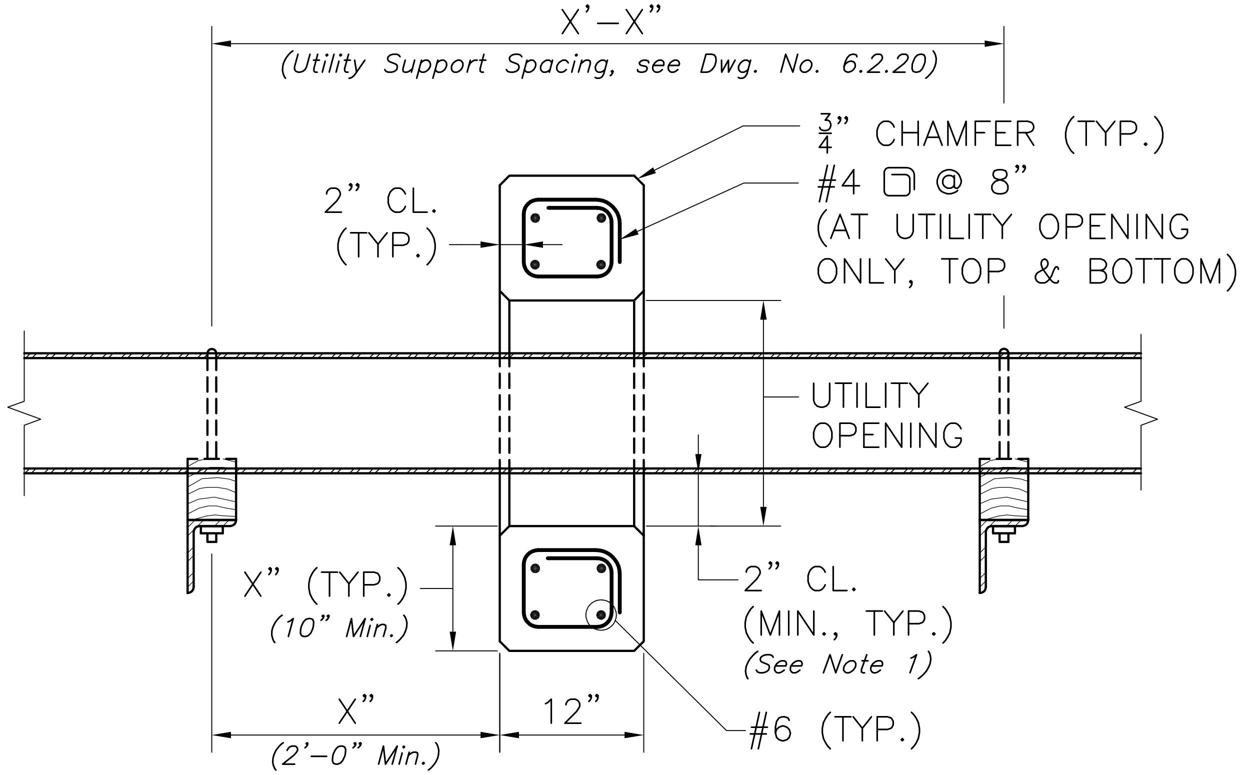
HEADED REINFORCEMENT BAR SPLICERS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THEY SHALL BE EMBEDDED AS REQUIRED TO PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 27.9 KIPS AS SPECIFIED BY THE MANUFACTURER.

INTERMEDIATE DIAPHRAGM WITH UTILITY

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

NOTES:

1. *In case of utility, the intermediate diaphragms shall be omitted for B-24, B-27, B-30 and B-33 beams. For deeper beams, the intermediate diaphragm may still have to be modified depending on the size of utility. The Designer shall consider modifying the diaphragm to an inverted U and designing the reinforcement as a frame.*
2. *The type of utility shown is conceptual and shall be modified to accommodate the actual type.*

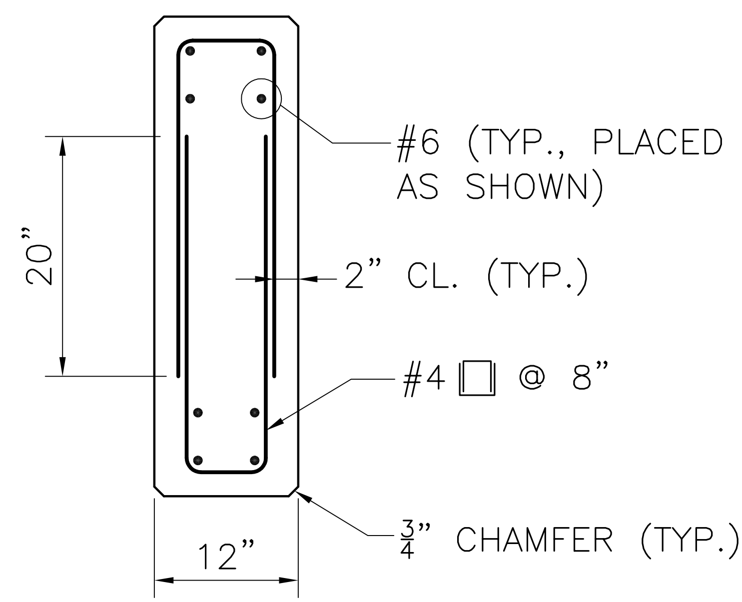


SECTION 2

SCALE: 3/4" = 1'–0"

NOTES:

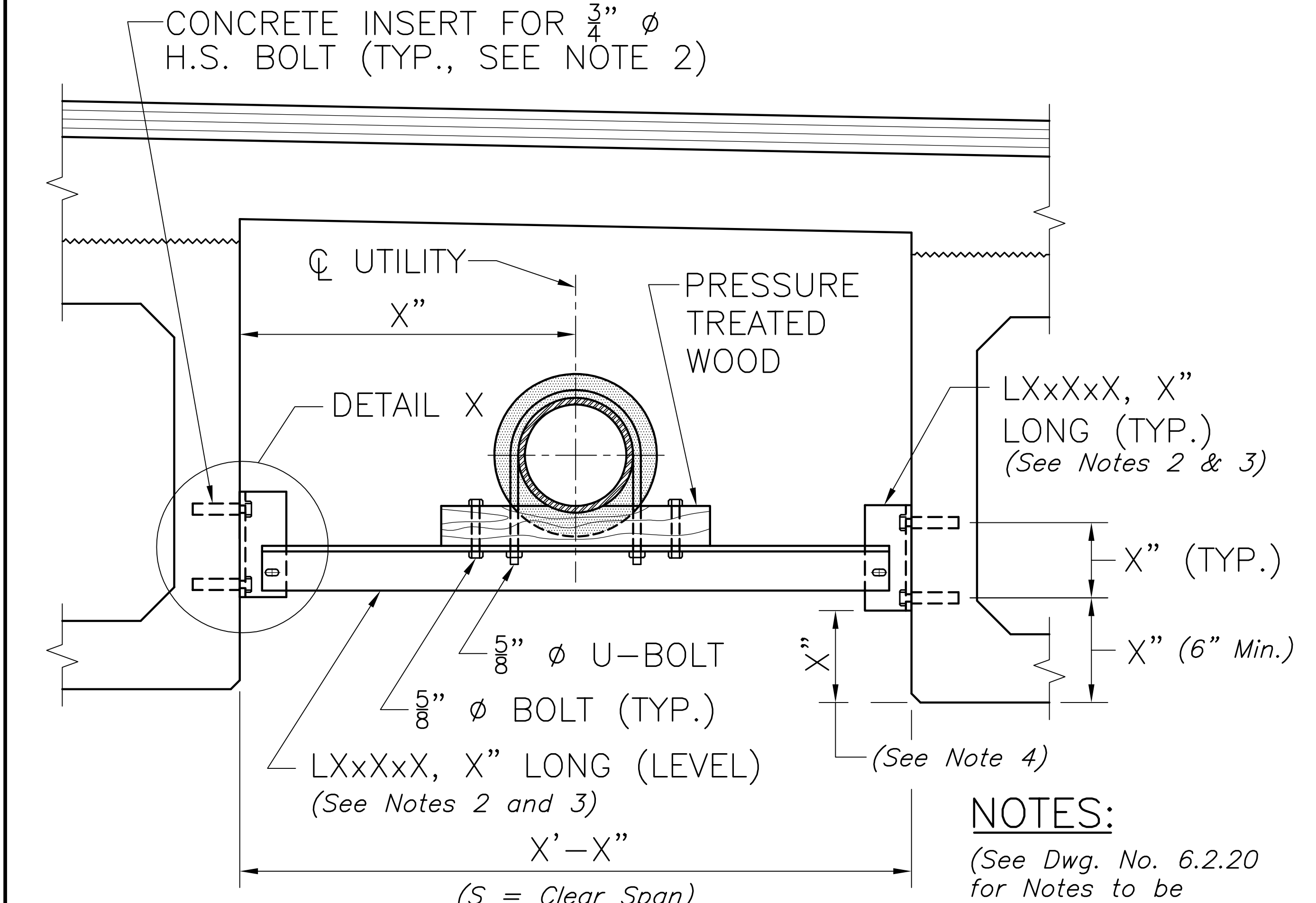
1. *The Designer shall verify that the clearances required by utilities are maintained.*
2. *The type of utility shown is conceptual and shall be modified to accommodate the actual type.*



SECTION 3

SCALE: 3/4" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE DIAPHRAGM SECTIONS WITH UTILITY PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.2.18**



UTILITY SUPPORT DETAIL

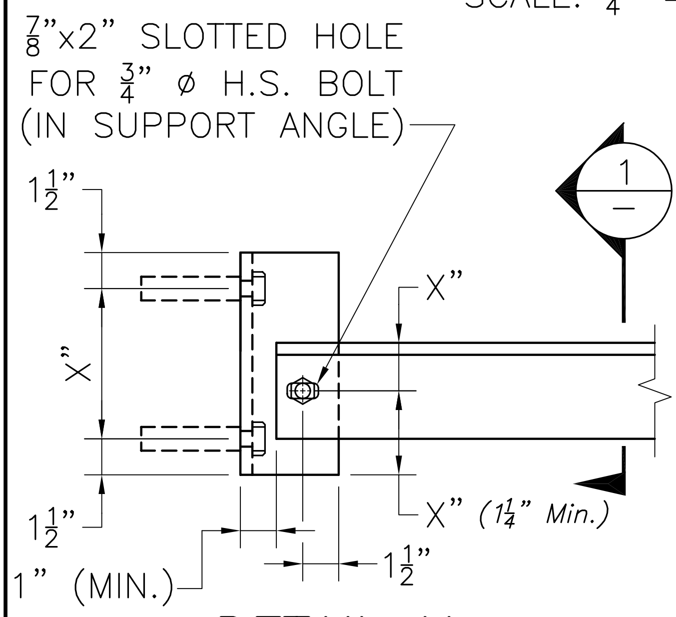
SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

(See Dwg. No. 6.2.20 for Notes to be included on Construction Drawings)

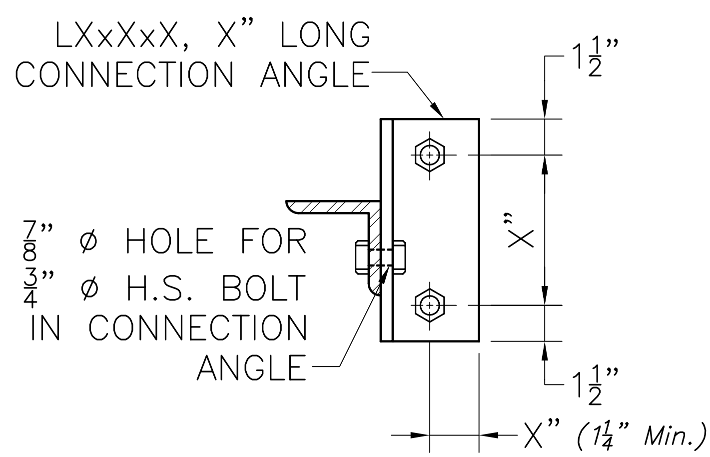
NOTES:

See Dwg. No. 6.2.20 for Designer Notes.



DETAIL X

SCALE: $1\frac{1}{2}$" = 1'–0"



SECTION 1

SCALE: $1\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	UTILITY SUPPORT DETAILS	DATE OF ISSUE: MAY 2005
	PRECAST CONCRETE BOX BEAMS	DRAWING NUMBER: **6.2.19**

NOTES: *(Include these Notes with details shown on Dwg. No. 6.2.19)*

1. ALL STRUCTURAL STEEL FOR UTILITY SUPPORTS SHALL CONFORM TO AASHTO M 270 GRADE 36. ALL STRUCTURAL STEEL AND FASTENERS SHALL BE HOT–DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 111 AND M 232.

2. INSERTS FOR $\frac{3}{4}$" Ø H.S. BOLTS SHALL BE CAST INTO THE PRECAST BEAMS BY THE FABRICATOR. THE $\frac{3}{4}$" Ø H.S. BOLT INSERTS SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 1.1 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 4.1 KIPS IN 3000 PSI CONCRETE. *(The Designer shall determine the required insert capacities if S > 12')*

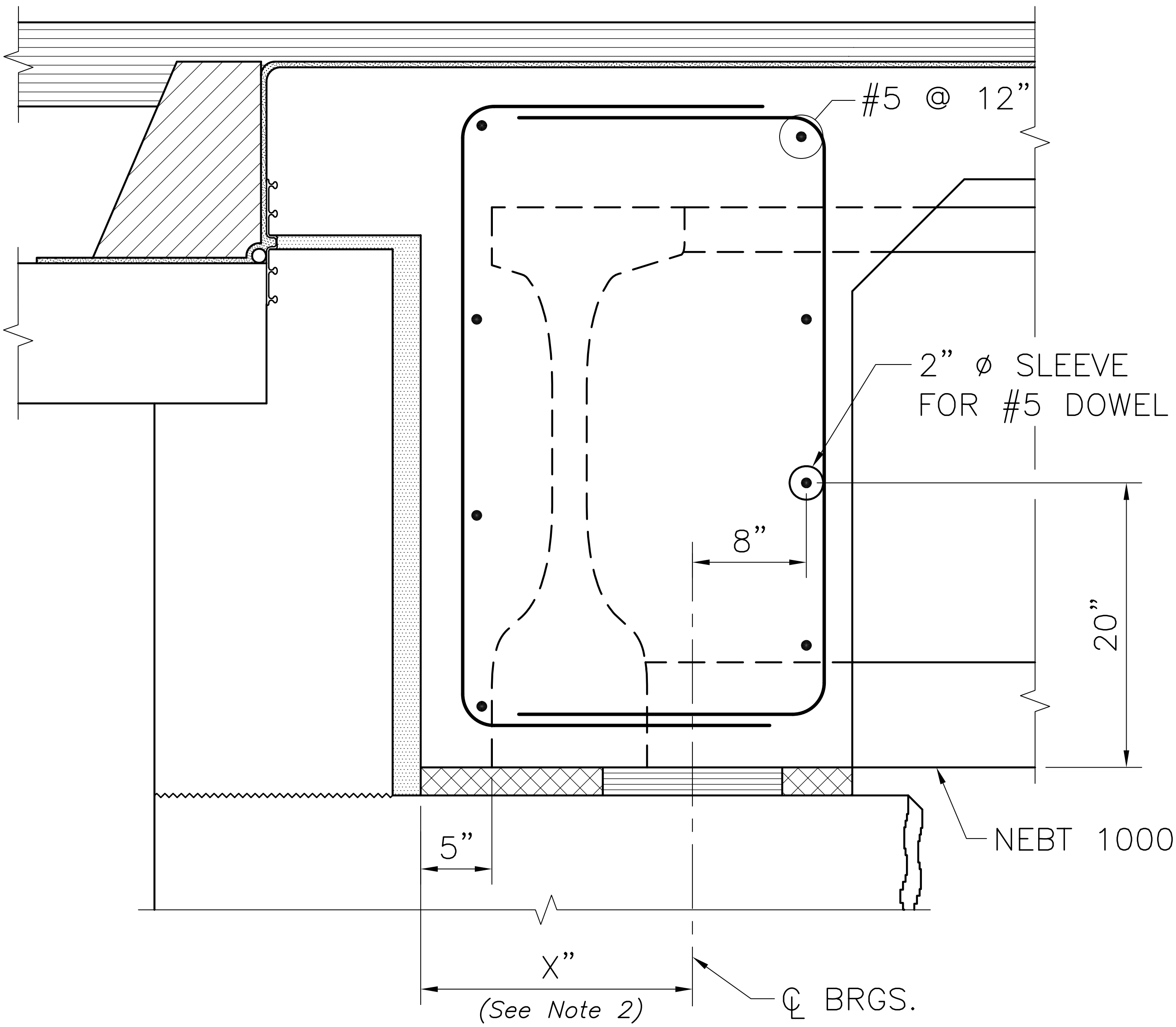
3. THE UTILITY SUPPORT ANGLE SHALL BE ERECTED WITH THE LONG LEG VERTICAL.

4. INSERTS SHALL BE POSITIONED TO AVOID INTERFERENCE WITH PRESTRESSING STRANDS.

NOTES: *(These Notes are for details shown on Dwg. No. 6.2.19)*

1. *The type of utility shown is conceptual and shall be modified to accommodate the actual type.*
2. *For S < 6'–6" use L5x3$\frac{1}{2}$x$\frac{1}{2}$*
   For 6'–6" ⩽ S ⩽ 12'–0" use L6x4x$\frac{5}{8}$
   For S > 12'–0" to be designed by Designer
3. *Maximum utility support spacing = 11'–6" and the maximum total utility weight = 250 lbs/ft. If either of these limits is exceeded, the Designer shall design the support angle.*
4. *The preferred dimension from the bottom of the beam to the bottom of the connection angle is 4". However, if more vertical clearance is required due to the size of the utility, this dimension can be reduced to $\frac{3}{4}$".*
5. *If more horizontal clearance is required, use a coped WT section with a bolt on both sides of the stem in place of the connection angle.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY SUPPORT NOTES PRECAST CONCRETE BOX BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.2.20**



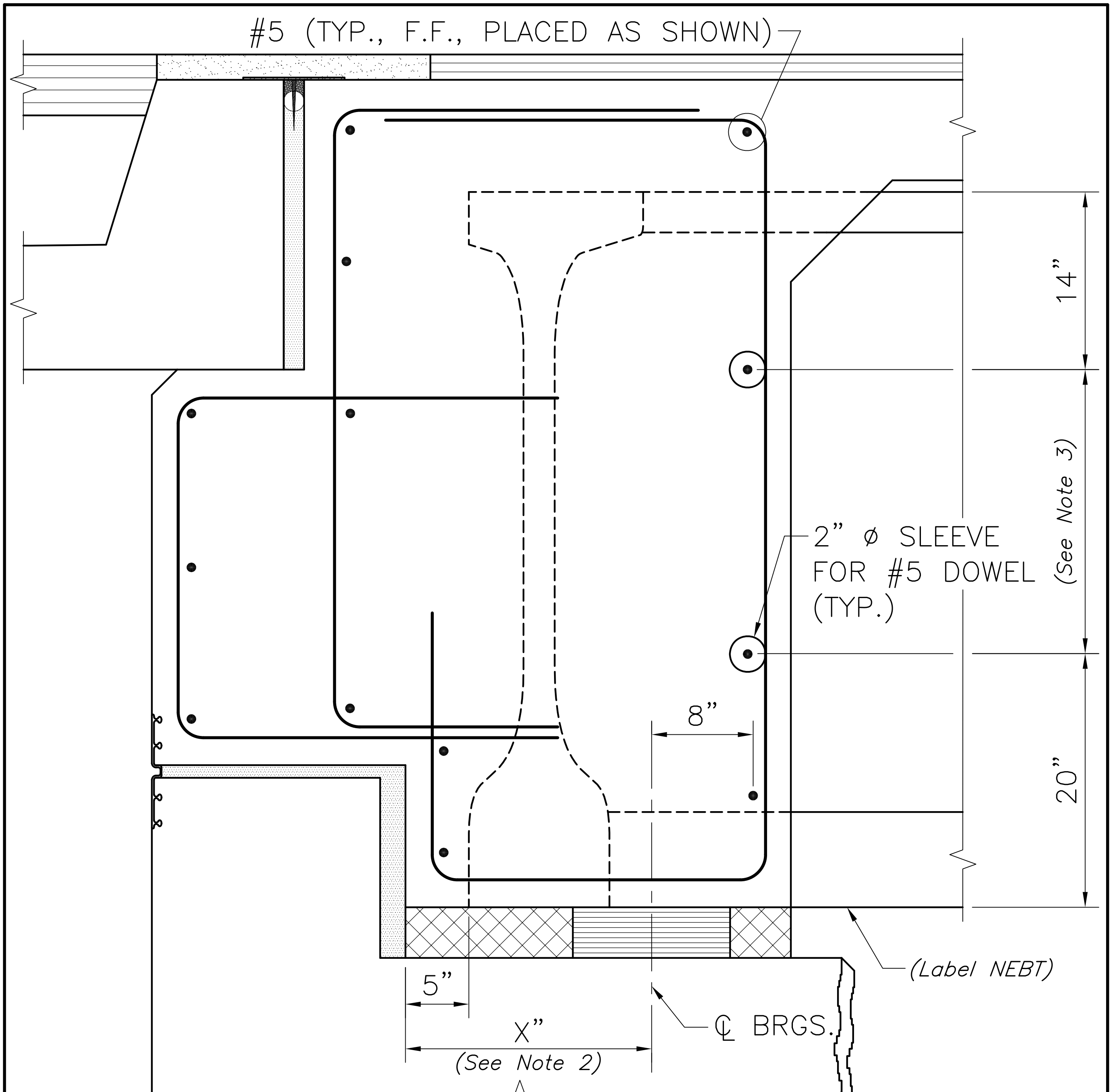
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.9 and 3.7.10 as shown above for NEBT 1000 beams.*
2. *Set this dimension as follows based on the skew:*
   17" for 0° ⩽ skew ⩽ 10°
   20" for 10° < skew ⩽ 25°
   22½" for 25° < skew ⩽ 45°

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION NEBT 1000 ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.3.1**



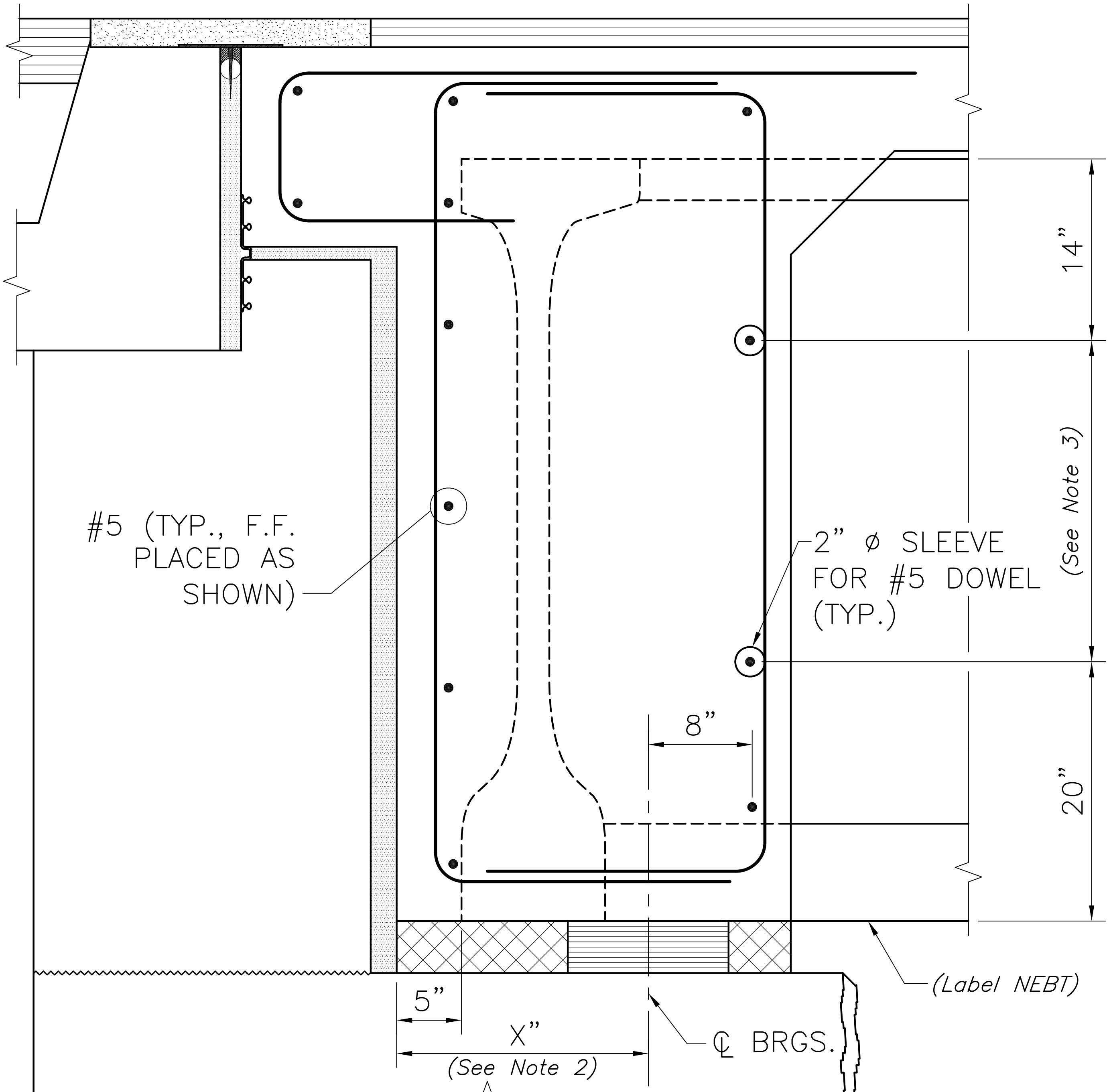
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.14 and 3.7.15 as shown above for NEBT beams.*
2. *Set this dimension as follows based on the skew:*
   17" for 0° ⩽ skew ⩽ 10°
   20" for 10° < skew ⩽ 25°
   22½" for 25° < skew ⩽ 45°
   Designer will have to determine this dimension for skews over 45°.
3. *For NEBT 1200 and NEBT 1400, use 2 sleeves as shown. For NEBT 1600 and NEBT 1800, use 3 sleeves equally spaced.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION NEBT 1200 AND DEEPER ABUTMENT DETAILS	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **6.3.2**



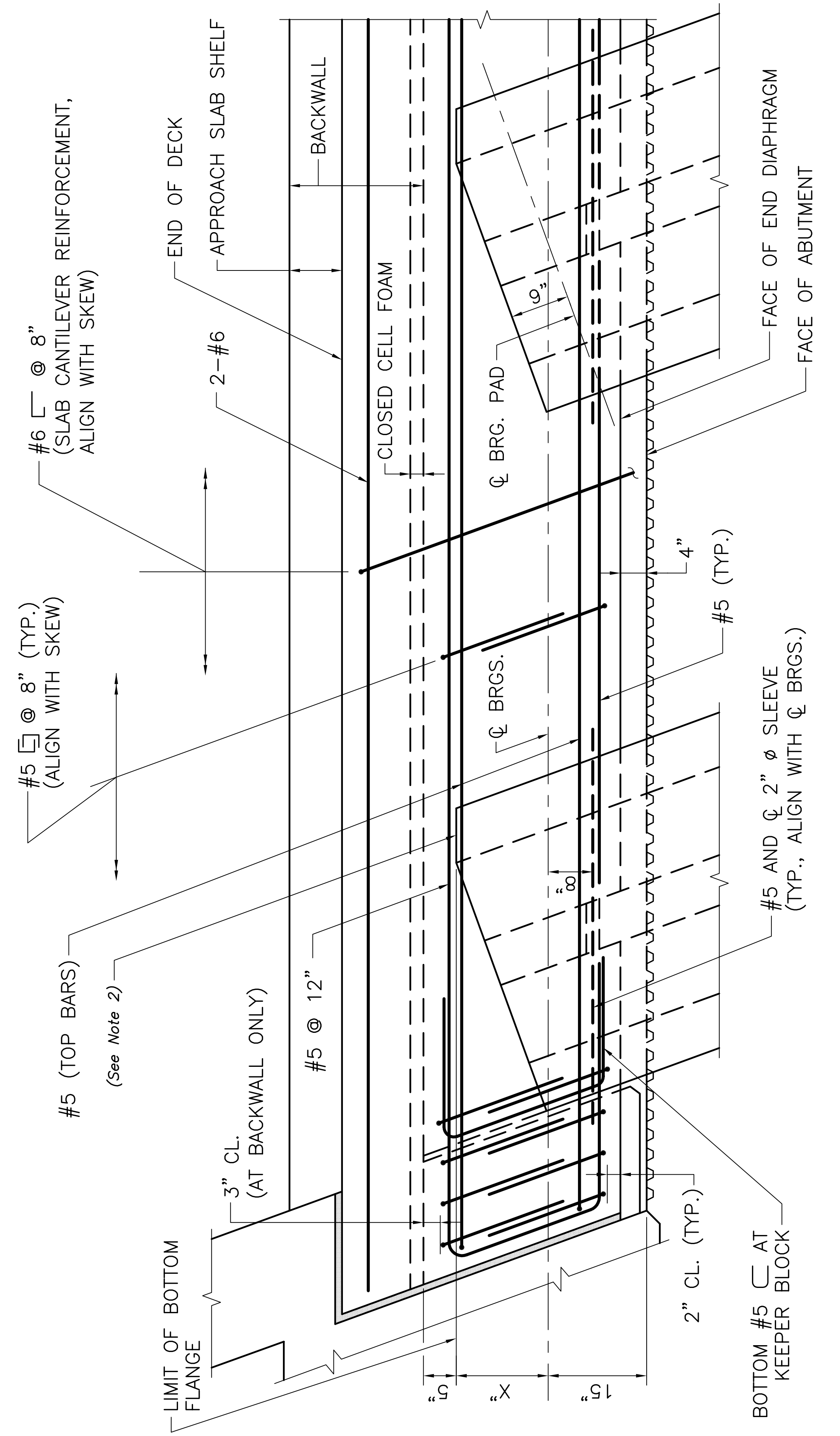
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'–0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.19 and 3.7.20 as shown above for NEBT beams.*
2. *Set this dimension as follows based on the skew:*
   17" for 0° ⩽ skew ⩽ 10°
   20" for 10° < skew ⩽ 25°
   22½" for 25° < skew ⩽ 45°
   Designer will have to determine this dimension for skews over 45°.
3. *For NEBT 1000, use 1 sleeve at mid–height. For NEBT 1200 and NEBT 1400, use 2 sleeves. For NEBT 1600 and NEBT 1800, use 3 sleeves equally spaced.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION NEBT'S WITH BRIDGE JOINT ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.3.3**



AT KEEPER BLOCK/CURTAIN WALL

TYPICAL INTERIOR BAY

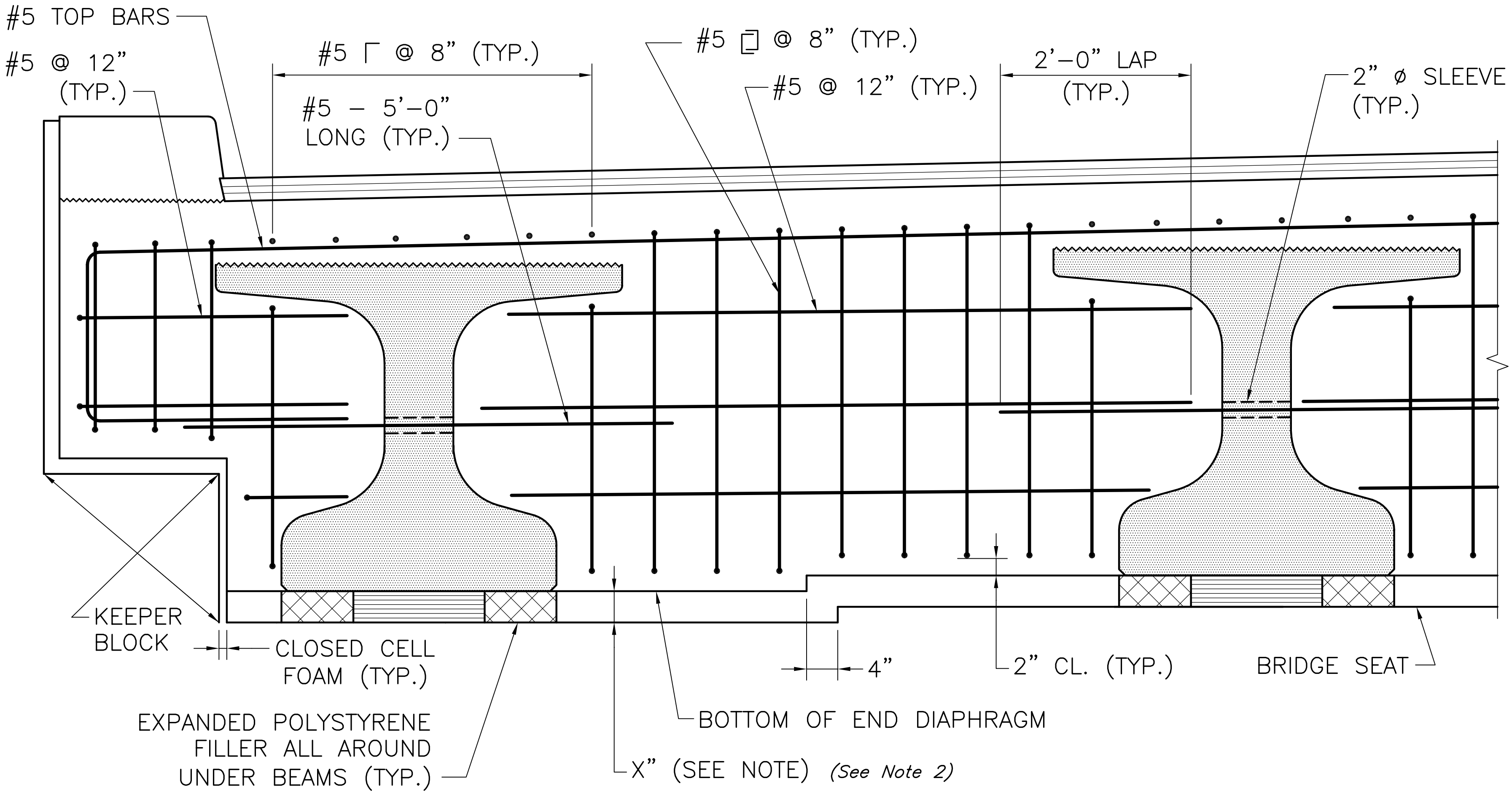
END DIAPHRAGM PLAN

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

1. Detail shown is for NEBT 1000. Modify drawing as needed for the NEBT or the abutment type used.
2. Designer must verify if top flange must be coped to ensure a 5" minimum clearance to backwall. If required, the Designer shall note it on the Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	END DIAPHRAGM TYPICAL PLAN FOR NEBT'S ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.3.4**



AT KEEPER BLOCK/CURTAIN WALL

TYPICAL INTERIOR BAY

NOTE:

CONTRACTOR MAY USE EXPANDED POLYSTYRENE FILLER OR A REMOVABLE FORM TO FORM THE BOTTOM OF THE END DIAPHRAGM.

END DIAPHRAGM ELEVATION

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Detail shown is for NEBT 1000. Modify drawing as needed for the NEBT being used.*
2. *Dimension to be provided is equal to Total Thickness of Bearing.*

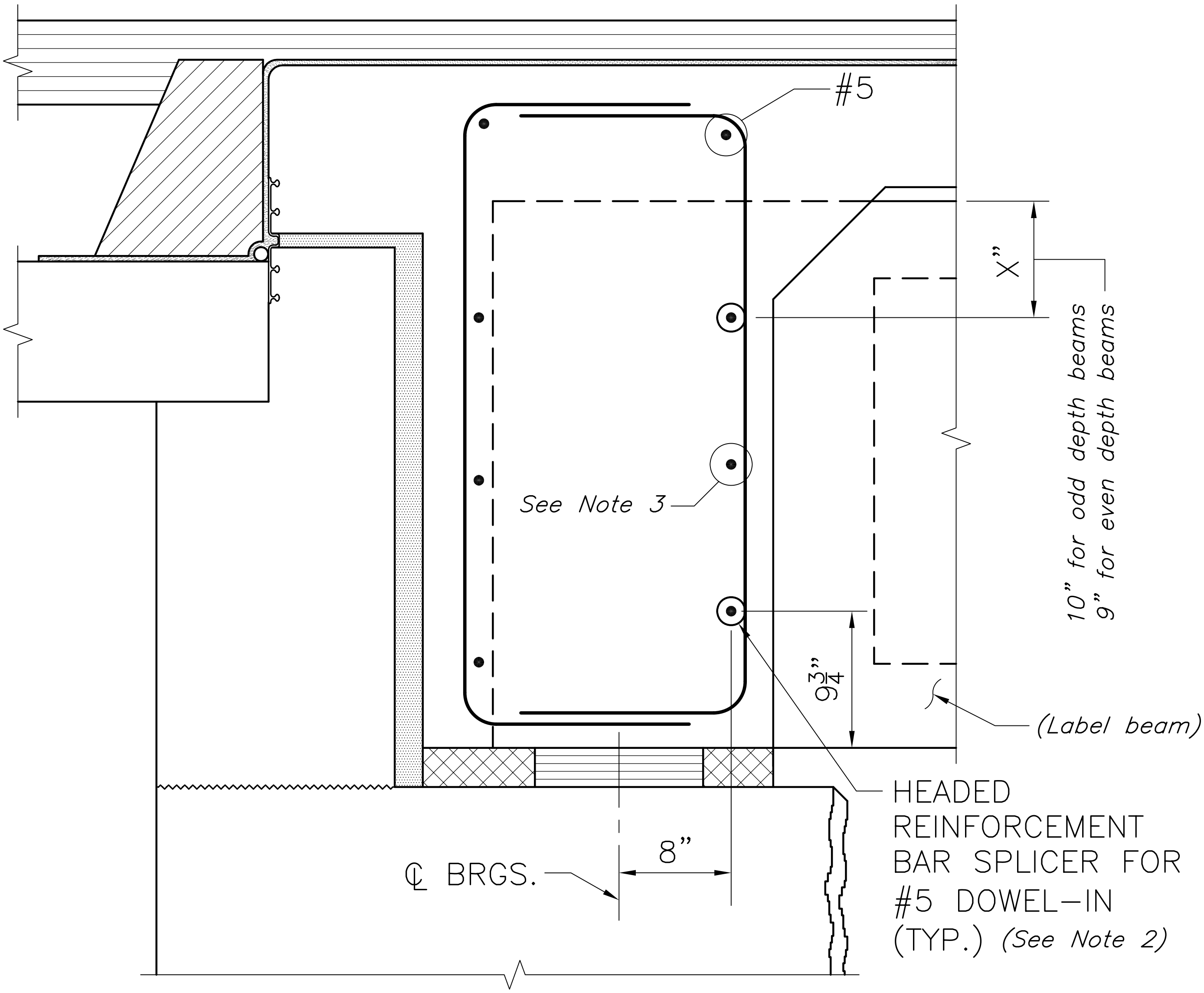
MASS HIGHWAY BRIDGE MANUAL

END DIAPHRAGM ELEVATION FOR NEBT'S

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.3.5



DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'-0"

NOTES:

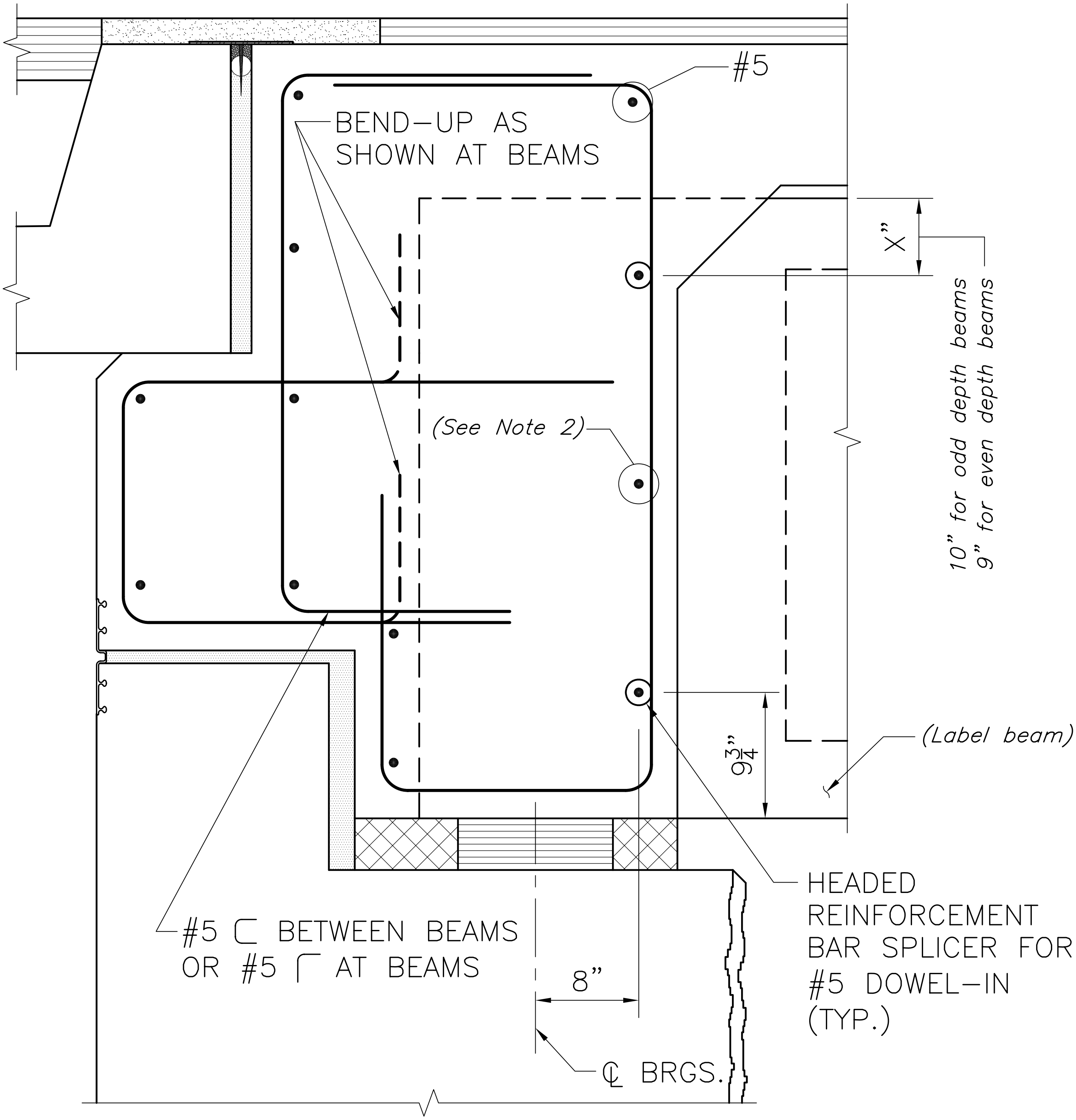
1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.9 and 3.7.10 as shown above for spread box beam bridges.*
2. *Provide Headed Reinforcement Bar Splicers by beam designation as follows:*

B–24, B–27 and B–30	*1 Splicer in midbeam*
B–33, B–36, B–39, B–42, B–45 and B–48	*2 Splicers as shown*

3. *Provide intermediate reinforcing bars by beam designation as follows:*

B–24, B–27, B–30 and B–33	*no intermediate bars*
B–36, B–39, B–42, B–45 and B–48	*1 bar midway between splicers*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION SPREAD BOXES 42" AND LESS ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010
		DRAWING NUMBER **6.3.6**



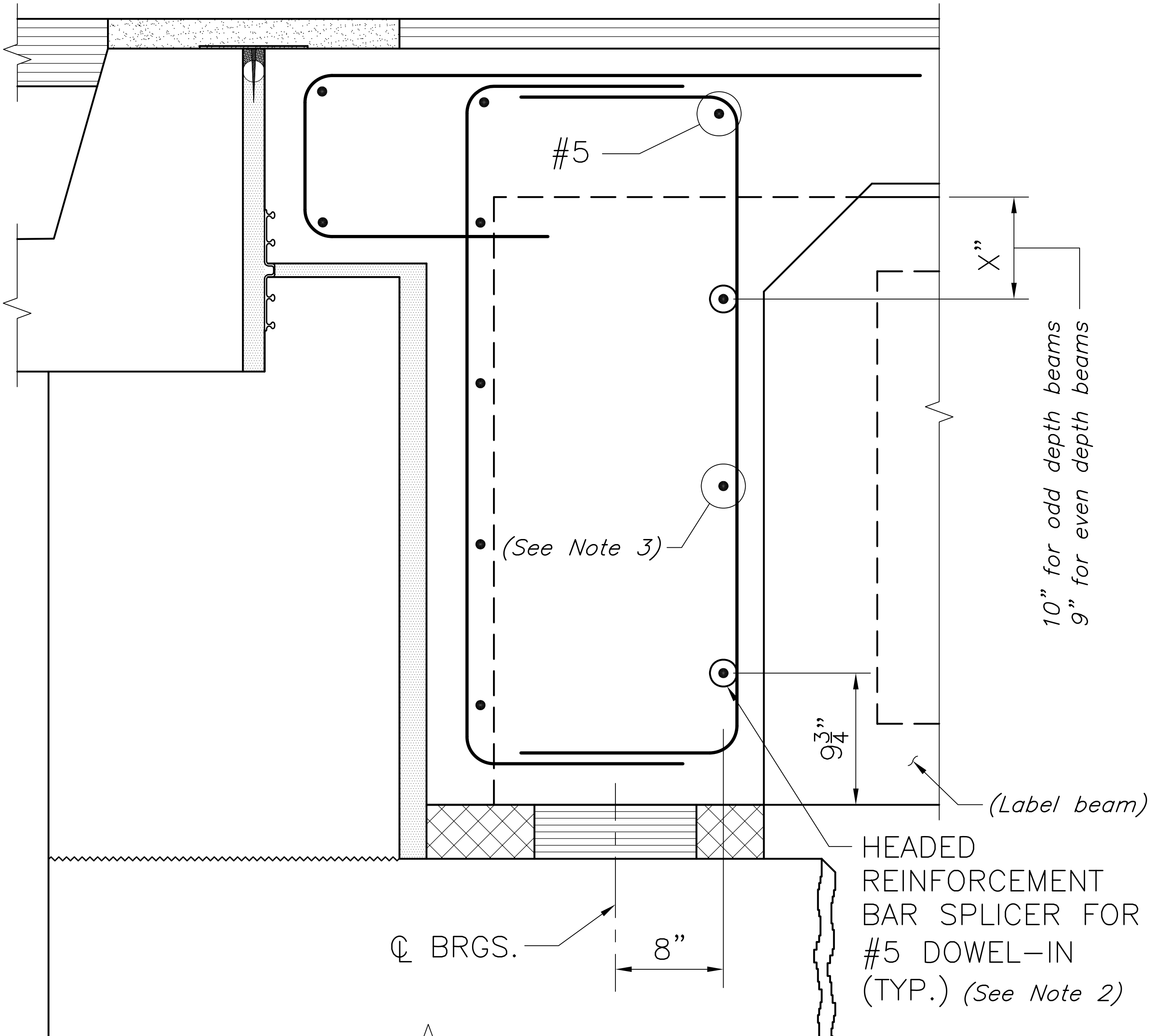
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'-0"

NOTES:

1. *Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.14 and 3.7.15 as shown above for 45" and deeper spread box beam bridges.*
2. *Provide 1 intermediate bar midway between Headed Reinforcement Bar Splicers.*

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION SPREAD BOXES 45" AND DEEPER ABUTMENT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.3.7**



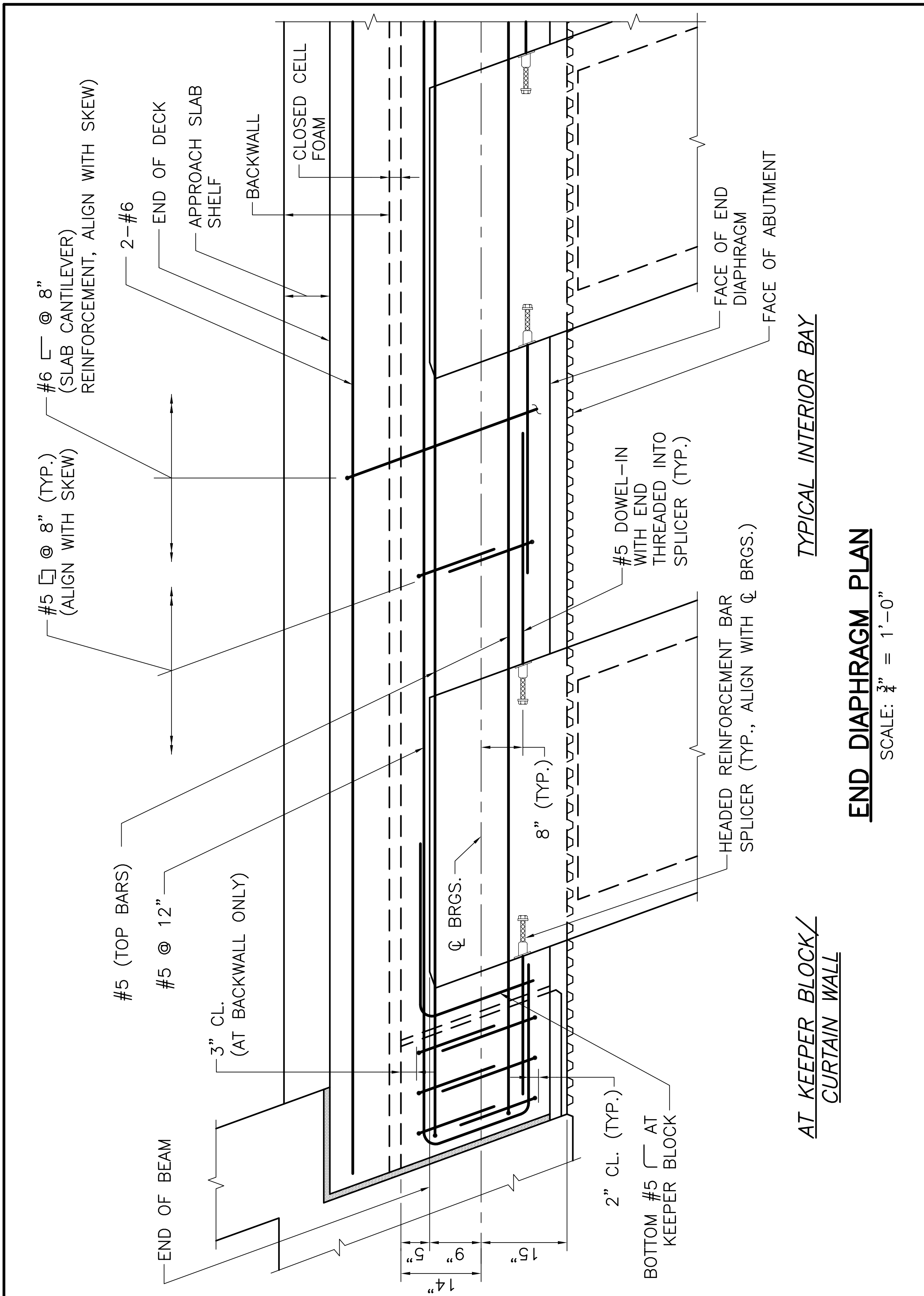
DETAILS AT ABUTMENT – ROADWAY SECTION

SCALE: 1" = 1'-0"

NOTES:

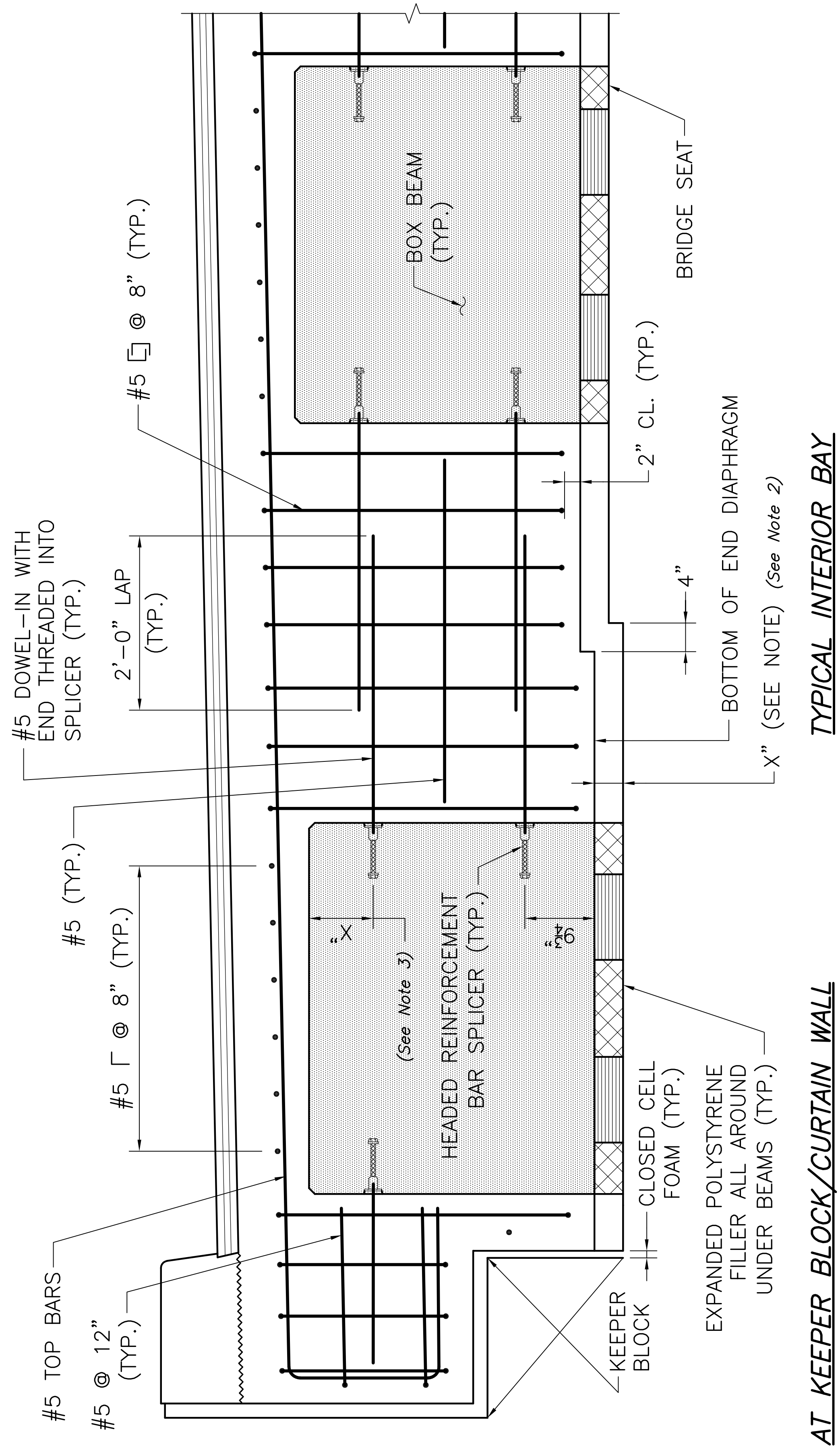
1. Modify the generic Roadway/Sidewalk Section details of Dwg. No.'s 3.7.19 and 3.7.20 as shown above for spread box beam bridges.
2. Provide Headed Reinforcement Bar Splicers by beam designation as follows:
   B-24, B-27 and B-30 — 1 Splicer at mid-beam
   B-33, B-36, B-39, B-42, B-45 and B-48 — 2 Splicers, as shown
3. Provide intermediate reinforcing bars by beam designation as follows:
   B-24, B-27, B-30 and B-33 — No intermediate bars
   B-36, B-39, B-42, B-45, and B-48 — 1 bar midway between splicers

MASS HIGHWAY BRIDGE MANUAL	ROADWAY SECTION SPREAD BOXES WITH BRIDGE JOINT ABUTMENT DETAILS	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: 6.3.8



NOTES:
Detail shown is for beam depths 42" and less. Modify drawing as needed for the 45" deep beam or abutment type being used.

MASS HIGHWAY BRIDGE MANUAL	END DIAPHRAGM PLAN FOR SPREAD BOXES ABUTMENT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.3.9**



AT KEEPER BLOCK/CURTAIN WALL

TYPICAL INTERIOR BAY

NOTE:

CONTRACTOR MAY USE EXPANDED POLYSTYRENE FILLER OR A REMOVABLE FORM TO FORM THE BOTTOM OF THE END DIAPHRAGM.

END DIAPHRAGM ELEVATION

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

1. *Detail shown is for beams depths 42" and less. Modify drawing as needed for the beams used.*
2. *Dimension to be provided is equal to Total Thickness of Bearing.*
3. *10" for odd depth beams, 9" for even depth beams.*

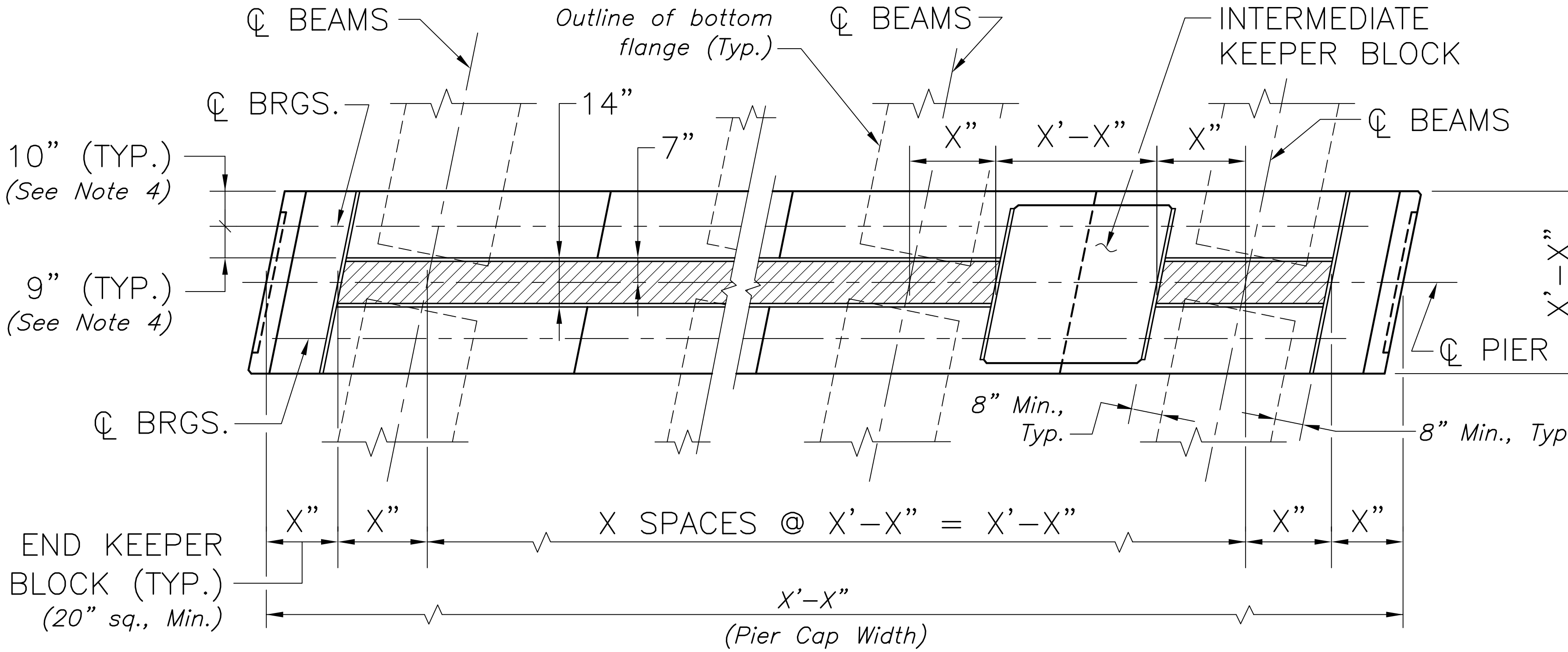
MASS HIGHWAY
BRIDGE MANUAL

END DIAPHRAGM ELEVATION FOR SPREAD BOXES

ABUTMENT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.3.10



BRIDGE WITHOUT INTERMEDIATE KEEPER BLOCK

BRIDGE WITH INTERMEDIATE KEEPER BLOCK

NOTES:

1. ▨ DENOTES LIMITS OF 14" BY 12" MIN. DEEP SHEAR KEY.

2. ALL SURFACES OF THE SHEAR KEY SHALL BE LINED WITH 1" THICK CLOSED CELL FOAM.

PLAN OF PIER CAP

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Remainder of pier has been omitted for clarity.*
2. *Plan of pier shall be drawn without breaks and to scale on the Construction Drawings. Include all relevant dimensions, angles, survey information and North Arrow.*
3. *NEBT beams shown, spread box beams are similar.*
4. *If the bearing exceeds 16" in diameter, set the 10" dimension to (Bearing Dia./2 + 2"), and set the 9" dimension to (Bearing Dia./2 + 1").*

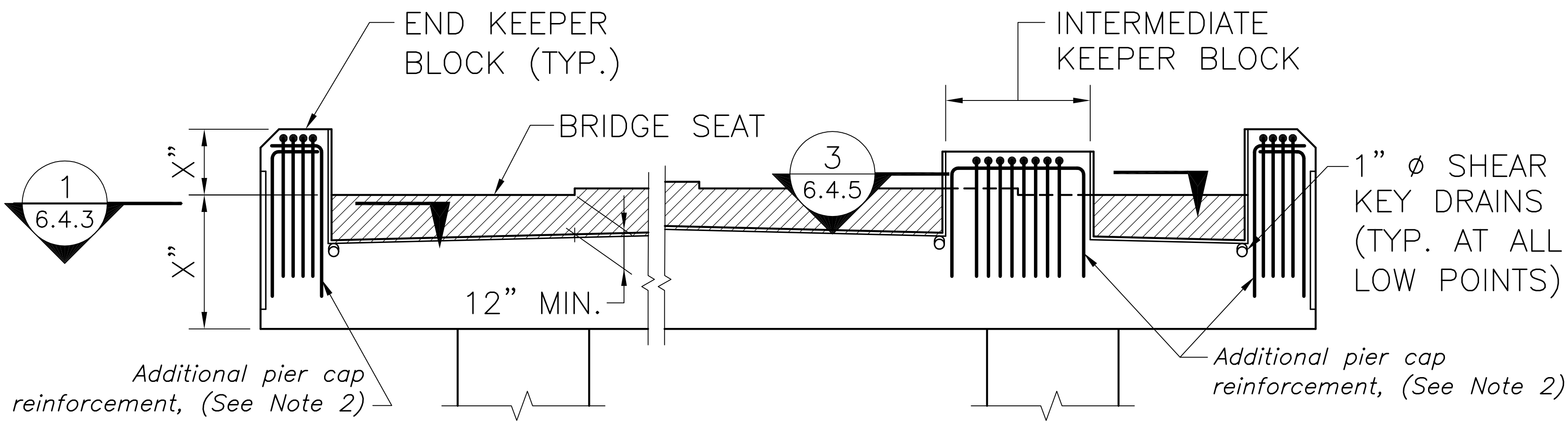
MASS HIGHWAY
BRIDGE MANUAL

PLAN OF PIER CAP

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.4.1



BRIDGE WITHOUT INTERMEDIATE KEEPER BLOCK

BRIDGE WITH INTERMEDIATE KEEPER BLOCK

NOTES:

1. ▨ DENOTES LIMITS OF 14" BY 12" MIN. DEEP SHEAR KEY.

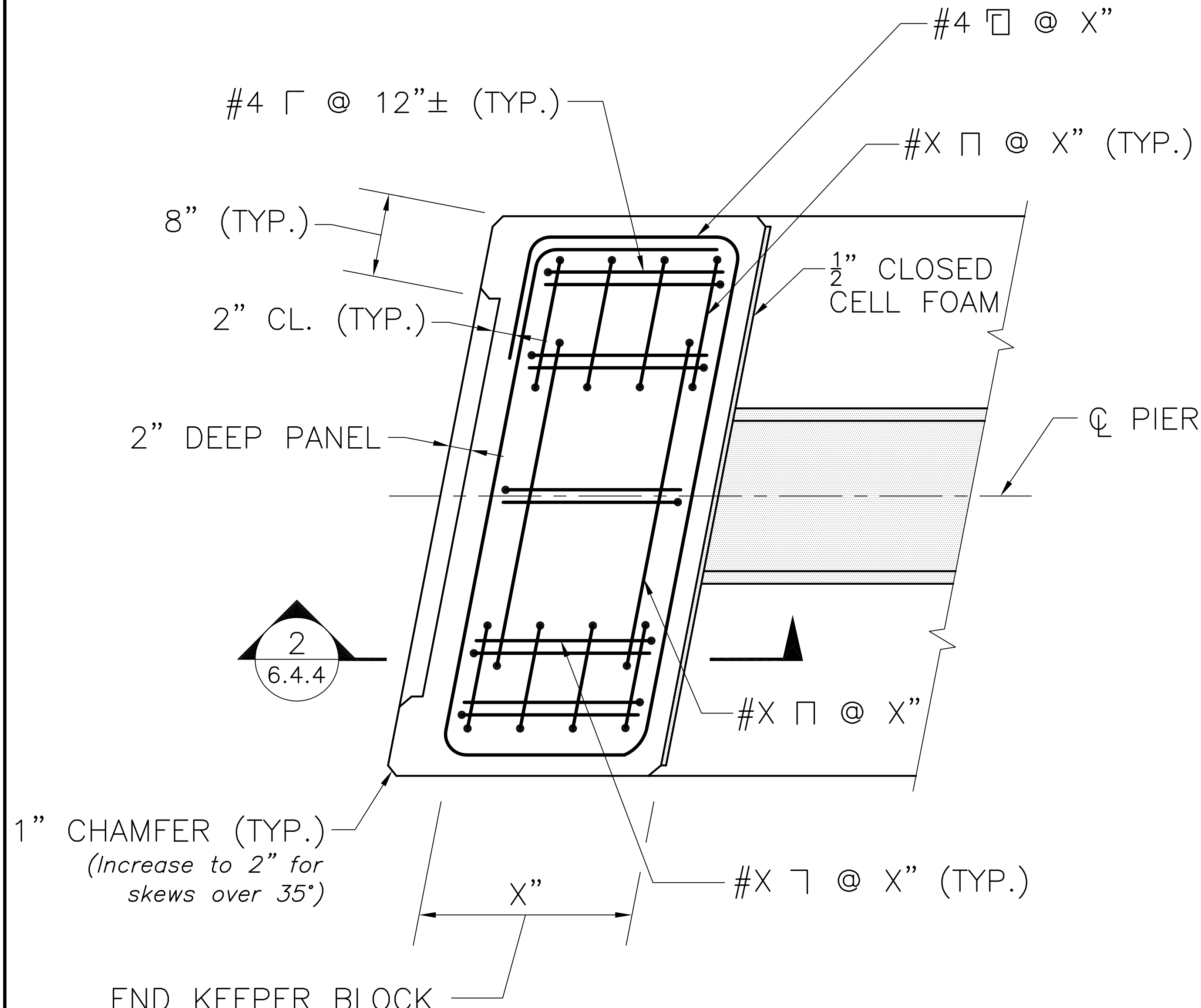
2. ALL SURFACES OF THE SHEAR KEY SHALL BE LINED WITH 1" THICK CLOSED CELL FOAM.

SECTION THRU PIER CAP

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Remainder of pier and pier reinforcement omitted for clarity.*
2. *Additional pier cap reinforcement shall be designed as a restraint for transverse seismic loads.*
3. *Transverse section shall be drawn without breaks and to scale on the Construction Drawings and all reinforcement shall be included.*
4. *Intermediate keeper blocks should be considered if end keeper blocks are insufficient to resist transverse seismic loads. Do not locate intermediate keeper blocks in utility bays of NEBT beam bridges.*



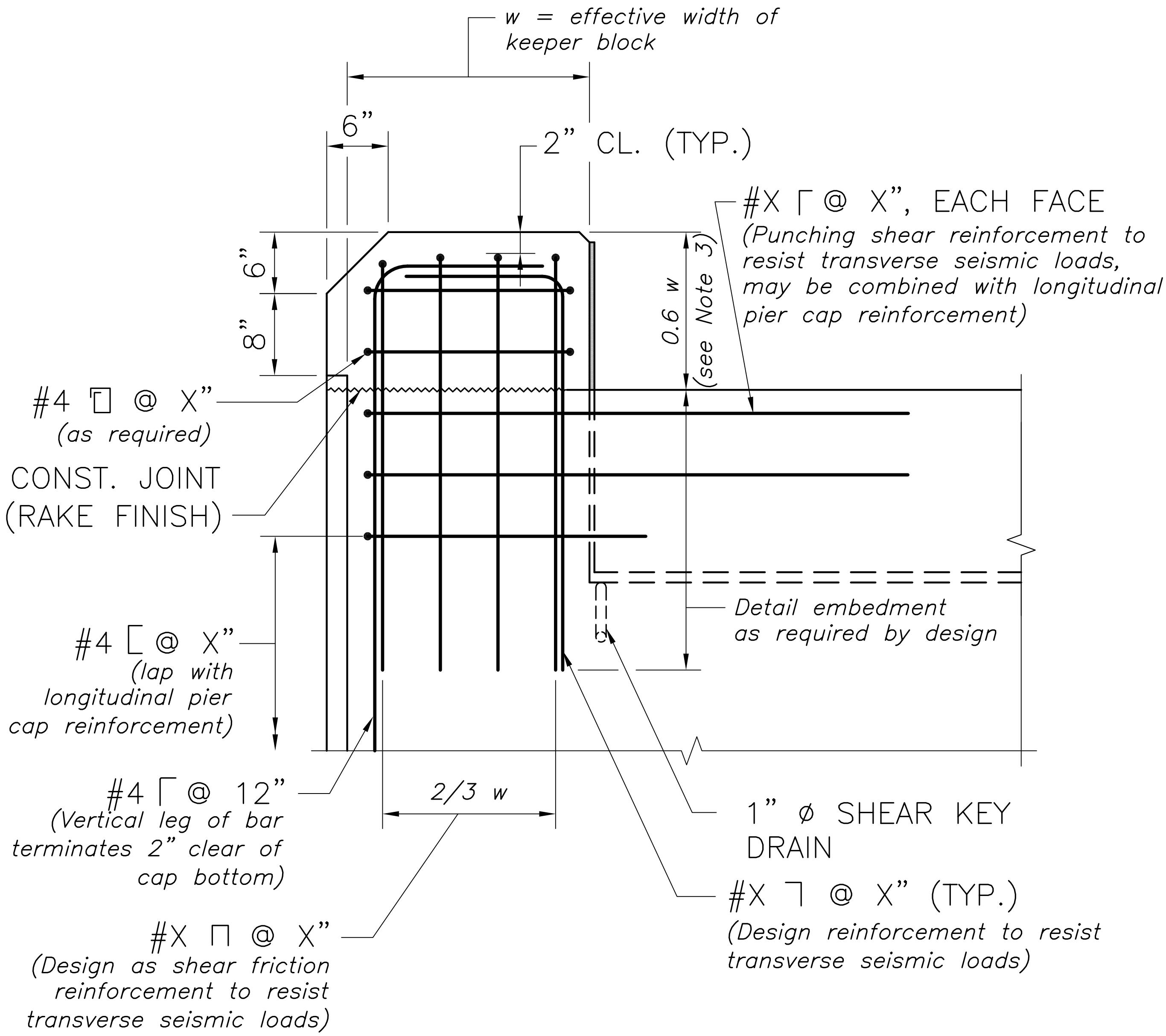
SECTION 1

SCALE: ¾" = 1'–0"

NOTE:

Reinforcement configuration shown is conceptual. The Designer will modify the arrangement or add additional hoops as required by the actual design. The Designer shall also verify that the reinforcement provided does not duplicate or interfere with the typical pier reinforcement.

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTION OF END KEEPER BLOCK PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.3**



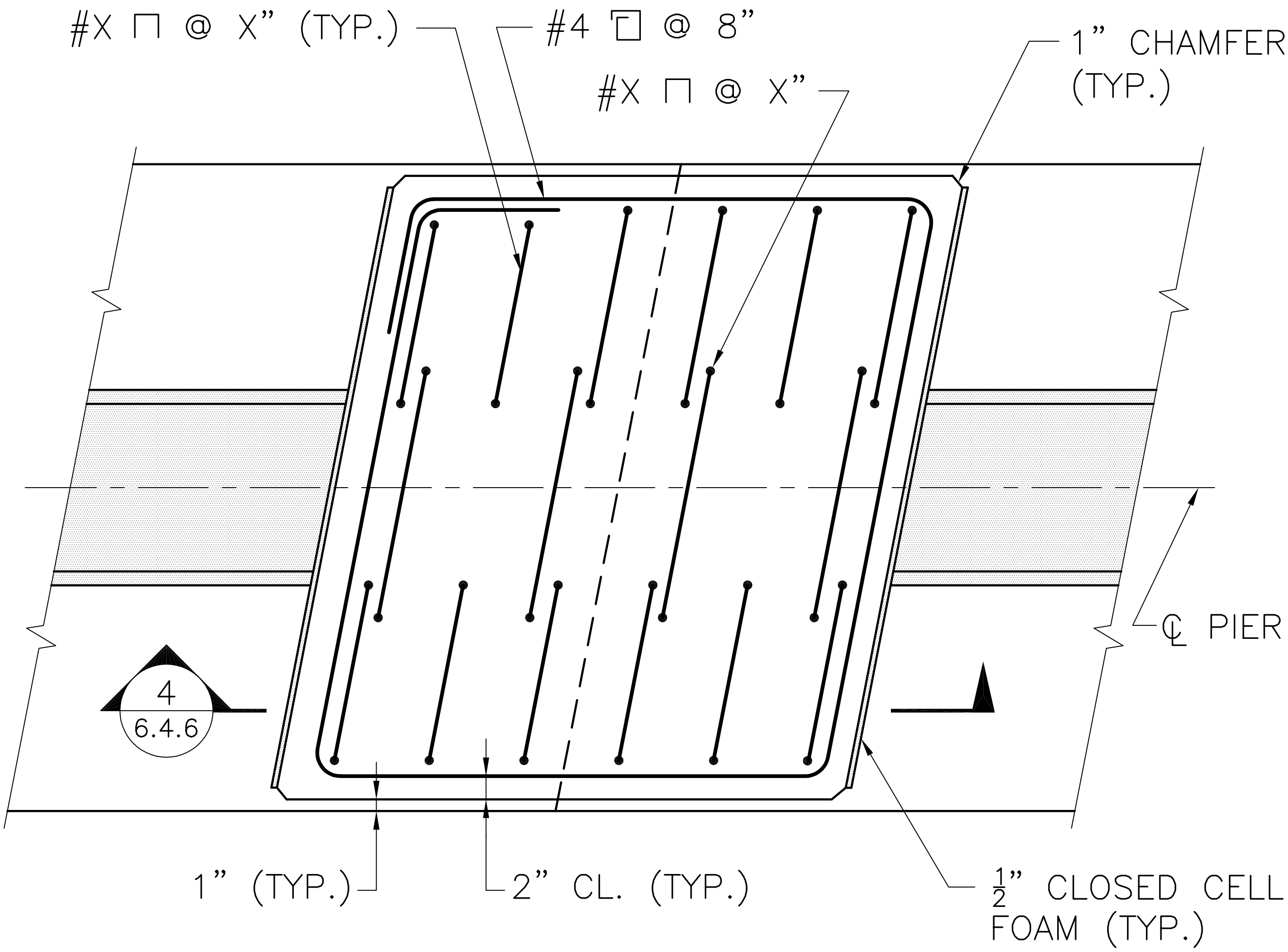
SECTION 2

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Remainder of pier cap reinforcement has been omitted for clarity.*
2. *Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement or add additional hoops as required by the actual design. The Designer shall also verify that the reinforcement provided does not duplicate or interfere with the typical pier reinforcement.*
3. *The minimum height of the keeper block shall extend to the top of the bottom bulb of NEBT.*

MASS HIGHWAY BRIDGE MANUAL	VERTICAL SECTION OF END KEEPER BLOCK PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.4**



NOTE:

INTERMEDIATE KEEPER BLOCKS SHALL BE CAST BEFORE BEAMS ARE SET AND THE PIER DIAPHRAGM CONCRETE IS PLACED.

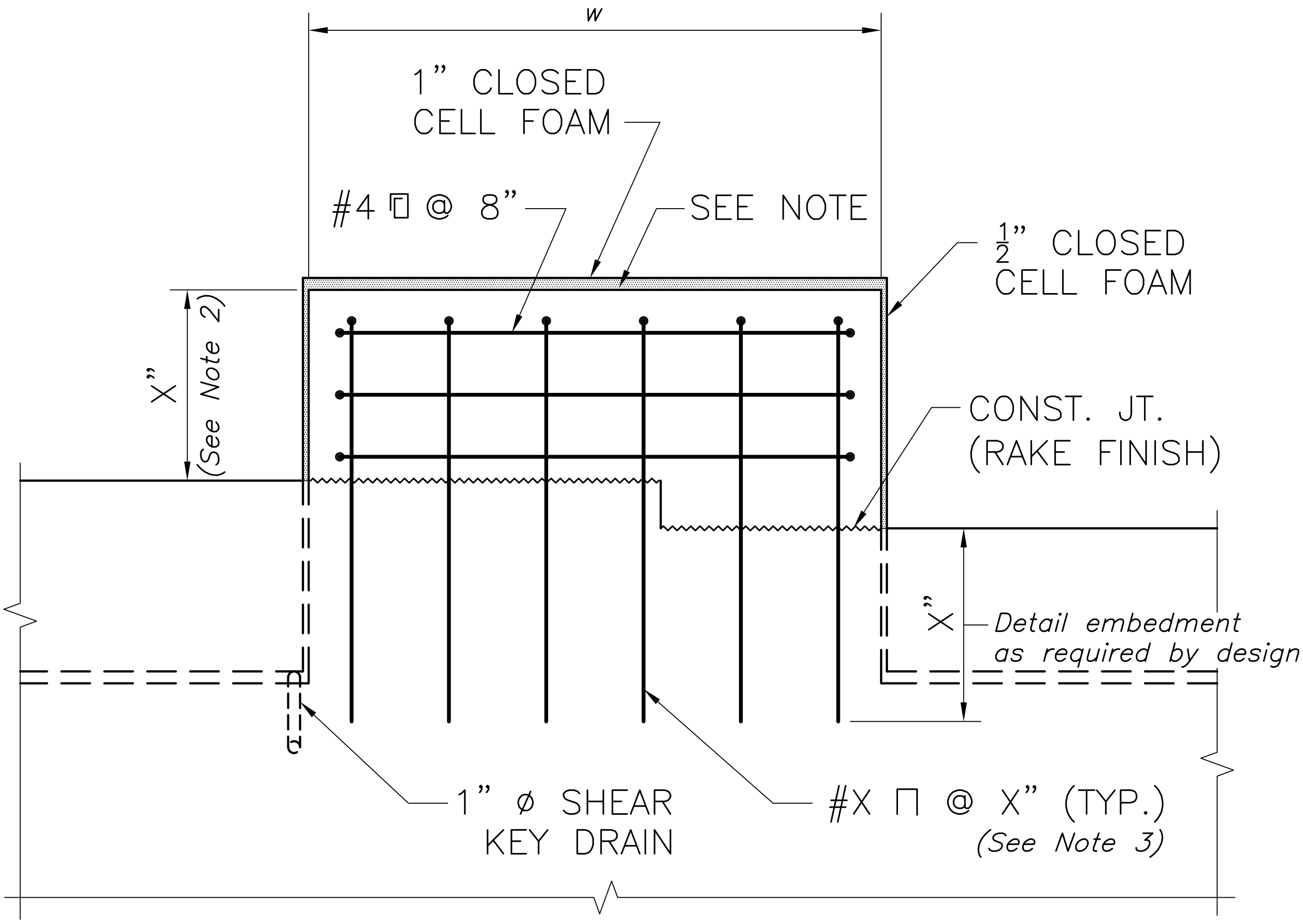
SECTION 3

SCALE: $\frac{3}{4}$" = 1'-0"

NOTE:

Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement or add additional hoops as required by the actual design. The Designer shall also verify that the reinforcement provided does not duplicate or interfere with the typical pier reinforcement.

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE KEEPER BLOCK – PLAN SECTION PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.5**



NOTE:

TOP OF INTERMEDIATE KEEPER BLOCK SHALL BE TROWELED SMOOTH PARALLEL TO PROFILE GRADE.

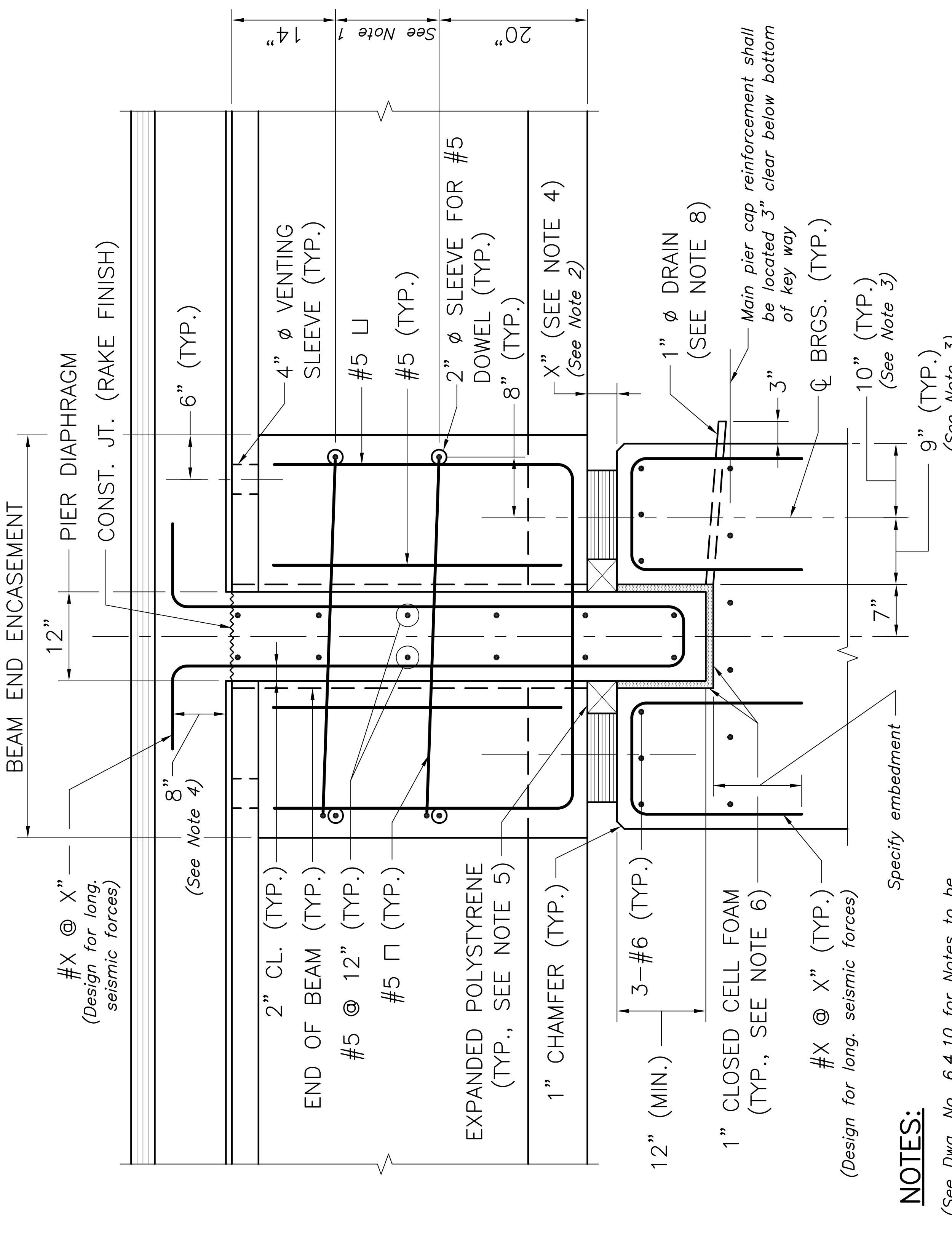
SECTION 4

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Remainder of pier cap reinforcement has been omitted for clarity.*
2. *Height of keeper block: 10" < h < w/3.*
3. *Design as shear friction reinforcement to resist transverse seismic loads. Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement or add additional hoops as required by the actual design. The Designer shall also verify that the reinforcement provided does not duplicate or interfere with the typical pier reinforcement.*

MASS HIGHWAY BRIDGE MANUAL	INTERMEDIATE KEEPER BLOCK – VERTICAL SECTION PIER DETAILS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **6.4.6**



DETAILS OVER PIER

SCALE: $\frac{3}{4}$" = 1'-0"

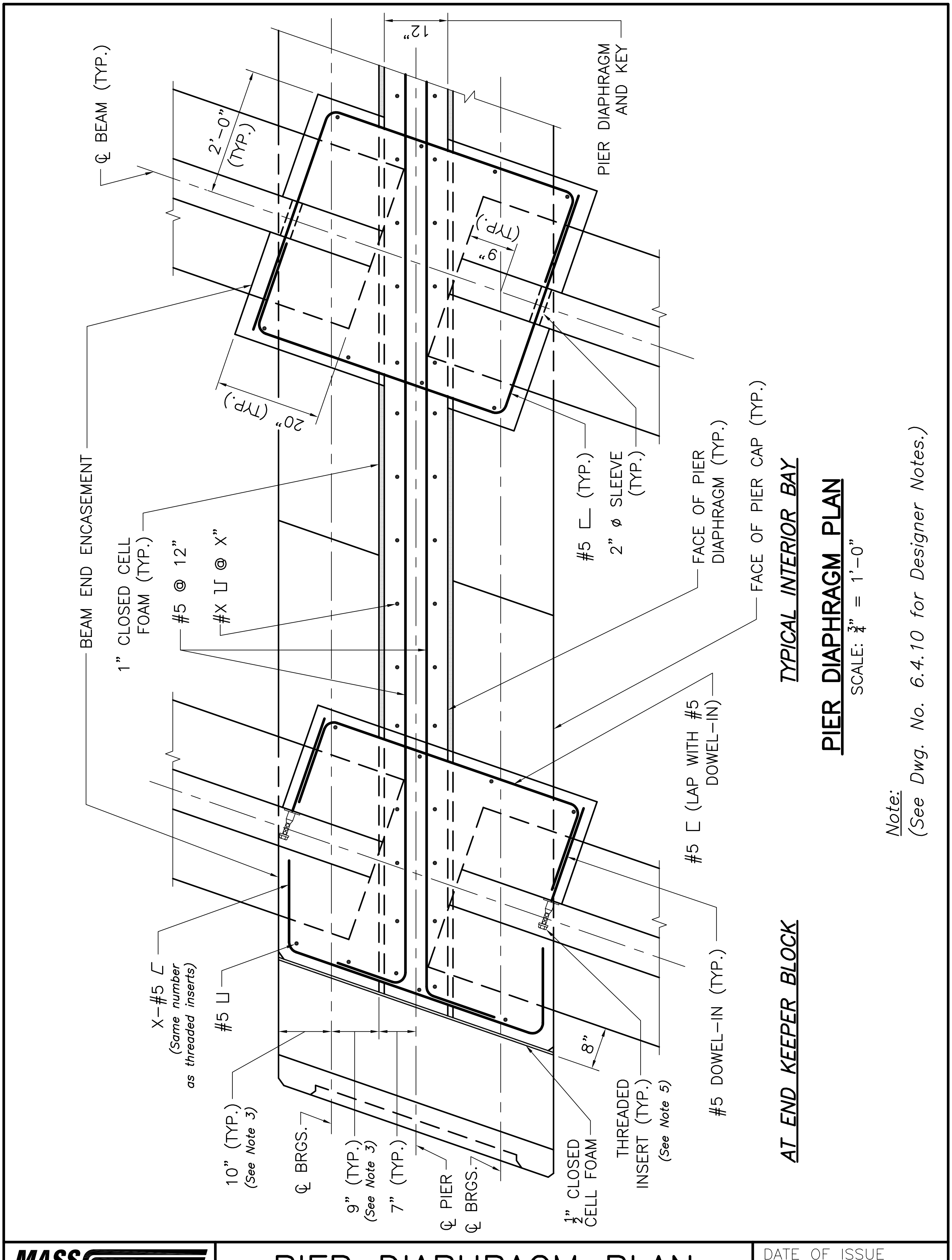
NOTES:

(See Dwg. No. 6.4.10 for Notes to be included on Construction Drawings.)

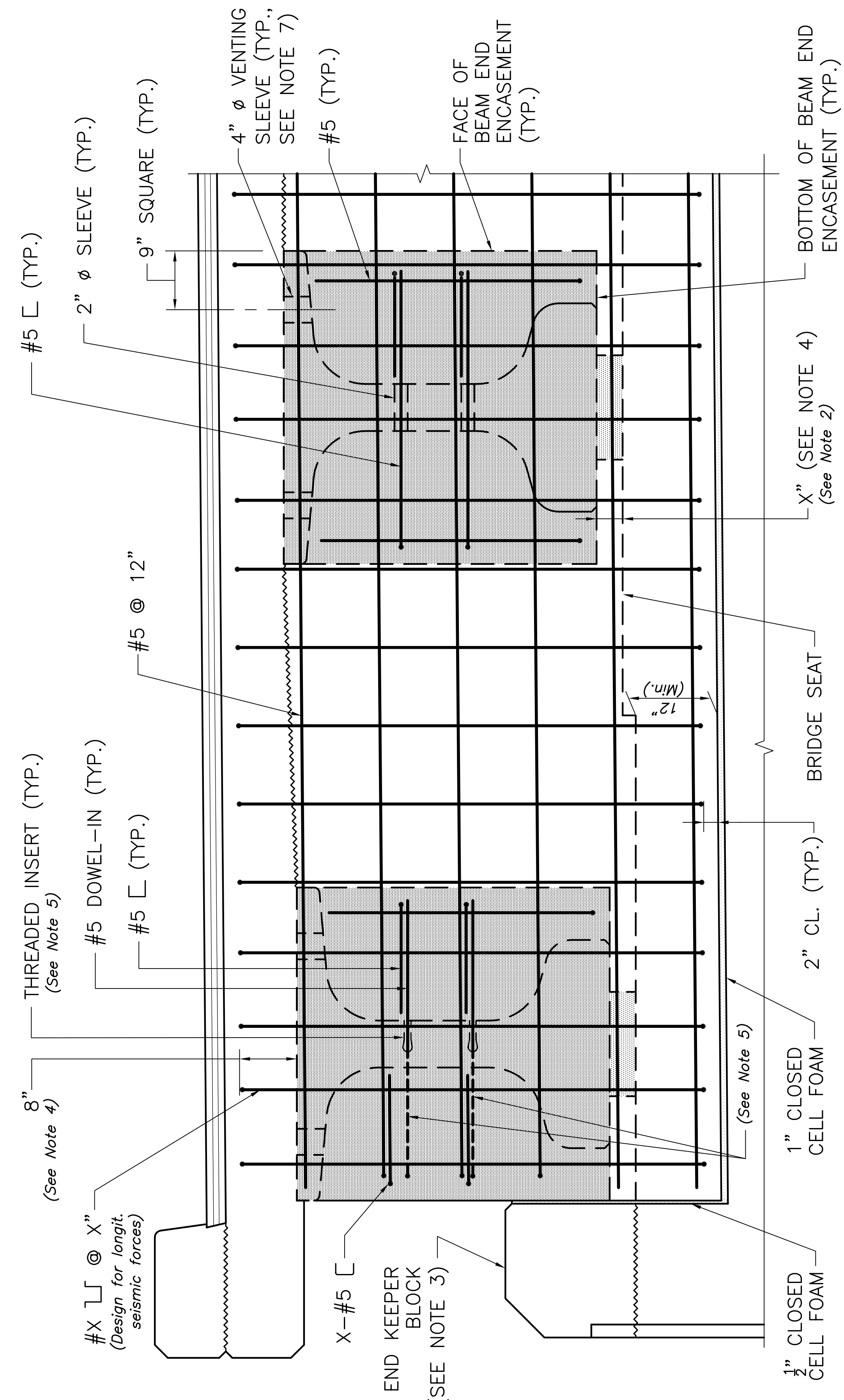
NOTES:

(See Dwg. No. 6.4.10 for Designer Notes.)

MASS HIGHWAY BRIDGE MANUAL	DETAILS OVER PIER FOR NEBT BEAMS PIER DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.4.7**



MASS HIGHWAY BRIDGE MANUAL	PIER DIAPHRAGM PLAN FOR NEBT BEAMS PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.8**



NOTES:

(See Dwg. No. 6.4.10 for Notes to be included on Construction Drawings)

PIER DIAPHRAGM SECTION

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

(See Dwg. No. 6.4.10 for Designer Notes)

MASS HIGHWAY BRIDGE MANUAL	PIER DIAPHRAGM SECTION FOR NEBT BEAMS PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.9**

DETAILS OVER PIER NOTES:

(Include these Notes with details shown on Dwg. No.'s 6.4.7, 6.4.8, and 6.4.9)

1. ALL REINFORCEMENT SHOWN IN THESE DETAILS SHALL BE COATED.

2. ALL PIER DIAPHRAGM AND BEAM END ENCASEMENT CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

3. END KEEPER BLOCKS *(and intermediate keeper blocks, if any)* SHALL BE CAST BEFORE BEAMS ARE SET AND PIER DIAPHRAGM AND BEAM END ENCASEMENT ARE CAST.

4. CONTRACTOR MAY USE EXPANDED POLYSTYRENE FILLER OR A REMOVABLE FORM TO FORM THE BOTTOM OF THE BEAM END ENCASEMENT.

5. PLACE EXPANDED POLYSTYRENE FILLER UNDER THE BOTTOM FLANGE AT THE EDGE OF THE SHEAR KEY.

6. PRIOR TO PLACING PIER DIAPHRAGM CONCRETE, LINE ALL SURFACES OF THE SHEAR KEY WITH CLOSED CELL FOAM AS SHOWN. PIER DIAPHRAGM CONCRETE MAY NOT COME IN DIRECT CONTACT WITH THE PIER CAP CONCRETE MASONRY.

7. PROVIDE VENTING SLEEVES IN THE TOP FLANGE OF THE NEBT BEAMS AS SHOWN.

8. SLOPE SHEAR KEY DRAIN 5% MIN. TOWARDS FACE OF PIER CAP.

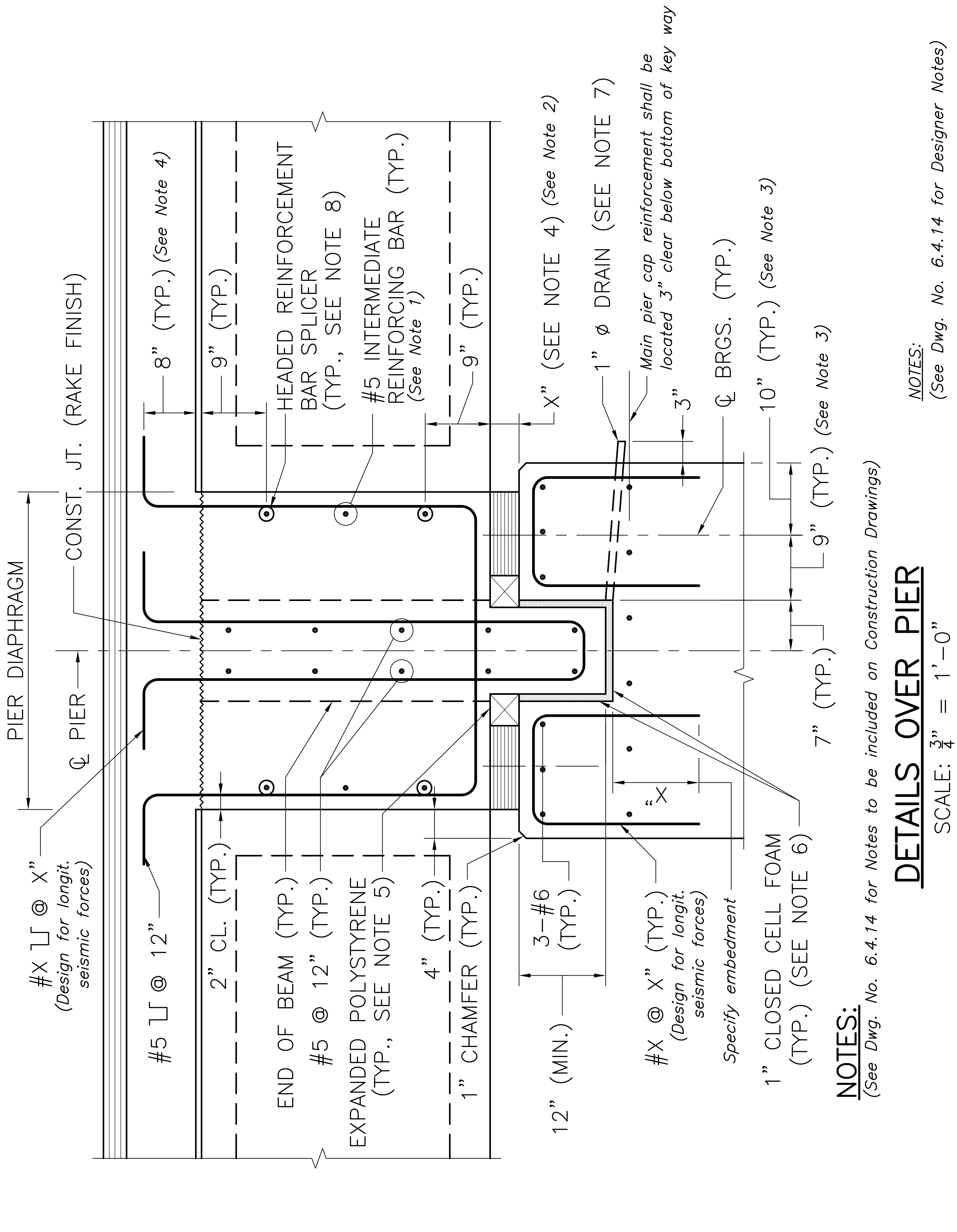
9. INSERTS FOR #5 REINFORCING BARS SHALL BE CAST-IN-PLACE IN THE PRECAST BEAMS BY THE FABRICATOR AND SHALL PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 11 KIPS AND A MINIMUM ULTIMATE SHEAR CAPACITY OF 9 KIPS IN 3000 PSI CONCRETE.

NOTES:

(These Notes are for details shown on Dwg. No.'s 6.4.7, 6.4.8, and 6.4.9)

1. *For NEBT 1000 use 1 dowel at midbeam,*
   For NEBT 1200 and NEBT 1400, use 2 dowels,
   For NEBT 1600 and NEBT 1800, use 3 dowels equally spaced.
2. *Dimension to be provided is equal to total thickness of bearing.*
3. *If the bearing exceeds 16" in diameter, set the 9" dimension to (Bearing Dia.)/2 + 1", and set the 10" dimension to (Bearing Dia.)/2 + 2".*
4. *The Designer shall ensure that at least 2" clear cover is maintained to the top of the deck at all locations.*
5. *Threaded inserts shall be used only on skewed bridges with a skew angle exceeding 10°. For all other bridges use 2" ø sleeves and #5 ⊏ bars as shown for typical interior bay.*

MASS HIGHWAY BRIDGE MANUAL	DETAILS OVER PIER NOTES FOR NEBT BEAMS PIER DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **6.4.10**



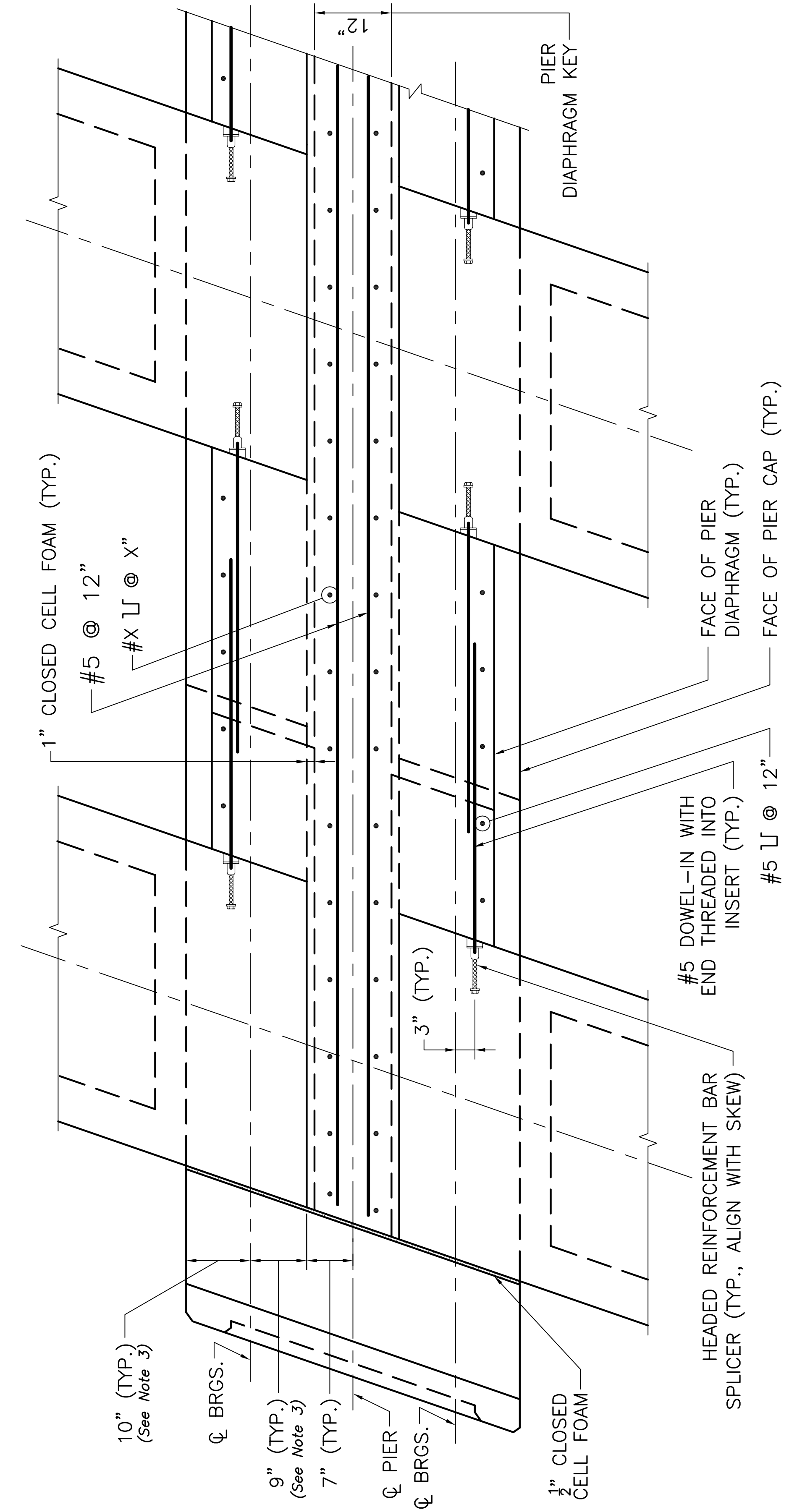
MASS HIGHWAY
BRIDGE MANUAL

DETAILS OVER PIER FOR BOX BEAMS

PIER DETAILS

DATE OF ISSUE
NOVEMBER 2010

DRAWING NUMBER
6.4.11



TYPICAL INTERIOR BAY

AT END KEEPER BLOCK

PIER DIAPHRAGM PLAN

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:
See Dwg. No. 6.4.14 for Designer Notes.

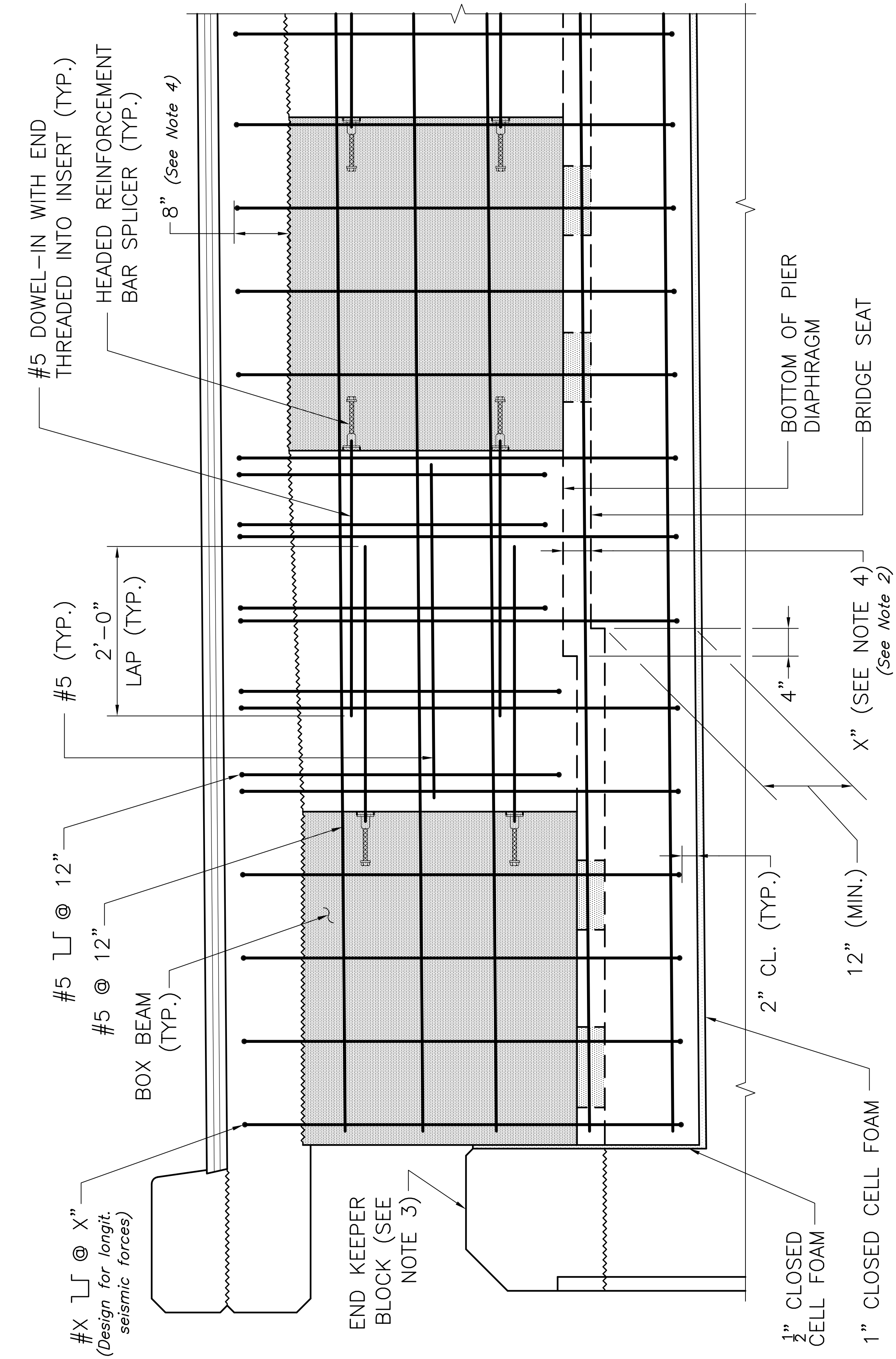
MASS HIGHWAY
BRIDGE MANUAL

PIER DIAPHRAGM PLAN FOR BOX BEAMS

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.4.12



(See Dwg. No. 6.4.14 for Notes to be included on Construction Drawings)

PIER DIAPHRAGM SECTION

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:
See Dwg. No. 6.4.14 for Designer Notes.

MASS HIGHWAY BRIDGE MANUAL	PIER DIAPHRAGM SECTION FOR BOX BEAMS PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.13**

DETAILS OVER PIER NOTES: *(Include these Notes with the details shown on Dwg. No.'s 6.4.11, 6.4.12, and 6.4.13)*

1. ALL REINFORCEMENT SHOWN IN THESE DETAILS SHALL BE COATED.

2. ALL PIER DIAPHRAGM CONCRETE SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 610 CEMENT CONCRETE.

3. END KEEPER BLOCKS SHALL BE CAST AFTER THE BEAMS ARE ERECTED AND THE PIER DIAPHRAGM HAS BEEN CAST. ATTACH CLOSED CELL FOAM TO THE BEAMS AND DIAPHRAGM PRIOR TO PLACING END KEEPER BLOCK CONCRETE.

4. CONTRACTOR MAY USE EXPANDED POLYSTYRENE FILLER OR A REMOVABLE FORM TO FORM THE BOTTOM OF THE PIER DIAPHRAGM.

5. PLACE EXPANDED POLYSTYRENE FILLER UNDER THE BOTTOM FLANGE AT THE EDGE OF THE SHEAR KEY.

6. PRIOR TO PLACING PIER DIAPHRAGM CONCRETE, LINE ALL SURFACES OF THE SHEAR KEY WITH CLOSED CELL FOAM AS SHOWN. PIER DIAPHRAGM CONCRETE MAY NOT COME IN DIRECT CONTACT WITH THE PIER CAP CONCRETE MASONRY.

7. SLOPE SHEAR KEY DRAIN 5% MIN. TOWARDS FACE OF PIER CAP.

8. THREADED REINFORCEMENT BAR SPLICERS SHALL BE CAST–IN–PLACE BY THE FABRICATOR AND SHALL BE EMBEDDED AS REQUIRED TO PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 18 KIPS AS SPECIFIED BY THE MANUFACTURER.

<u>NOTES:</u> (These Notes are for details shown on Dwg. No.'s 6.4.11, 6.4.12, and 6.4.13)

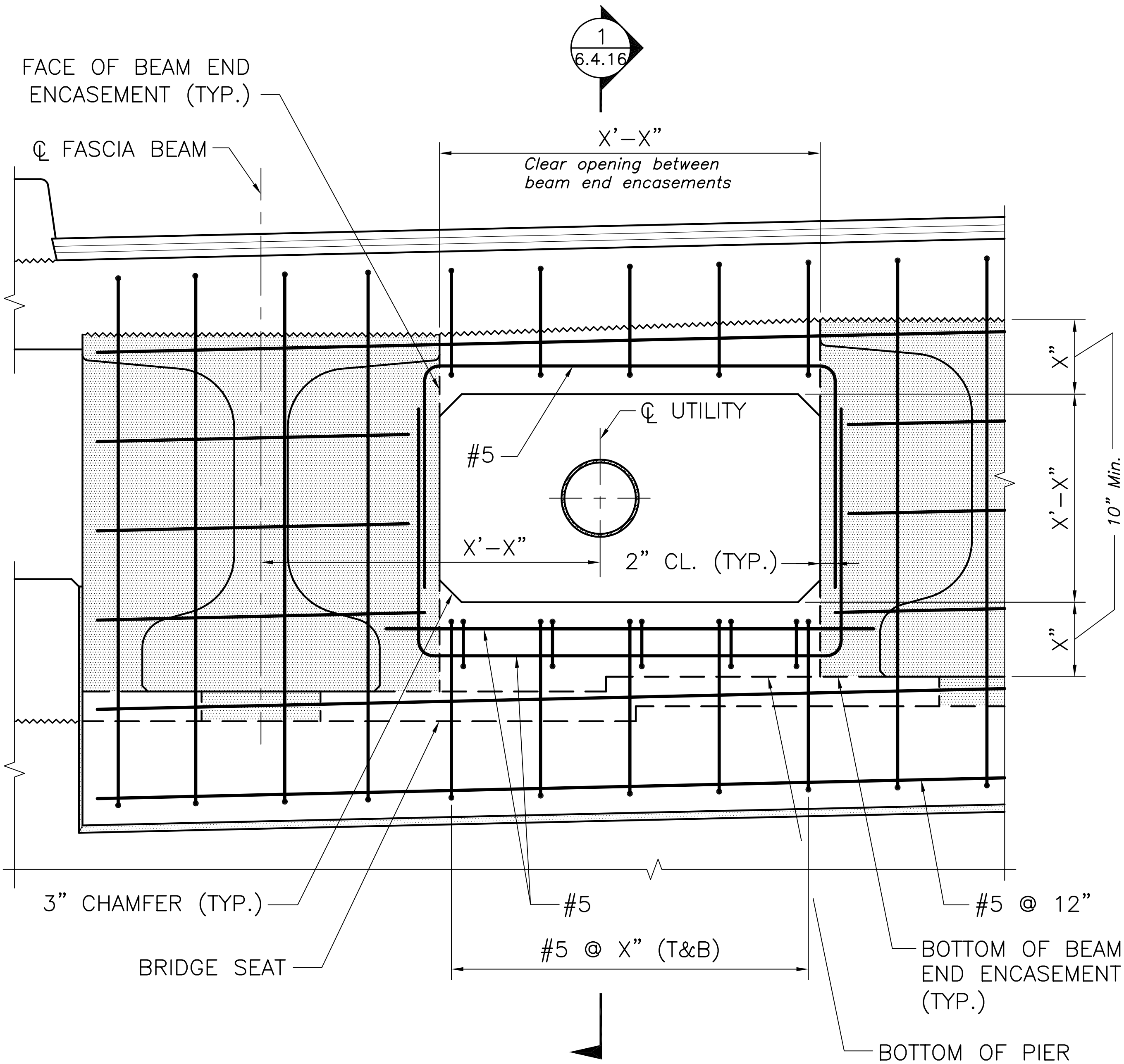
1. *Provide headed reinforcement bar splicers by beam designation as follows:*

B–24 thru B–30 beams	*1 headed reinforcement bar splicer mid beam;*
B–33 thru B–48 beams	*2 headed reinforcement bar splicers as shown.*

   Provide #5 intermediate reinforcing bars by beam designation as follows:

B–24 thru B–30 beams	*No intermediate bars;*
B–33 thru B–48 beams	*1 intermediate bar midway between splicers.*

2. *Dimension to be provided is equal to total thickness of bearing.*
3. *If the bearing exceeds 16" in diameter, set the 9" dimension to (Bearing Dia.)/2 + 1", and set the 10" dimension to (Bearing Dia.)/2 + 2".*
4. *The Designer shall ensure that at least 2" clear cover is maintained to the top of the deck at all locations.*



NOTE:

BEAM END ENCASEMENT REINFORCEMENT NOT SHOWN FOR CLARITY.

UTILITY DETAIL AT PIER

SCALE: $\frac{3}{4}$" = 1'–0"

NOTE:

The type of utility is conceptual and shall be modified to accommodate the actual type.

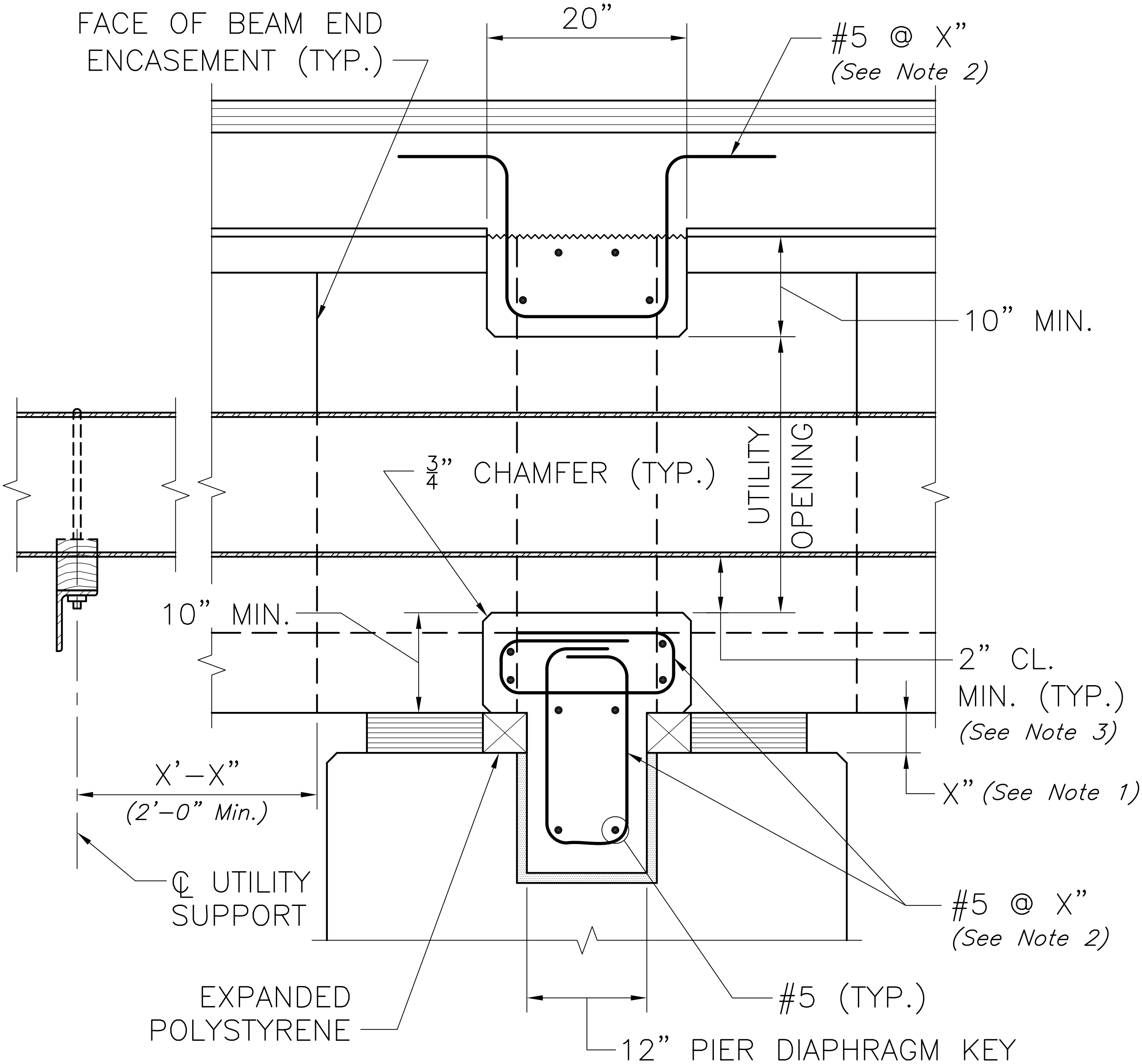
MASS HIGHWAY BRIDGE MANUAL

UTILITY BAY DETAILS FOR NEBT BEAMS

PIER DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
6.4.15



NOTE:

BEAM END ENCASEMENT REINFORCEMENT AND PIER CAP REINFORCEMENT NOT SHOWN FOR CLARITY.

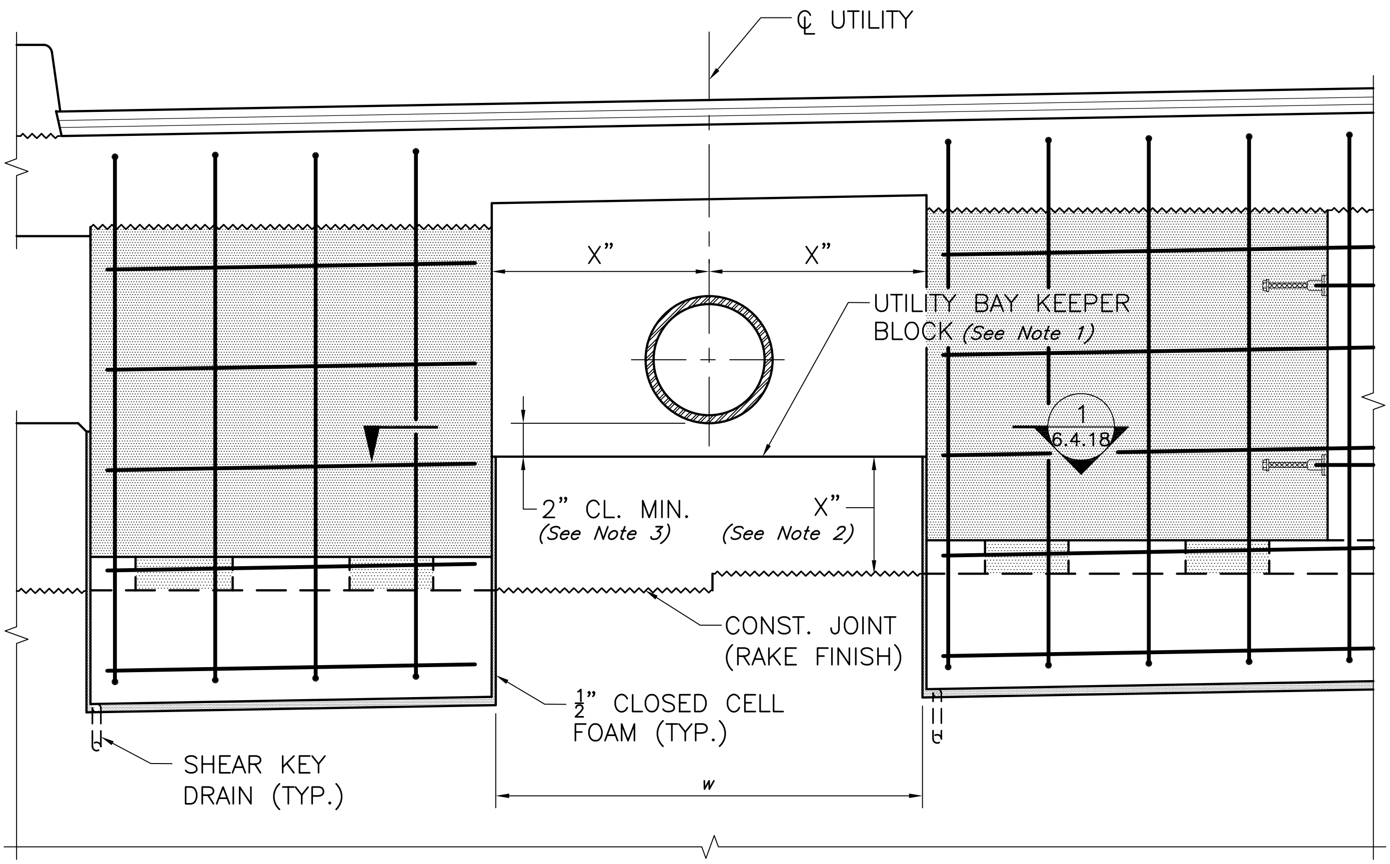
SECTION 1

SCALE: $\frac{3}{4}$" = 1'–0"

NOTES:

1. *Dimension to be provided is equal to Total Thickness of Bearing.*
2. *Use same spacing as for the typical pier diaphragm reinforcement.*
3. *The Designer shall verify that the clearances required by utilities are maintained.*
4. *The type of utility is conceptual and shall be modified to accommodate the actual type.*

MASS HIGHWAY BRIDGE MANUAL	SECTION THRU UTILITY BAY FOR NEBT BEAMS PIER DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.4.16**



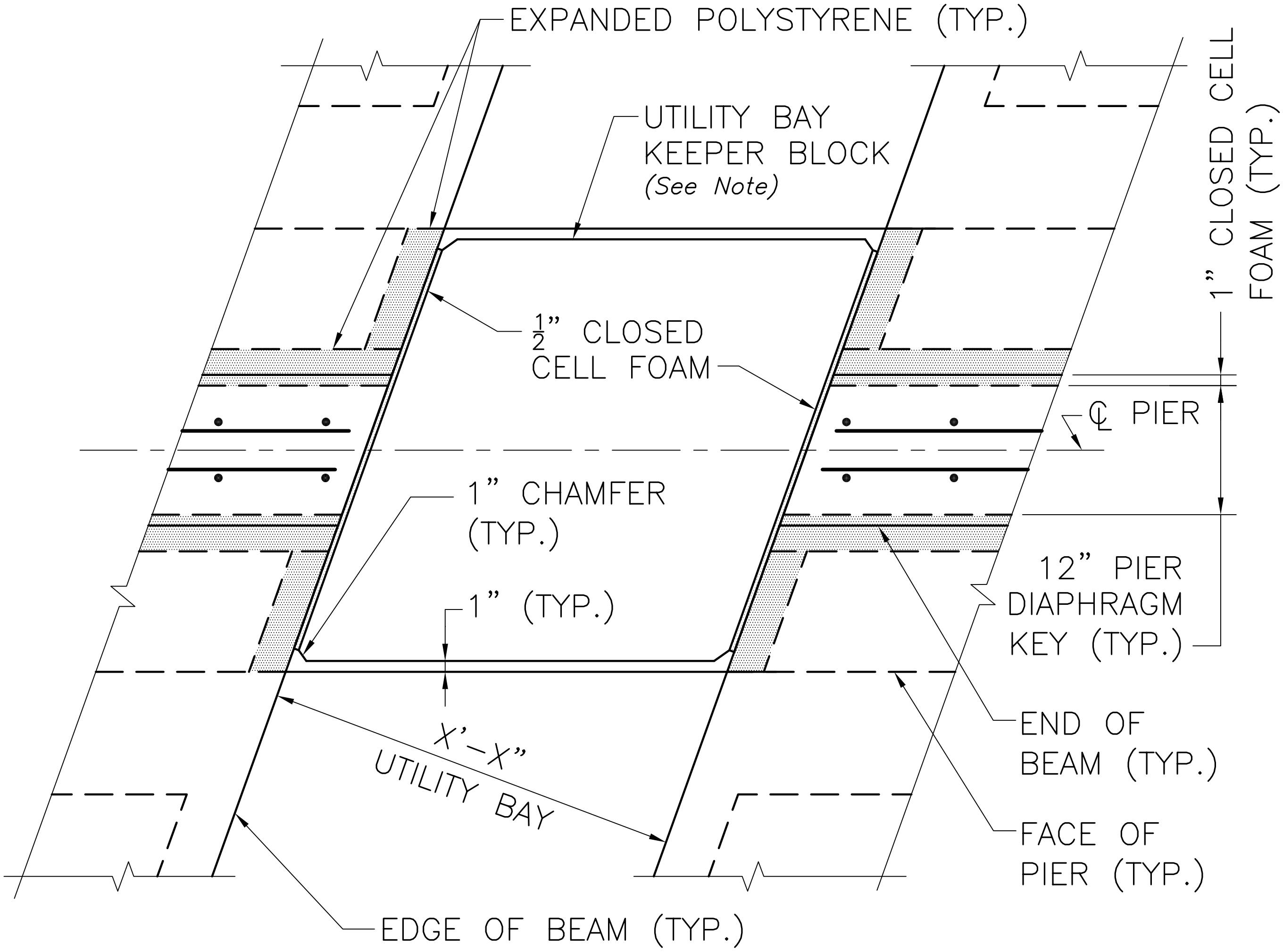
UTILITY DETAIL AT PIER

SCALE: ¾" = 1'–0"

NOTES:

1. *Reinforcement for utility bay keeper block shall be the same as for the intermediate keeper blocks. Refer to Dwg. No. 6.4.5 and show all relevant details on the Construction Drawings.*
2. *Height of keeper block: h shall be less or equal to w/3, 10" Min.*
3. *The Designer shall verify that the clearances required by utilities are maintained.*
4. *The type of utility is conceptual and shall be modified to accommodate the actual type.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY BAY DETAILS FOR BOX BEAMS PIER DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **6.4.17**



NOTE:

KEEPER BLOCK SHALL BE CAST AFTER BEAMS ARE ERECTED AND THE PIER DIAPHRAGM HAS BEEN CAST. ATTACH CLOSED CELL FOAM TO THE BEAMS AND DIAPHRAGM PRIOR TO PLACING KEEPER BLOCK CONCRETE.

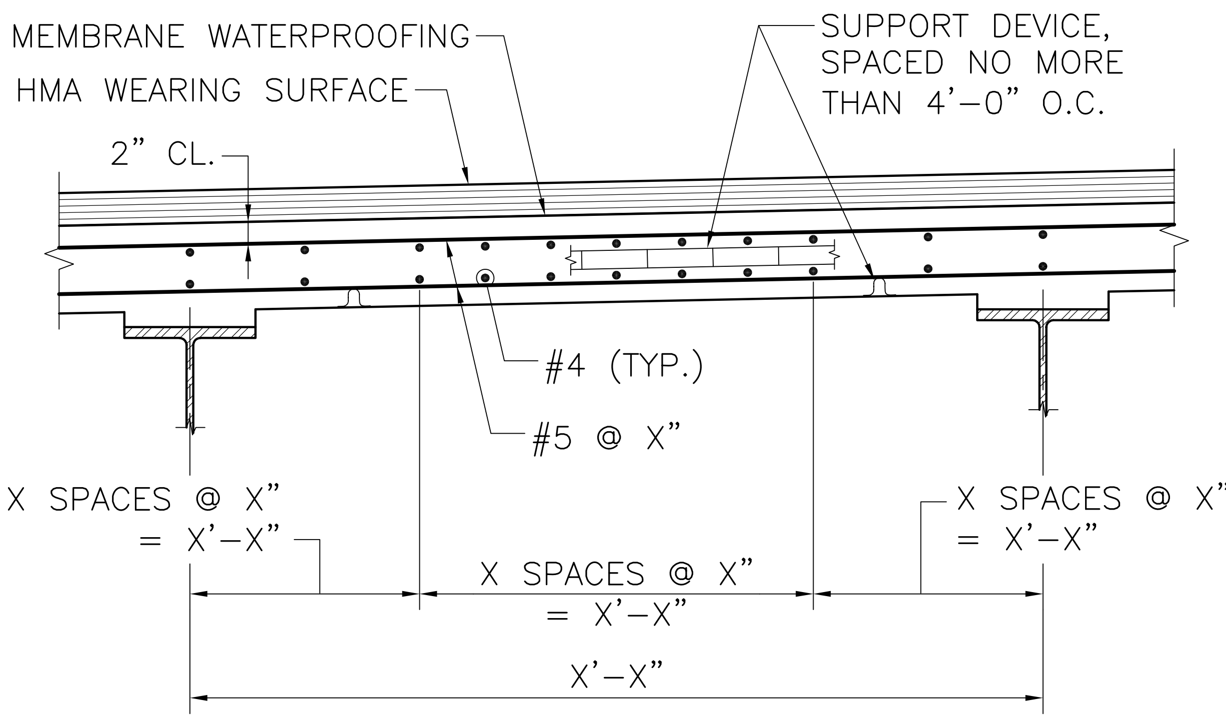
SECTION 1

SCALE: $\frac{3}{4}$" = 1'–0"

NOTE:

Reinforcement for utility bay keeper block shall be the same as for the intermediate keeper blocks. For additional dimensions, details and Designer Notes, refer to Dwg. No. 6.4.5 and show all on the Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	SECTION THRU UTILITY BAY FOR BOX BEAMS PIER DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **6.4.18**



NOTES:

1. ROADWAY DECK SLAB SHALL BE 4000 PSI, $\frac{3}{4}$ IN, 585 HP CEMENT CONCRETE.

2. #4 LONGITUDINAL REINFORCEMENT SHALL BE PLACED PARALLEL TO THE ℄ OF CONSTRUCTION.
   #5 MAIN REINFORCEMENT SHALL BE PLACED PERPENDICULAR TO THE ℄ OF CONSTRUCTION.

3. ALL REINFORCEMENT AND SUPPORT DEVICES SHALL BE COATED.

4. THE FINISHED SURFACE OF BRIDGE DECK SHALL BE SMOOTH AND WITHOUT ANY PROJECTIONS THAT COULD PUNCTURE THE MEMBRANE WATERPROOFING OR DEPRESSIONS THAT COULD RETAIN WATER.
   (Include this note for bridges with HMA wearing surface)

4. BRIDGE DECK SHALL BE GROOVED TRANSVERSELY USING MULTI–BLADED SELF–PROPELLED SAWCUTTING EQUIPMENT.
   (Include this note for bridges with exposed decks)

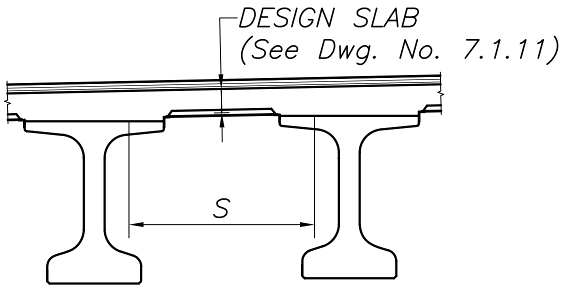
TYPICAL DECK REINFORCEMENT

SCALE: $\frac{3}{4}$" = 1'–0"

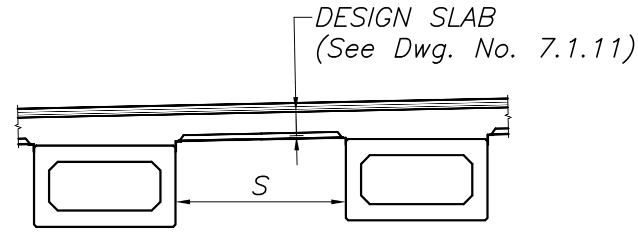
NOTES:

1. *Modify the above drawing as required when exposed deck is used. Show actual beam type used.*
2. *See Dwg. No. 7.1.2 for design of main reinforcement. See Dwg. No. 7.1.3 for design of distribution reinforcement.*
3. *For decks continuous over piers show deck reinforcement at piers in a separate detail.*

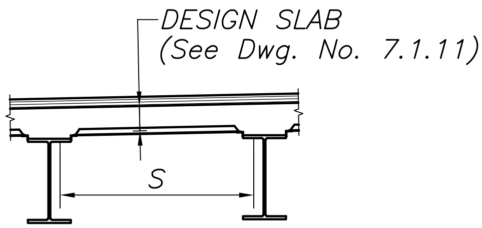
MASS HIGHWAY BRIDGE MANUAL	TYPICAL DECK REINFORCEMENT GENERAL DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **7.1.1**



NEBT BEAMS

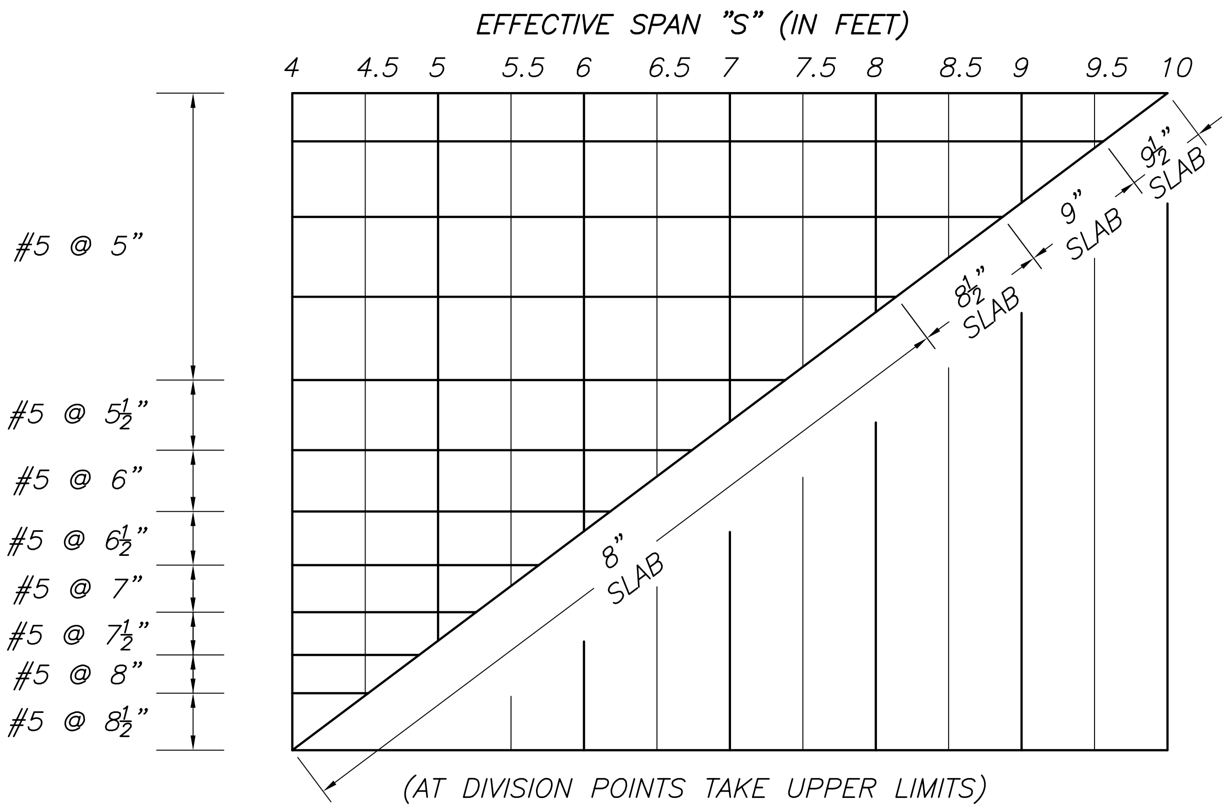


SPREAD BOX/DECK BEAMS



STEEL STRINGERS/GIRDERS

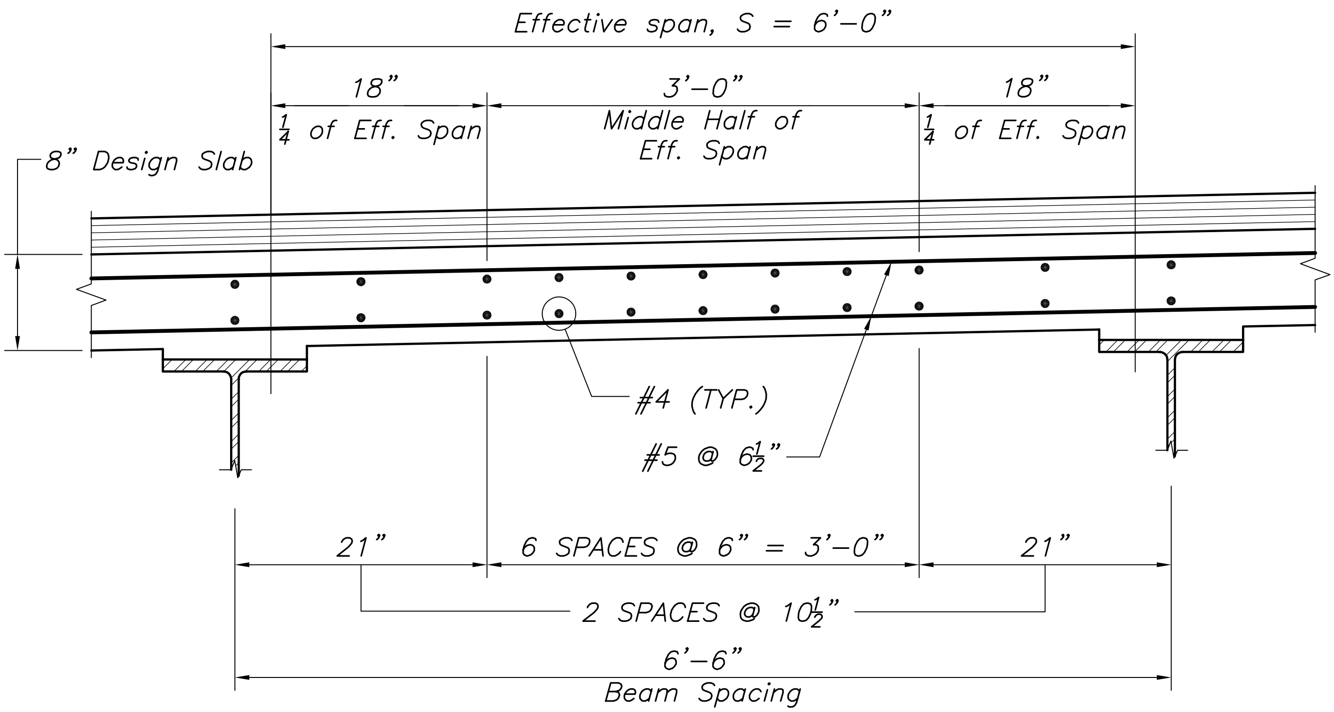
BEAM TYPE	FORMULA FOR S
NEBT BEAMS	S = DISTANCE BETWEEN FLANGE EDGES + 20"
SPREAD BOX/DECK BEAMS	S= DISTANCE BETWEEN FLANGE EDGES
STEEL STRINGERS/ GIRDERS	S= DISTANCE BETWEEN FLANGE EDGES + $\frac{1}{2}$ WIDTH OF FLANGE



NOTES:

1. S = Effective Span Length; the span length shall be determined based upon stringer type used.
2. Span is to be measured in the direction of the main reinforcement. All main steel is to be placed perpendicular to the centerline of construction.
3. Distribution steel is to be placed parallel to the centerline of construction.
4. Deck reinforcement shall conform to AASHTO M 31, Grade 60.
5. Assumptions: HS25 wheel load, f'c = 4000 psi, 3" HMA wearing surface.

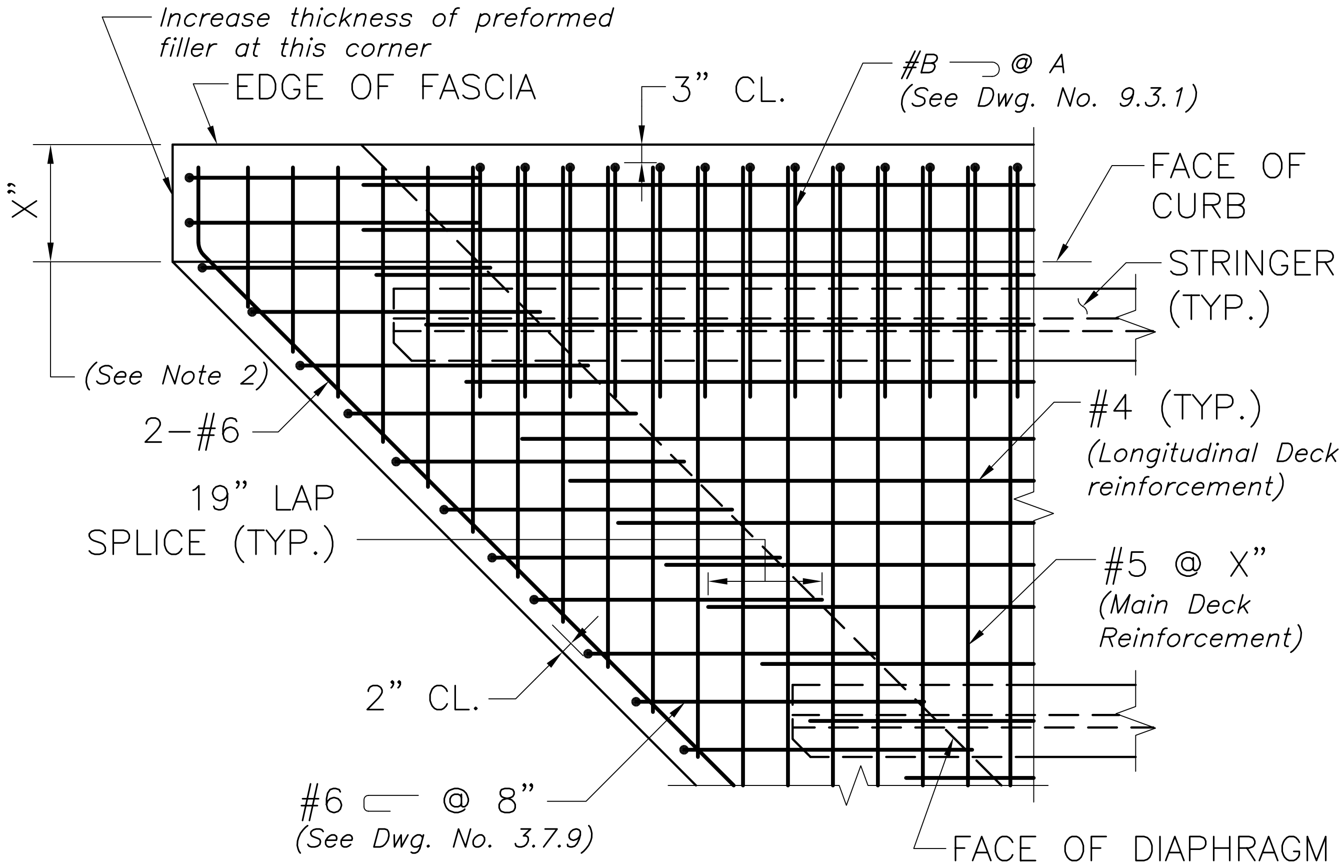
MASS HIGHWAY BRIDGE MANUAL	DESIGN OF MAIN REINFORCEMENT GENERAL DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER 7.1.2



EXAMPLE CALCULATION

1. Beam Spacing = 6'–6", Flange Width = 12".
2. From Dwg. No. 7.1.2, Main Slab Reinforcement = #5 @ 6½", area of main steel per foot = number of bars per foot x area of one bar (Area = 12 in/ft ÷ 6½" x 0.31 in² = 0.572 in/ft²) and effective span, S = 6'–0".
3. % distribution steel for middle half of effective span = $220 \div \sqrt{S}$ = $220 \div \sqrt{6'}$ = 90%. However, maximum allowable percentage is 67%.
4. Total area of distribution steel in middle half of effective span = S ÷ 2 x 67% of Main Reinforcement = 6.0' ÷ 2 x 0.67 x 0.572 in²/ft = 1.15 in².
5. Spacing of distribution steel in middle half of effective span = S ÷ 2 x (Area of one bar ÷ Total Required Area) = (6.0' ÷ 2 x 0.2 in² ÷ 1.15 in)² x 12 in = 6.3 in.
6. Use #4 @ 6" in middle half of effective span.
7. The spacing of the reinforcement in the outer ¼ strips shall not exceed twice the reinforcement spacing of the middle half, use #4 @ 10½".
8. The above steps meet the AASHTO requirements for distribution steel.

MASS HIGHWAY BRIDGE MANUAL	DESIGN OF DISTRIBUTION REINFORCEMENT GENERAL DECK DETAILS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: 7.1.3

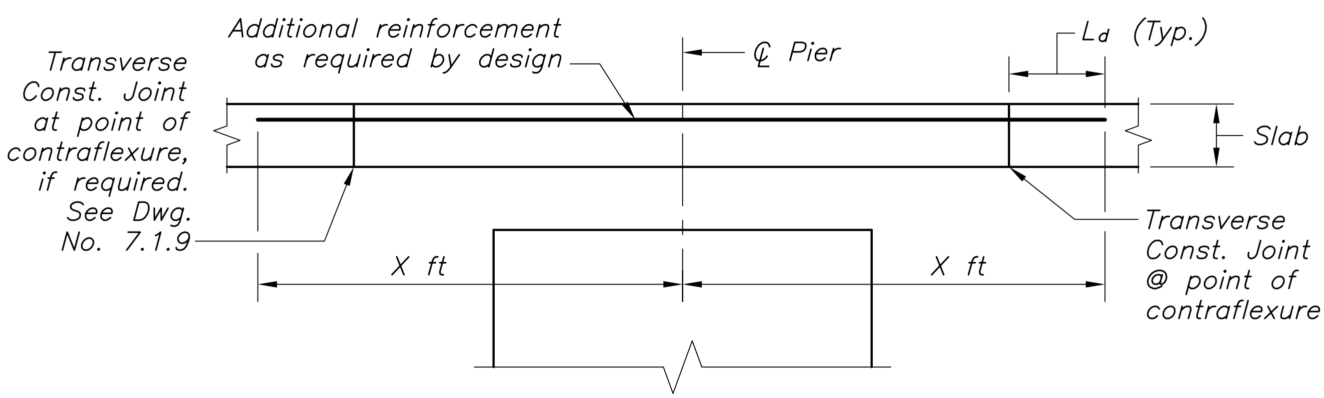


PLAN AT ACUTE CORNER

SCALE: $\frac{3}{8}$" = 1'–0"

NOTES:

1. Provide detail shown above, modified as required, on bridges with skew angles greater than 35°.
2. Width of barrier or 2'–0" at sidewalk.



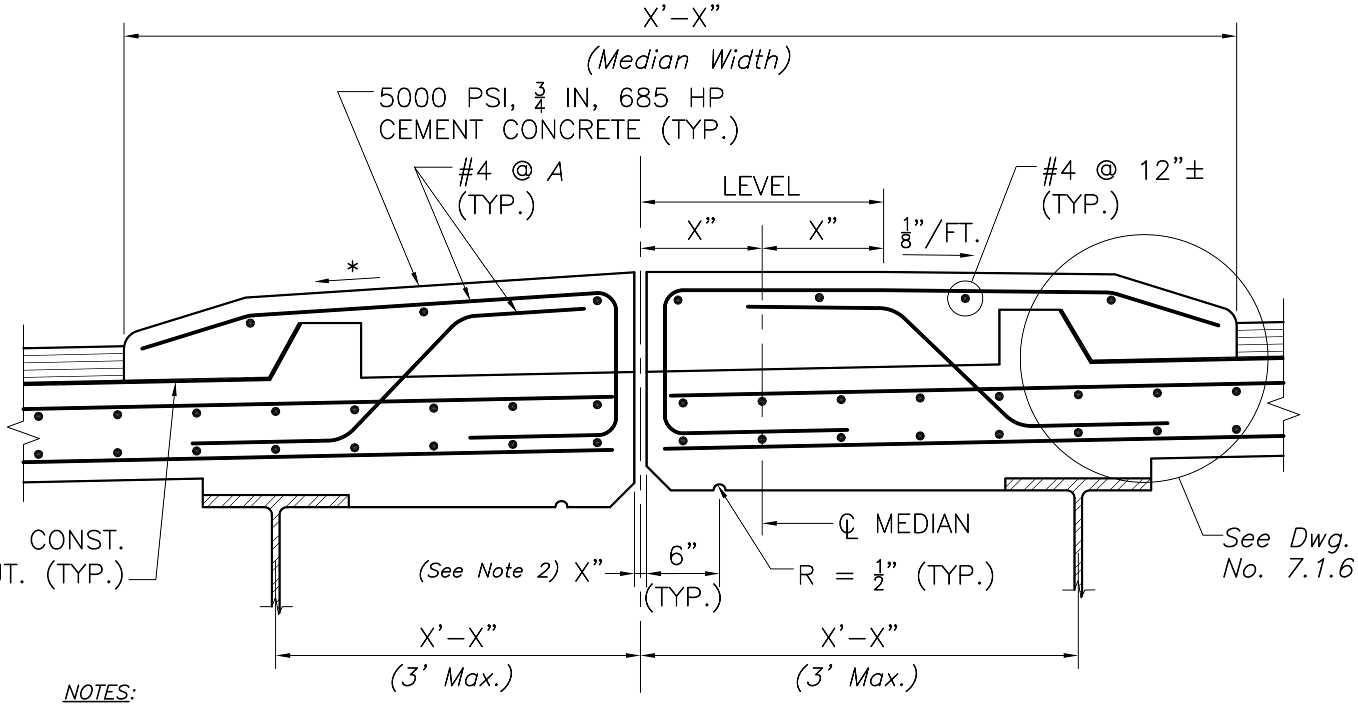
SECTION AT PIER

NOT TO SCALE

NOTE:

Deck slabs of Continuous Spans over piers shall have additional reinforcement placed in the top of the slab. Details shall be shown on the Construction Drawings. If bars larger than #5 are used for this reinforcement, the Designer shall check the clearance between the reinforcing mats.

MASS HIGHWAY BRIDGE MANUAL	REINFORCEMENT DETAILS GENERAL DECK DETAILS	DATE OF ISSUE MAY 2005
		DRAWING NUMBER **7.1.4**



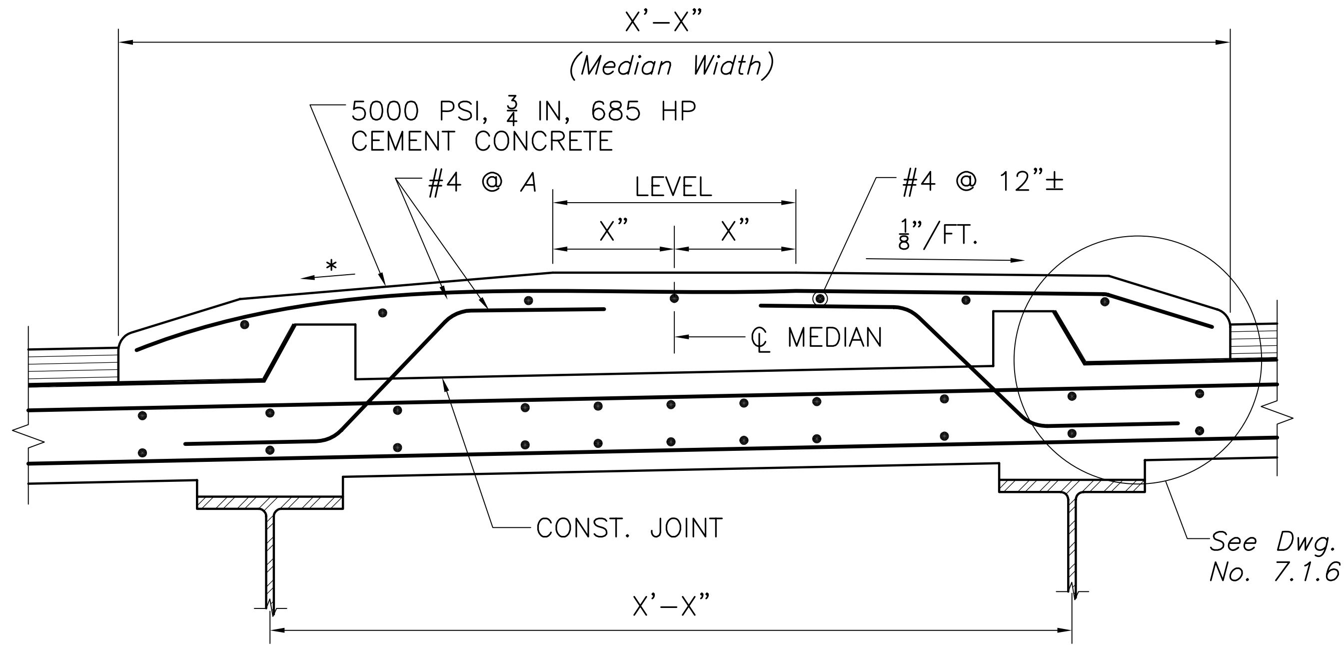
NOTES:

1. *Bearings shall be designed to provide for transverse movement.*
2. *Dimension X" is equal to the Amount of Thermal Expansion + 1").*

* $\frac{1}{8}$"/FT. MIN., SLOPE TO SUIT

WITH LONGITUDINAL JOINT

(To be used only where total width of bridge exceeds 72'±)



WITHOUT LONGITUDINAL JOINT

* $\frac{1}{8}$"/FT. MIN., SLOPE TO SUIT

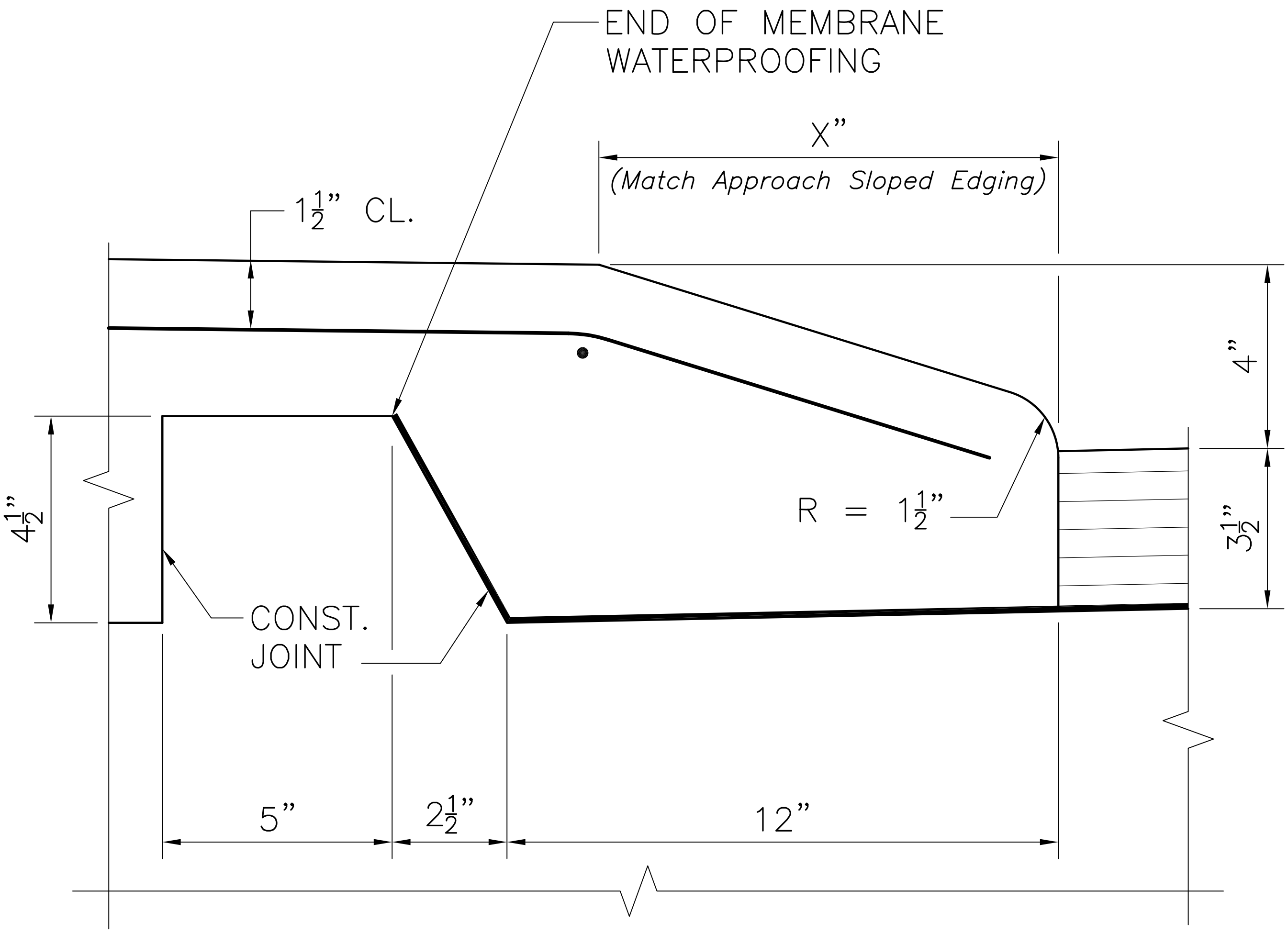
MEDIAN DETAILS

SCALE: 1" = 1'–0"

NOTES:

1. *A = same spacing as deck slab reinforcement.*
2. *If a median rail or barrier is required, consult Bridge Engineer for appropriate Crash Tested System. Omit level surface on bridges without median rail or barrier.*
3. *Details for separated precast beams are similar.*

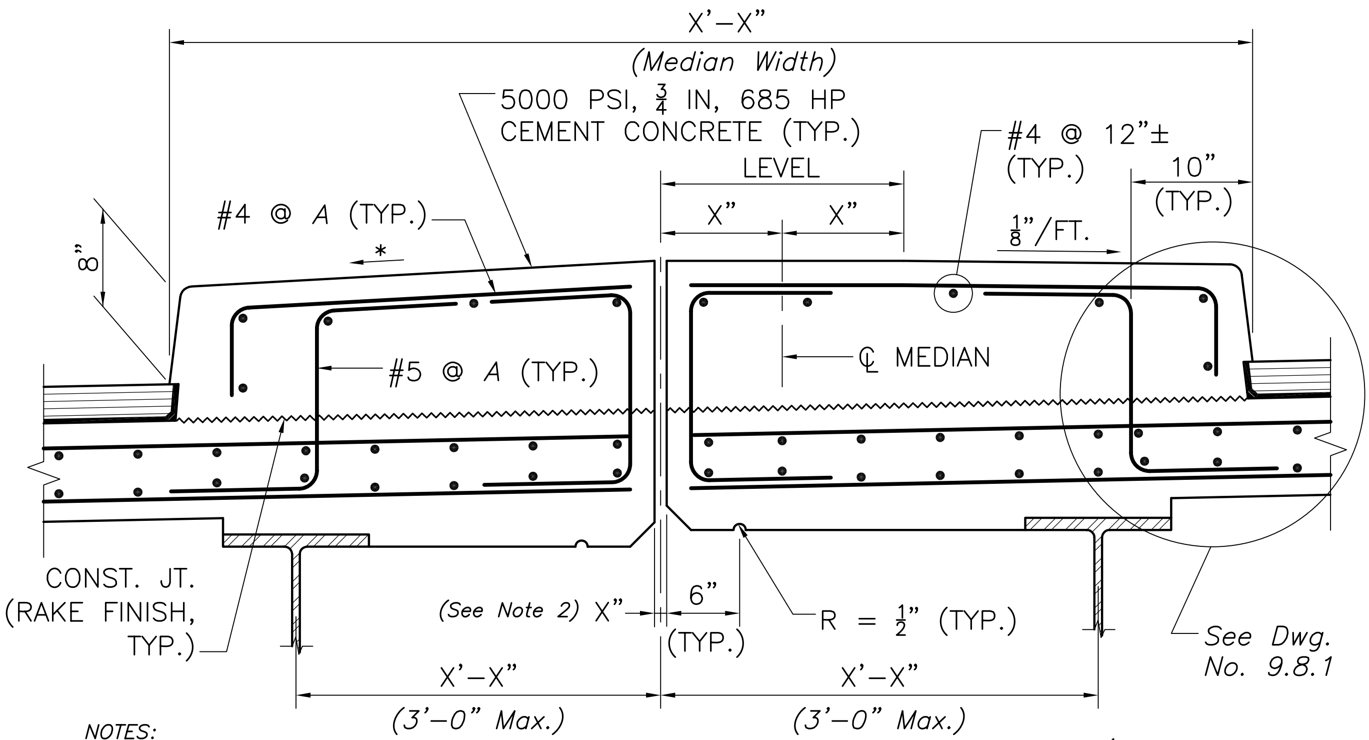
MASS HIGHWAY BRIDGE MANUAL	MEDIAN DETAILS WITHOUT APPROACH CURB GENERAL DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **7.1.5**



MEDIAN CURB DETAIL

SCALE: 3" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	MEDIAN CURB DETAIL WITHOUT APPROACH CURB GENERAL DECK DETAILS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **7.1.6**



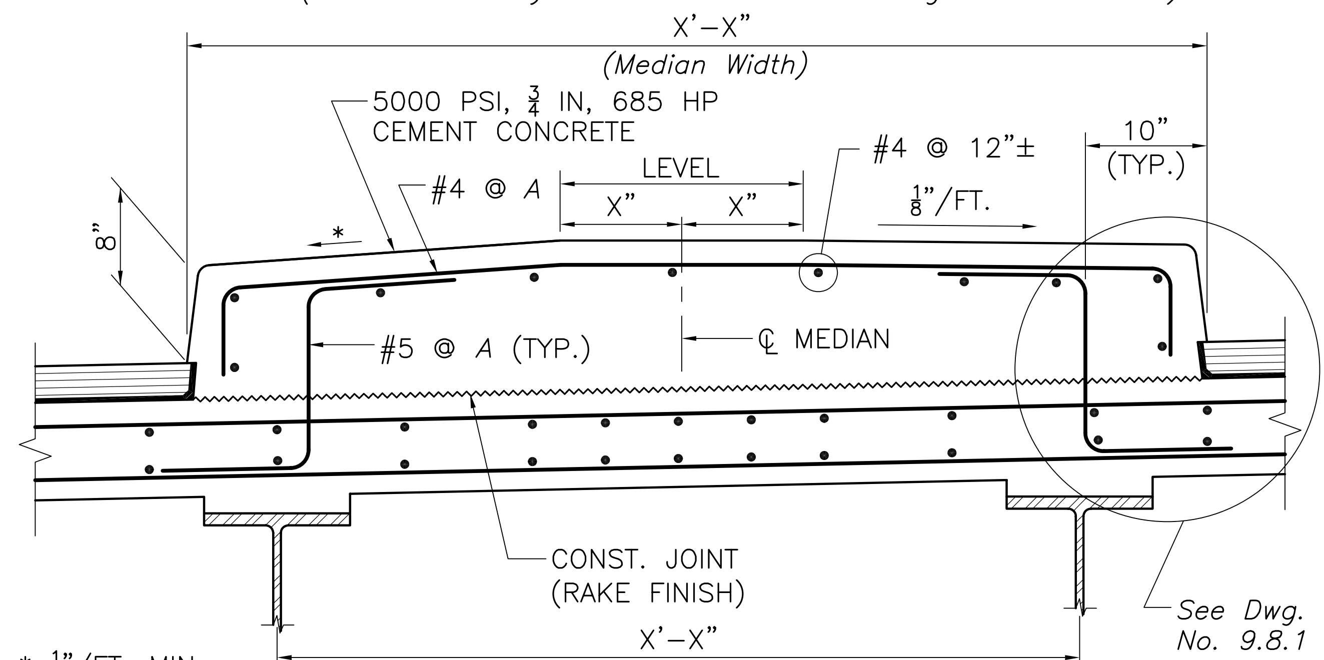
NOTES:

1. *Bearings shall be designed to provide for transverse movement.*
2. *Dimension X" is equal to the Amount of Thermal Expansion + 1").*

* 1/8"/FT. MIN., SLOPE TO SUIT

WITH LONGITUDINAL JOINT

(To be used only where total width of bridge exceeds 72'±)



* 1/8"/FT. MIN., SLOPE TO SUIT

WITHOUT LONGITUDINAL JOINT

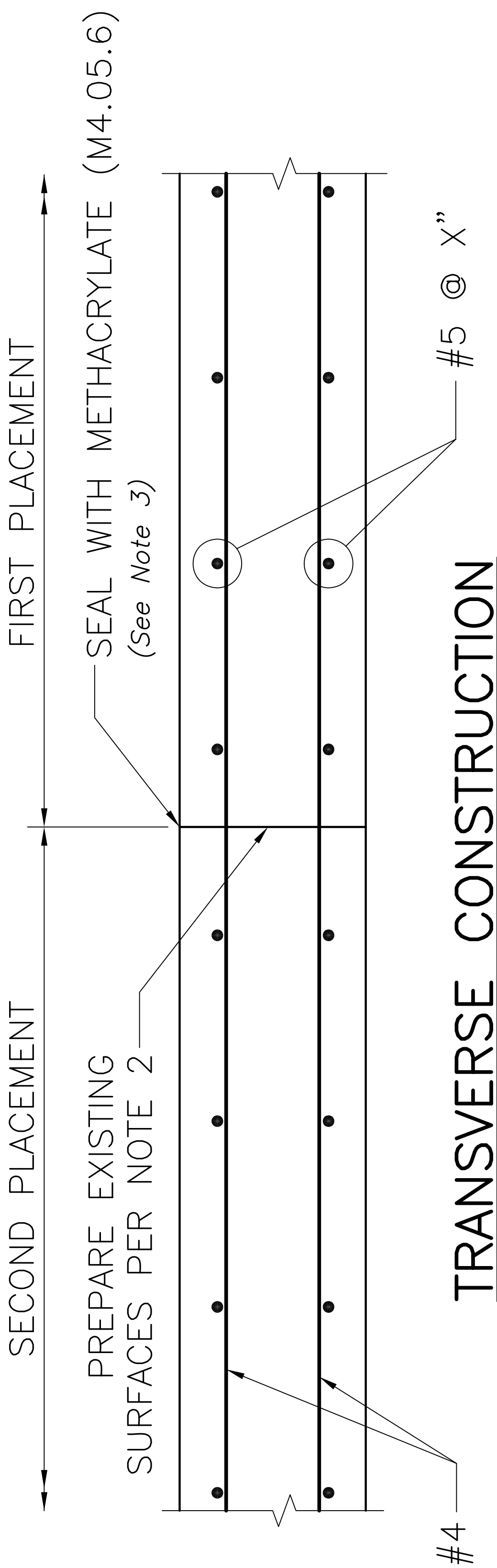
MEDIAN DETAILS

SCALE: 1" = 1'–0"

NOTES:

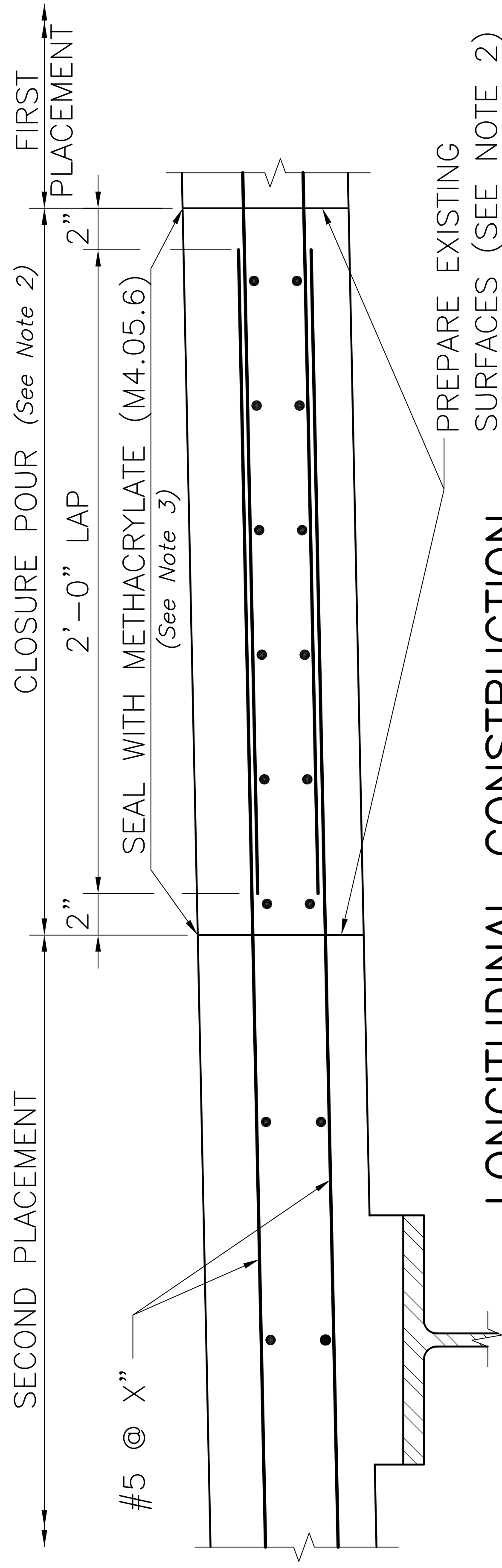
1. *A = same spacing as deck slab reinforcement.*
2. *If a median rail or barrier is required, consult Bridge Engineer for appropriate Crash Tested System. Omit level surface on bridges without median rail or barrier.*
3. *Details for separated precast beams are similar.*

MASS HIGHWAY BRIDGE MANUAL	MEDIAN DETAILS WITH APPROACH CURB GENERAL DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **7.1.7**



TRANSVERSE CONSTRUCTION JOINT DETAIL IN DECK SLAB

SCALE: $1\frac{1}{2}$" = 1'-0"



LONGITUDINAL CONSTRUCTION JOINT DETAIL IN DECK SLAB

SCALE: $1\frac{1}{2}$" = 1'-0"

For Construction and Designer Notes see Dwg. No. 7.1.9

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION JOINTS GENERAL DECK DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **7.1.8**

NOTES:

1. BRIDGE DECK SLAB SHALL BE PLACED IN ONE CONTINUOUS OPERATION WITH THE APPROVAL OF THE ENGINEER PROVIDED THAT THE INITIAL SET (Fc = 500 PSI) OF ALL CONCRETE DOES NOT OCCUR UNTIL AFTER THE COMPLETION OF THE PLACEMENT. AN APPROVED RETARDER SHALL BE USED, WHEN NECESSARY, TO RETAIN THE WORKABILITY OF THE CONCRETE.
   (Include this note on single span integral abutment bridges)
1. BRIDGE DECK SLAB SHALL BE PLACED IN ACCORDANCE WITH THE PLACEMENT SEQUENCE SHOWN ON THE PLANS. THE CONTRACTOR MAY PLACE THE ENTIRE DECK IN ONE CONTINUOUS OPERATION WITHOUT CONSTRUCTION JOINTS WITH THE APPROVAL OF THE ENGINEER PROVIDED THAT THE INITIAL SET (Fc = 500 PSI) OF ALL CONCRETE DOES NOT OCCUR UNTIL AFTER THE COMPLETION OF THE PLACEMENT. AN APPROVED RETARDER SHALL BE USED, WHEN NECESSARY, TO RETAIN THE WORKABILITY OF THE CONCRETE. IF MULTIPLE PLACEMENTS ARE MADE, POSITIVE MOMENT REGIONS SHALL BE PLACED PRIOR TO NEGATIVE MOMENT REGIONS AND A MINIMUM OF 72 HOURS SHALL PASS BETWEEN PLACEMENTS.
   (Include this note on continuous span bridges)
2. THE SURFACE OF THE PREVIOUSLY CAST CONCRETE SHALL BE BLAST CLEANED, ROUGHENED, WETTED WITH CLEAN WATER, AND THEN FLUSHED WITH A MORTAR COMPOSED OF EQUAL PARTS OF THE CEMENT AND SAND SPECIFIED FOR THE NEW CONCRETE, BEFORE NEW CONCRETE IS PLACED ADJACENT THERETO. NEW CONCRETE SHALL BE PLACED BEFORE MORTAR HAS TAKEN INITIAL SET.

3. IN LIEU OF THE MORTAR, AN EPOXY ADHESIVE SUITABLE FOR BONDING FRESH CONCRETE TO HARDENED CONCRETE FOR LOAD BEARING APPLICATIONS MAY BE USED. THE EPOXY ADHESIVE SHALL CONFORM TO AASHTO M 235 TYPE V AND SHALL BE APPLIED IN ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATIONS.

4. THE CONTRACTOR MAY SUBMIT A PROPOSAL DETAILING THE ELIMINATION OF THE CLOSURE POUR FOR THE APPROVAL OF THE ENGINEER. THE PROPOSAL SHALL DETAIL THE CONTRACTOR'S MEANS AND METHODS FOR ACCURATELY CONSTRUCTING THE DECK SLAB TO THE LINES, GRADES, AND THICKNESS SHOWN ON THE PLANS WITHOUT LEAKAGE OF CONCRETE.

5. DOWEL BAR SPLICERS SHALL BE USED WHERE USE OF LAP SPLICES IS NOT FEASIBLE.

NOTES:

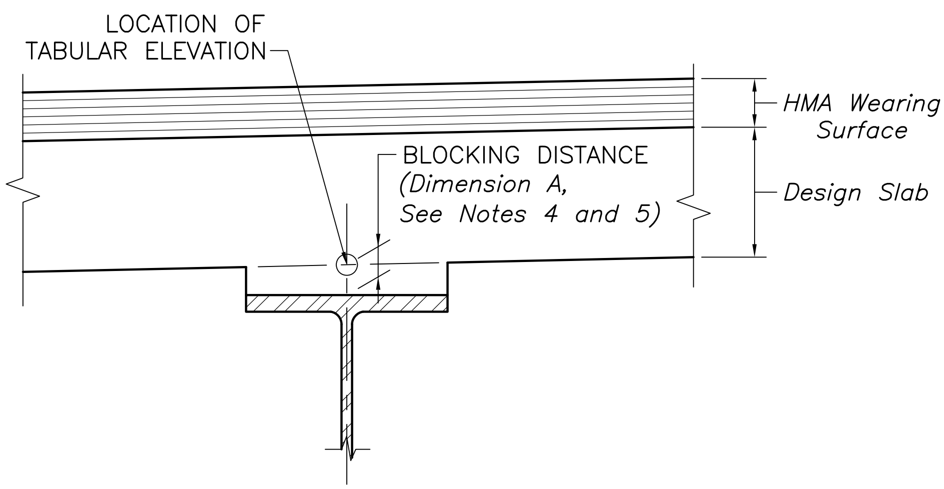
1. *Wherever feasible, the concrete bridge deck shall be continuously placed oner the full length and width of the bridge in order to minimize the potential for cracking and future deterioration. Concrete slabs for single non–integral spans and for each span of multiple simple span bridges shall be placed in one continuous operation without construction joints. In all other cases include the following:*
   - *a) The Construction Notes shown above;*
   - *b) Details of the deck construction joints;*
   - *c) Location of the longitudinal joints, if any;*
   - *d) Location of the transverse construction joints on continuous structures, if any (at the dead load point of contraflexure).*
2. *Closure pours are generally only required for stage construction conditions where large differential deflections are anticipated and/or diaphragm action between deck placement stages is limited.*
3. *Methacrylate seal shall be used for exposed decks, as well as for bridges with HMA wearing surface.*
4. *Exposed deck is shown. Show HMA wearing surface when applicable.*

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION JOINT NOTES	DATE OF ISSUE AUGUST 2007
	GENERAL DECK DETAILS	DRAWING NUMBER **7.1.9**

	TOP OF FORM ELEVATIONS FOR DECK SLAB PRIOR TO PLACEMENT OF CONCRETE								
BEAM NO.	INCREASING STATIONS ⟶								
	℄ BRG.	1/8 PT.	1/4 PT.	3/8 PT.	1/2 PT.	5/8 PT.	3/4 PT.	7/8 PT.	℄ BRG.

NOTE:

AFTER THE BEAMS ARE ERECTED BUT BEFORE THE FORMS ARE BUILT, ELEVATIONS ON TOP OF THE FLANGE OF THE BEAMS ARE TO BE OBTAINED AT THE POINTS INDICATED IN THE TABLE. THE DIFFERENCE BETWEEN THE ELEVATIONS OBTAINED AND THOSE SHOWN IN THE TABLE GIVES THE ACTUAL BLOCKING DISTANCE FROM THE TOP OF BEAM TO THE BOTTOM OF THE SLAB AT CENTER LINE OF BEAM.



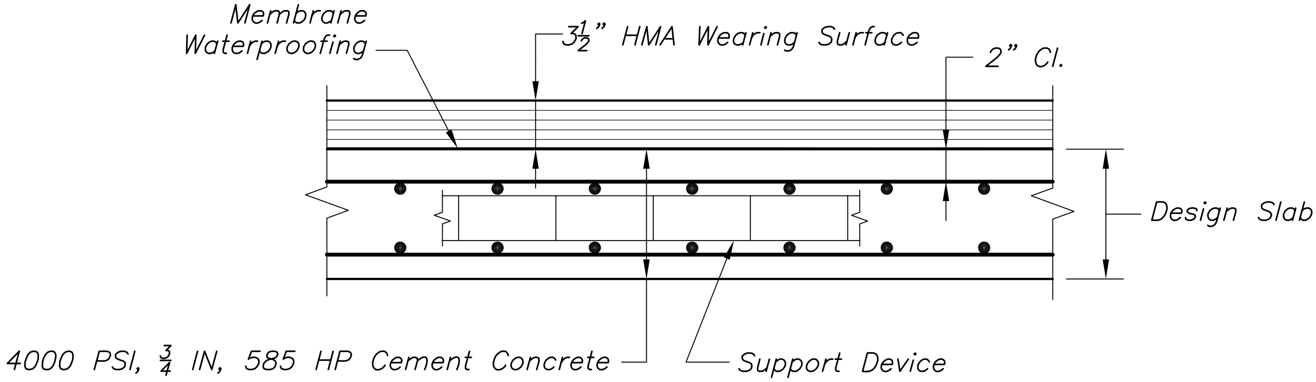
HAUNCH DETAIL

NOTES:

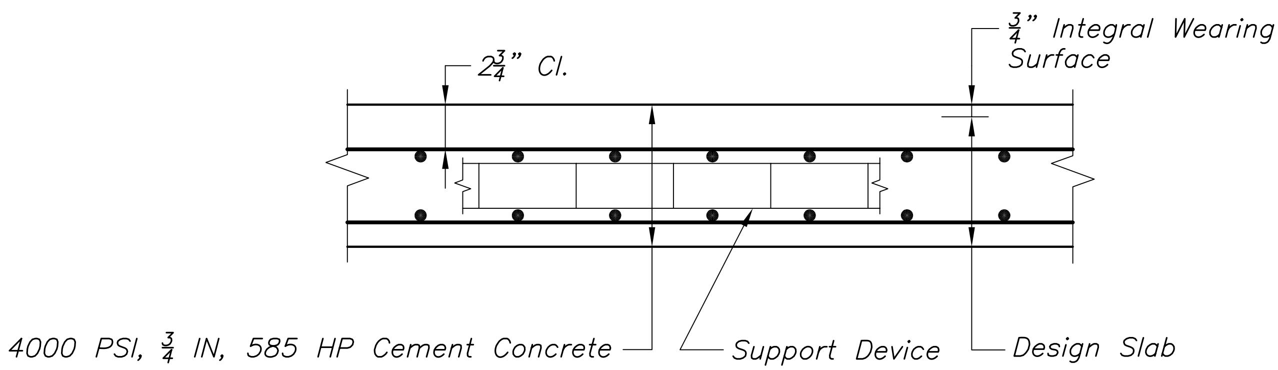
1. *The Top of Form Elevation Table and Haunch Detail shall appear on the construction plans.*
2. *For spans of 50 ft. and less, elevations are to be shown at 1/4 points only.*
3. *The tabular elevations shall be calculated by taking the proposed finished grade at the centerline of beams and:*
   - *A) Subtracting the surfacing and concrete slab thickness and*
   - *B) Adding the theoretical deflection of the beams due to the weight of the slab, surfacing, and all other superimposed dead loads.*
4. *At the point of maximum camber, dimension A shall be 1" for spans up to 50 ft. and 1½" for spans over 50 ft. Use dimension A for the computation of bridge seat elevations, but do not show on the construction drawings. Dimension A shall be considered as 0" when calculating the physical properties of composite beams, however, the weight of haunch shall be included in the design calculations.*
5. *For plate girders with different top flange plate thicknesses or rolled beams with top flange cover plate, Dimension A shall be measured form the top of the thickest plate or top of cover plate.*

TOP OF FORM DETAILS

NOT TO SCALE



HOT MIX ASPHALT (HMA) WEARING SURFACE



EXPOSED DECK

NOTES:

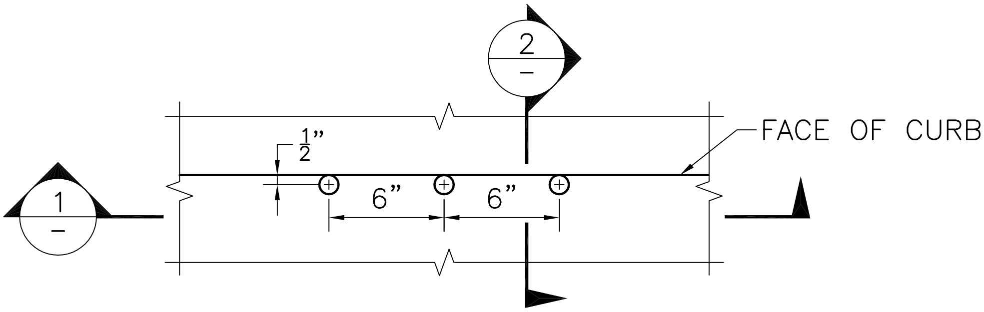
1. HMA wearing surface shall be placed on bridges only when the profile slope is less than or equal to 4%.
2. When the profile slope is greater than 4% or when special conditions may warrant the Designer shall select a wearing surface and protective system other than HMA. The Bridge Engineer shall be consulted in this selection.

THIS DRAWING HAS BEEN DELETED

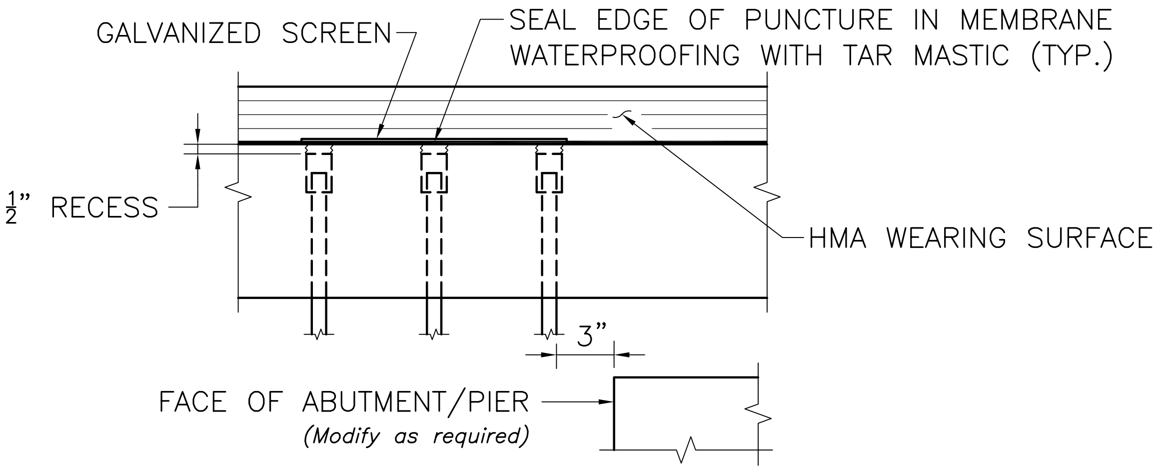
MASS HIGHWAY BRIDGE MANUAL	DETAILS STAY-IN-PLACE FORMS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **7.2.1**

THIS DRAWING HAS BEEN DELETED

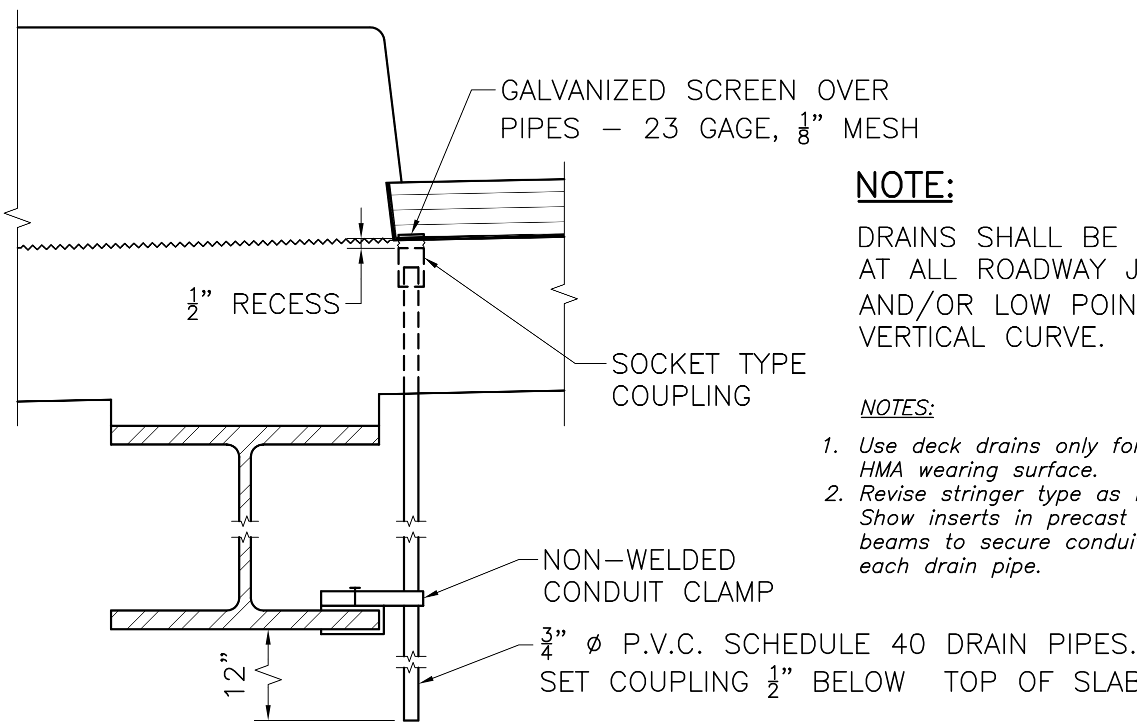
MASS HIGHWAY BRIDGE MANUAL	S.I.P. FORM NOTES	DATE OF ISSUE NOVEMBER 2010
	STAY-IN-PLACE FORMS	DRAWING NUMBER **7.2.2**



DECK PLAN



SECTION 1



NOTE:

DRAINS SHALL BE LOCATED AT ALL ROADWAY JOINTS AND/OR LOW POINT OF VERTICAL CURVE.

NOTES:

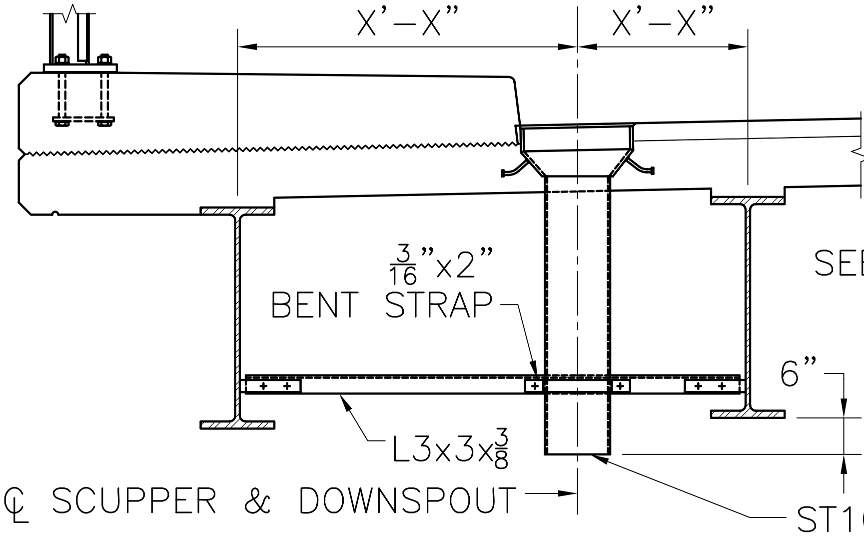
1. *Use deck drains only for bridges with HMA wearing surface.*
2. *Revise stringer type as required. Show inserts in precast concrete beams to secure conduit clamp at each drain pipe.*

SECTION 2

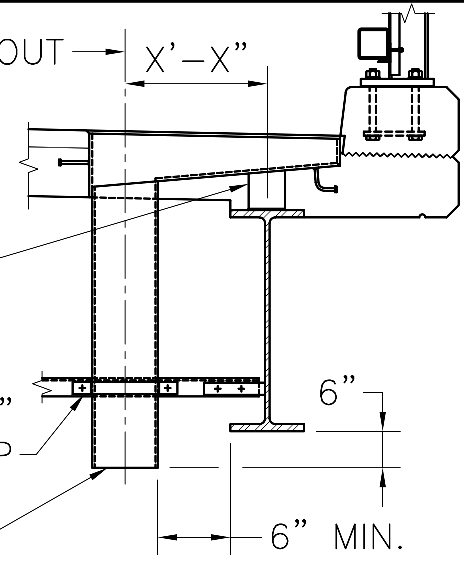
DECK DRAIN PIPES

SCALE: 1½" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	DECK DRAIN PIPES	DATE OF ISSUE MAY 2005
	DRAINAGE DETAILS	DRAWING NUMBER **7.3.1**



SECTION AT SIDEWALK



SECTION AT SAFETY CURB

NOTES:

1. ALL STEEL PLATES SHALL BE AASHTO M 270 GRADE 36 AND SQUARE TUBE SHALL BE ASTM A 500 GRADE A OR B.

2. ALL WELDS SHALL BE CONTINUOUS. ALL JOINTS SHALL BE WELDED USING TWO-SIDED $\frac{1}{4}$" FILLET WELDS OR $\frac{1}{4}$" PJP WELDS WITH A BACKING SEAL WELD, AS APPLICABLE.

3. ALL STEEL TO BE HOT-DIP GALVANIZED. 10" SQUARE TUBE TO BE GALVANIZED AND PAINTED TO MATCH COLOR OF THE STEEL GIRDERS. *(Omit paint for non-steel bridges)*

4. TEMPORARY SUPPORT IS REQUIRED. SUPPORT DESIGN SHALL BE SUBMITTED TO THE ENGINEER FOR APPROVAL.

SCUPPER SECTIONS

SCALE: $\frac{3}{8}$" = 1'–0"

NOTES:

1. *Scupper sections are conceptual and shall be modified to suit structure requirements.*
2. *Where beam geometry prevents use of scupper detailed on Dwg. No. 7.3.3, the scupper shall be redesigned and detailed consistent with section at safety curb depiction.*
3. *If grating span or spacing is altered, it shall be designed for HS25 Live Load and shall be bicycle friendly.*

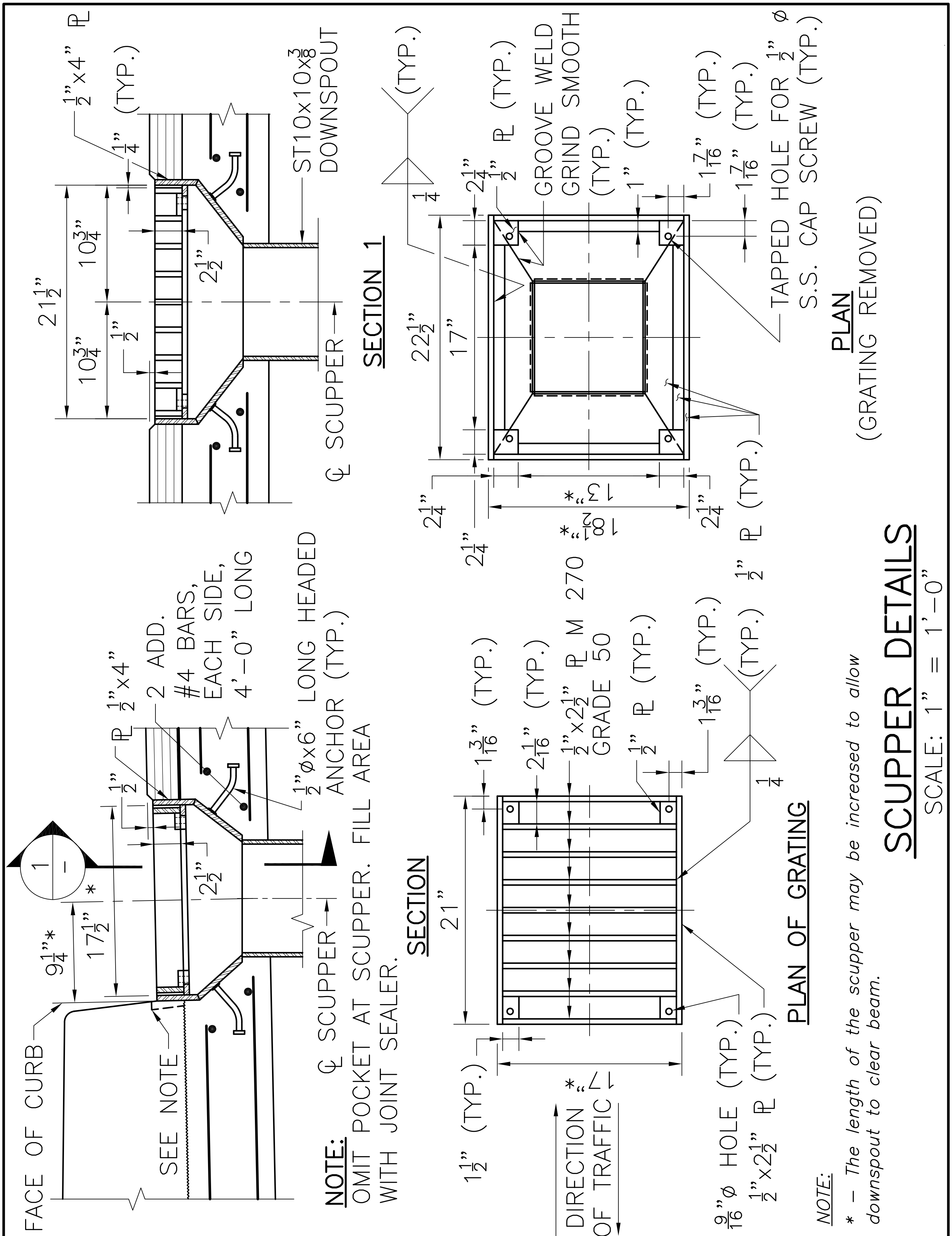
MASS HIGHWAY BRIDGE MANUAL

SCUPPER SECTIONS

DRAINAGE DETAILS

DATE OF ISSUE NOVEMBER 2010

DRAWING NUMBER **7.3.2**



MASS HIGHWAY

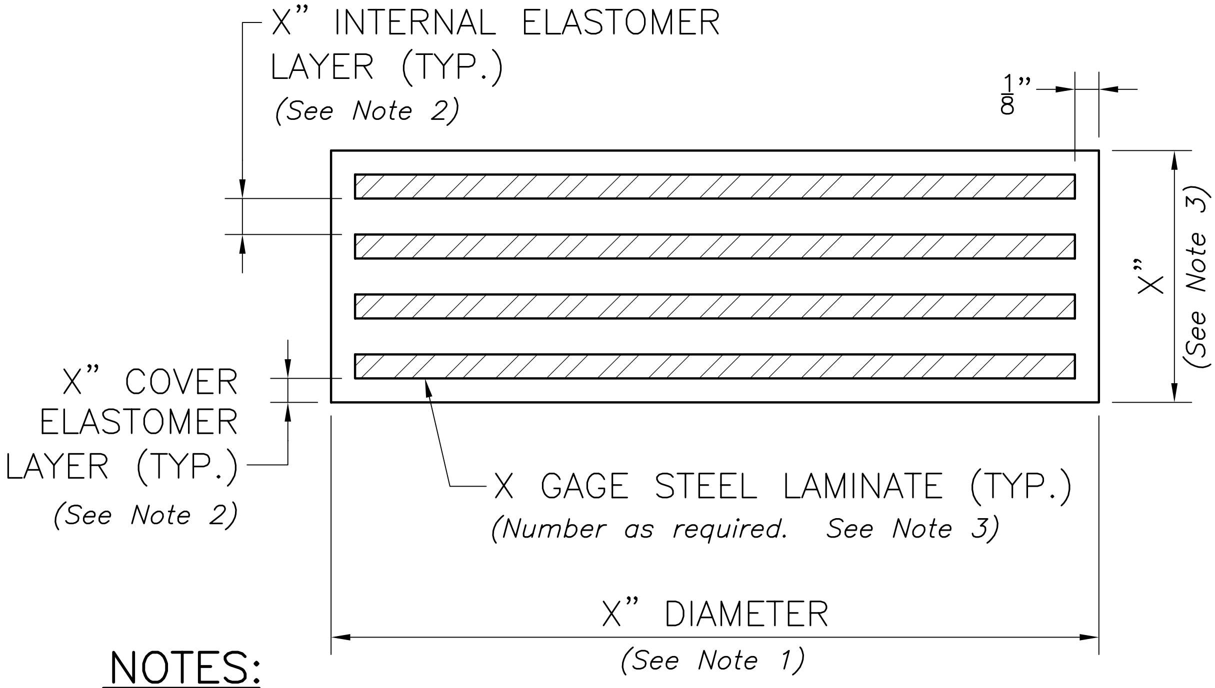
BRIDGE MANUAL

SCUPPER DETAILS

DRAINAGE DETAILS

DATE OF ISSUE
NOVEMBER 2010

DRAWING NUMBER
7.3.3



NOTES:

1. ELASTOMER SHALL HAVE A HARDNESS OF XX DUROMETER.
2. STEEL LAMINATES SHALL CONFORM TO ASTM A 1011 GRADE 36.
3. THE COMPRESSIVE DESIGN LOAD ON THE BEARING PAD IS XXX KIPS. THE COMPRESSIVE DESIGN STRESS IS THE RESULT OF DIVIDING THE COMPRESSIVE DESIGN LOAD BY THE AREA OF THE PAD AND IS EQUAL TO XXX KSI.
4. ELASTOMERIC BEARING PAD SHALL NOT BE VULCANIZED TO THE SOLE PLATE.

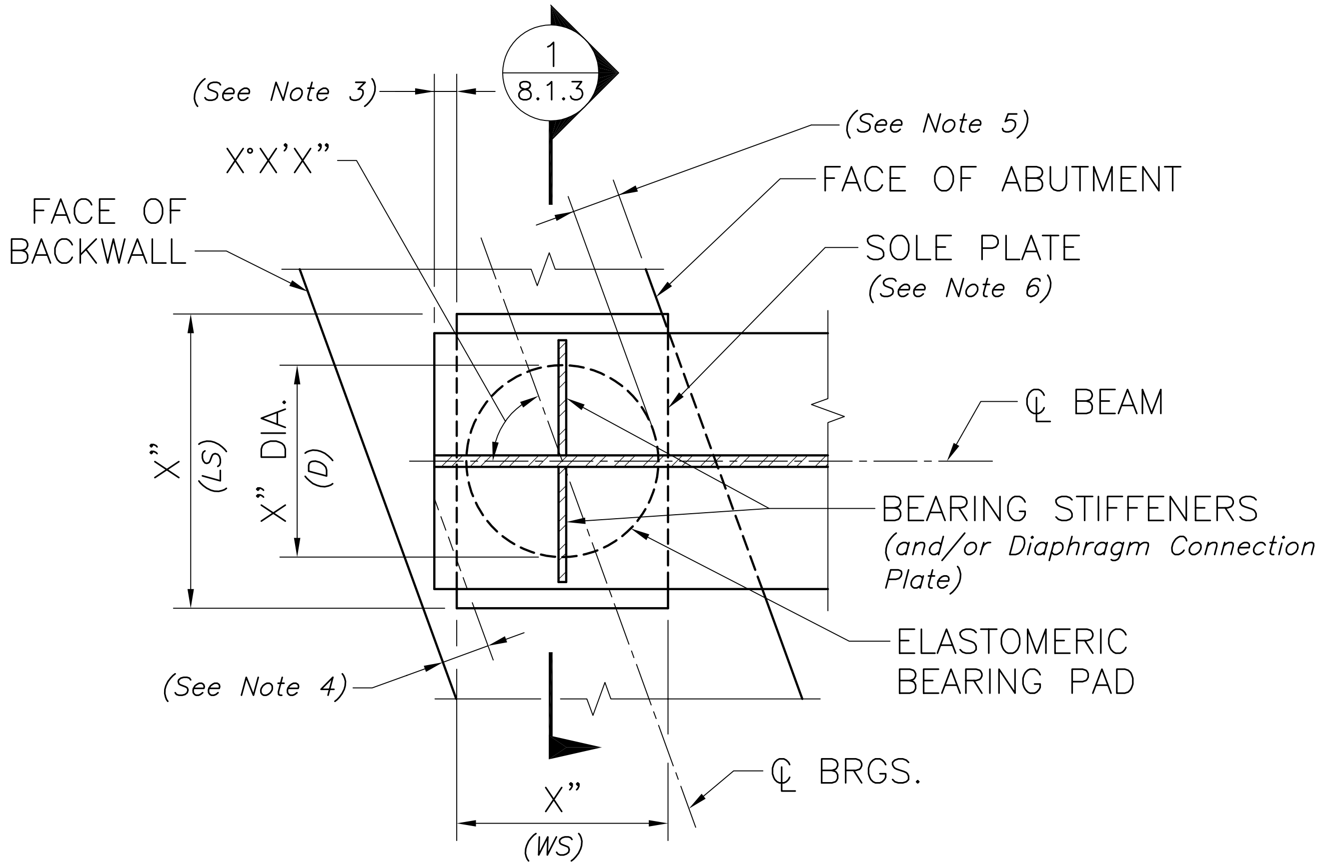
ELASTOMERIC BEARING PAD

NOT TO SCALE

NOTES:

1. *Bearing diameter shall be set to even increments of 1", for example: 6", 7", etc.*
2. *A minimum thickness of a single elastomer layer shall be $\frac{1}{4}$". Top and bottom cover layers shall be no thicker than 70% of the individual internal layer.*
3. *Steel laminates shall have a minimum thickness of 11 gage ($\frac{1}{8}$"). Thickness of steel laminates in inches shall be used to calculate total bearing thickness.*
4. *All elastomeric bearing pads for steel beams for a given structure shall have a constant thickness and shall be set level.*
5. *All elastomeric bearing pads on any substructure unit shall have the same nominal compressive stiffness.*
6. *See Chapters 3 and 5 of Part II of the Bridge Manual for additional guidelines on locating elastomeric bearings.*
7. *See Chapter 3, Part I of the Bridge Manual for additional information and bearing design requirements.*

MASS HIGHWAY BRIDGE MANUAL	ELASTOMERIC BEARING PAD STANDARD DETAIL ELASTOMERIC BEARINGS – STEEL BEAMS	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **8.1.1**



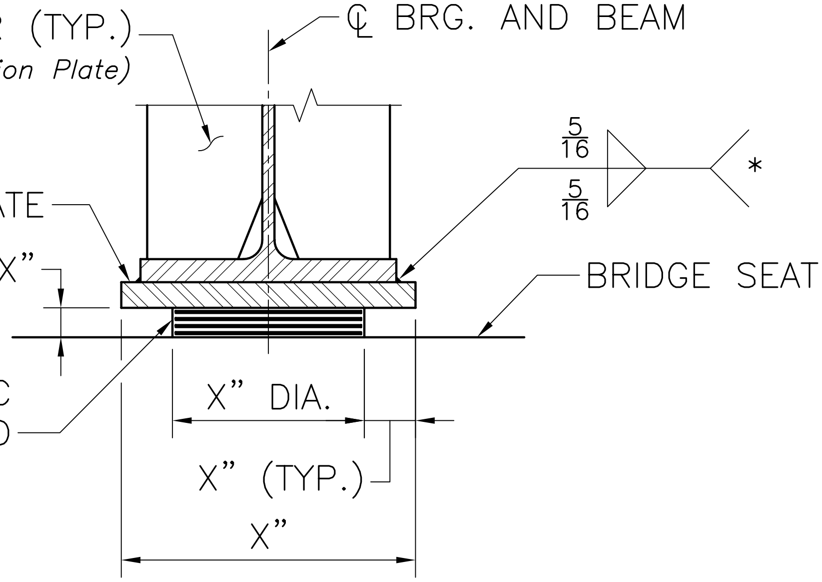
PLAN

SCALE: 1" = 1'–0"

NOTES:

1. This bearing detail shall only be used where keeper blocks, keys and backwalls provide longitudinal and transverse restraint to the superstructure.
2. D = Diameter of Elastomeric Bearing Pad;
   LS = Length of Sole Plate = The greatest of: (D + 2") or (Width of bottom flange + 2");
   WS = Width of Sole Plate = D + 2".
3. The end of the beam and sole plate may be flush, however the sole plate cannot extend beyond the beam end. If required, increase the length of beam so that it stays flush with the sole plate.
4. If necessary, cope sole plate and beam bottom flange to maintain a minimum of 3" clearance.
5. Depending on the bearing pad size, the width of the bridge seat may need to be increased to maintain a minimum of 3" clearance.
6. Sole plate should be tapered if slope of beam bottom flange due to roadway grade and camber exceeds 1%. Provide detail of tapered sole plate as shown on Dwg. No. 8.1.6.
7. Minimum thickness of sole plate after beveling shall be $1\frac{1}{2}$" if weld made in field is directly over elastomer. Beveled plates may be as thin as $\frac{3}{4}$" if there is a lateral separation between the weld and elastomer of $1\frac{1}{2}$" thick or greater.

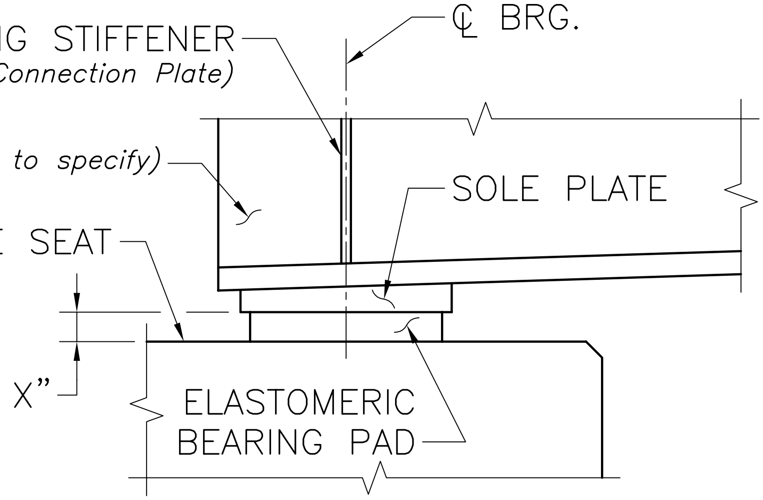
MASS HIGHWAY BRIDGE MANUAL	ELASTOMERIC BEARING PAD ASSEMBLY PLAN ELASTOMERIC BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.1.2**



(*) – WELDS SHALL TERMINATE ¼" FROM EDGE OF PLATE.

SECTION 1

SCALE: 1" = 1'–0"

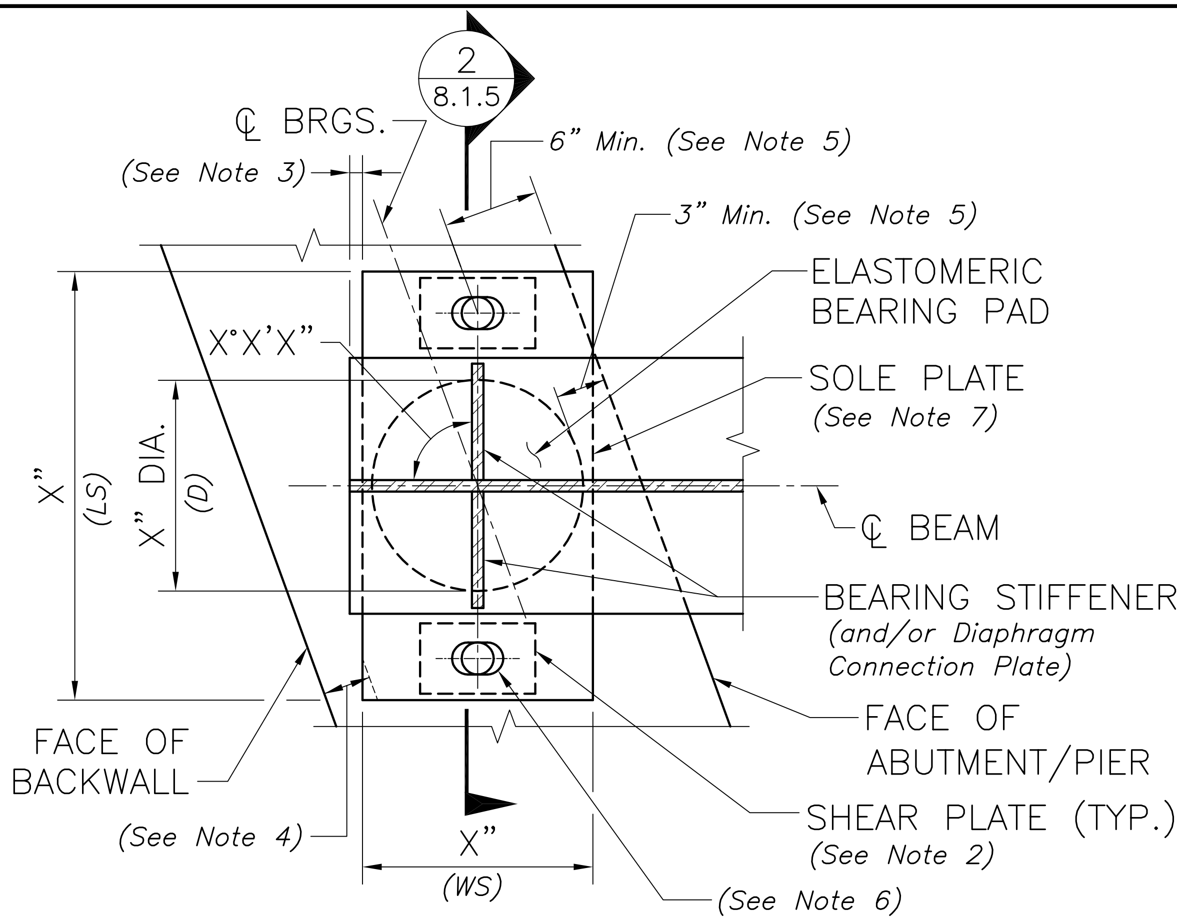


ELEVATION

SCALE: 1" = 1'–0"

For Designer Notes see Dwg. No. 8.1.2
For Construction Notes see Dwg. No. 8.1.6

MASS HIGHWAY BRIDGE MANUAL	STANDARD BEARING ASSEMBLY AND ELEVATION ELASTOMERIC BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.1.3**



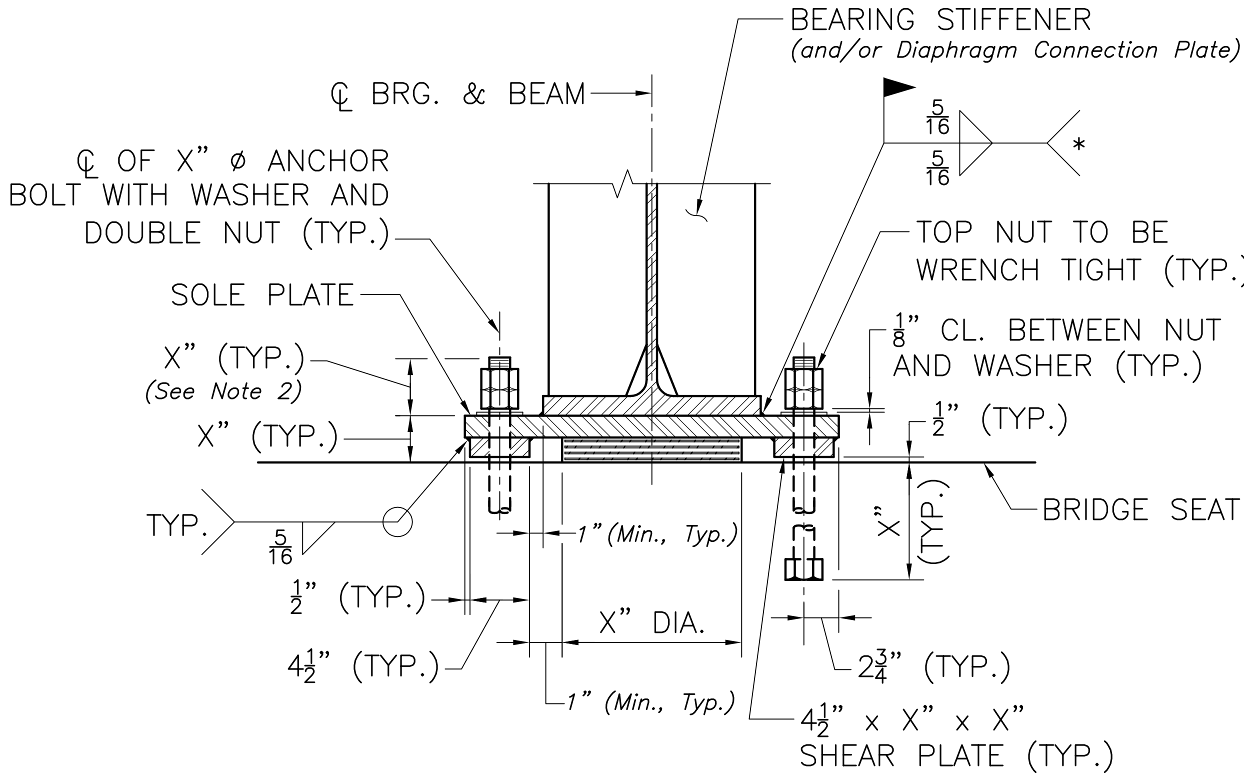
PLAN

SCALE: 1" = 1'–0"

NOTES:

1. *This bearing shall be used where there are no keeper blocks, keys and backwalls to provide longitudinal and/or transverse restraint to the superstructure and the bearing assembly must provide this restraint itself.*
2. *D = Diameter of Elastomeric Bearing Pad; WS = D+2";*
   For anchor bolts not exceeding $1\frac{1}{2}$" ø, LS = (D or width of bottom flange, whichever is greater)+12";
   For anchor bolts greater than $1\frac{1}{2}$" ø, LS shall be determined by Designer.
   Length of shear plate = (length of slot) + 3", or for oversized holes = WS/2.
3. *The end of the beam and sole plate may be flush, however the sole plate cannot extend beyond the beam end. If required, increase the length of beam so that it stays flush with sole plate.*
4. *If necessary, cope sole plate and beam bottom flange to maintain a minimum of 3" clearance.*
5. *Depending on the bearing size, the width of the bridge seat may need to be increased to maintain this clearance.*
6. *Use slotted hole where longitudinal expansion is required.*
   Width of slot = (bolt diameter x 1.25), rounded up to nearest $\frac{1}{4}$".
   Length of slot = (calculated total thermal movement range x 1.5) + (width of slot), rounded up to nearest $\frac{1}{4}$".
   Where a fixed bearing is required, substitute an oversized hole for a slot. Diameter of hole = (bolt diameter x 1.25), rounded up to nearest $\frac{1}{4}$".
7. *Sole plate must be tapered if slope of beam bottom flange due to roadway grade and camber exceeds 1%. Provide detail of tapered sole plate as shown on Dwg. No. 8.1.6.*

MASS HIGHWAY BRIDGE MANUAL	BEARING WITH ANCHOR BOLTS PLAN ELASTOMERIC BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.1.4**



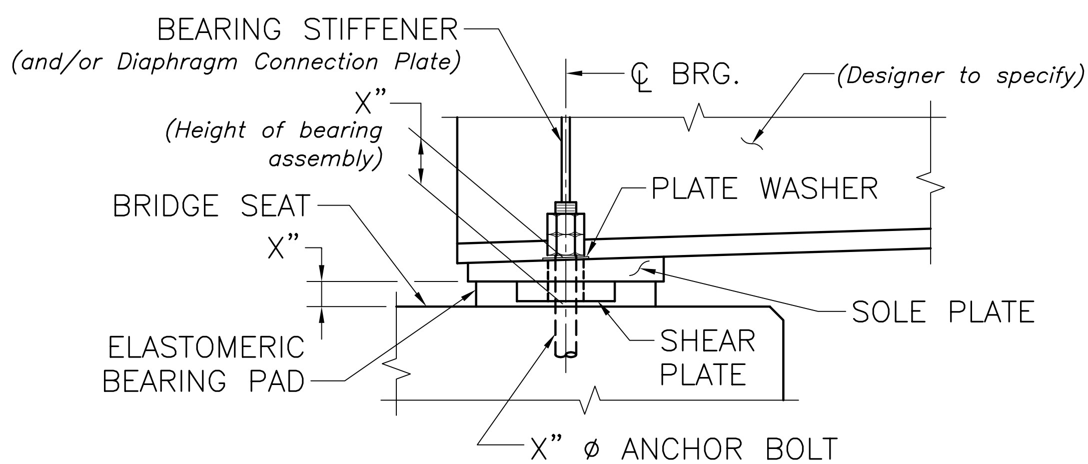
(*) – WELDS SHALL TERMINATE $\frac{1}{4}$" FROM EDGE OF PLATE, MASKING AND TOUCH–UP PER STANDARD SPECIFICATIONS.

NOTES:

1. *Typical dimensions shown are for anchor bolts no larger than $1\frac{1}{2}$" ø. For bolts of larger diameters these dimensions shall be adjusted accordingly.*
2. *Designer shall calculate this dimension to insure a minimum thread runout of $\frac{1}{2}$". Round up dimension to nearest $\frac{1}{2}$".*

SECTION 2

SCALE: 1" = 1'–0"

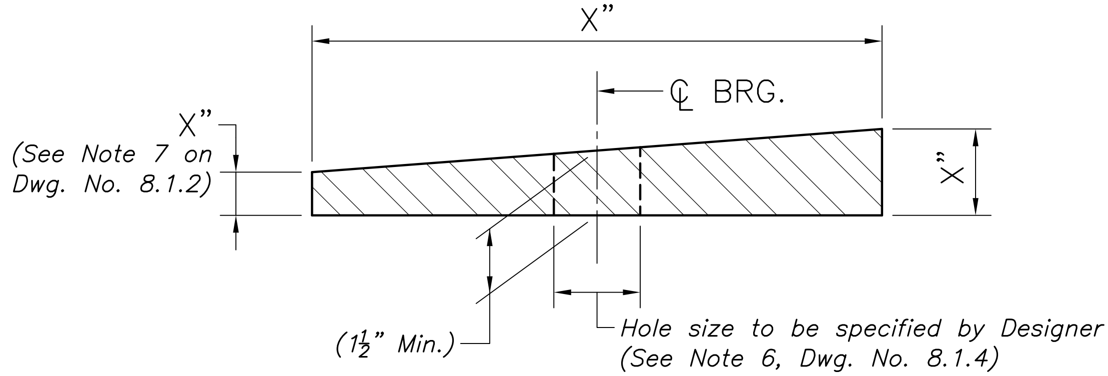


ELEVATION

SCALE: 1" = 1'–0"

For additional Designer Notes see Dwg. No. 8.1.4

MASS HIGHWAY BRIDGE MANUAL	BEARING WITH ANCHOR BOLTS SECTION AND ELEVATION ELASTOMERIC BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.1.5**



SOLE PLATE DETAIL

SCALE: 3" = 1'-0"

BEARING NOTES: *(for use with details on Dwg. No.'s 8.1.2 and 8.1.3)*

1. STEEL SOLE PLATE SHALL CONFORM TO AASHTO M 270 GRADE 36 AND SHALL BE HOT-DIP GALVANIZED.

2. CENTER THE ELASTOMERIC PAD UNDER THE SOLE PLATE DURING BEAM ERECTION.

3. BEAMS SHALL BE ERECTED WHEN THE AMBIENT TEMPERATURE IS BETWEEN 50 °F AND 77 °F. IF BEAMS ARE ERECTED AT OTHER AMBIENT TEMPERATURES, THEY WILL HAVE TO BE JACKED AND THE ELASTOMERIC BEARINGS RECENTERED WHEN THE TEMPERATURE RETURNS TO THAT RANGE.

BEARING NOTES: *(for use with details on Dwg. No.'s 8.1.4 and 8.1.5)*

1. STEEL SOLE PLATE AND SHEAR PLATES SHALL CONFORM TO AASHTO M 270 GRADE 36 AND SHALL BE HOT-DIP GALVANIZED.

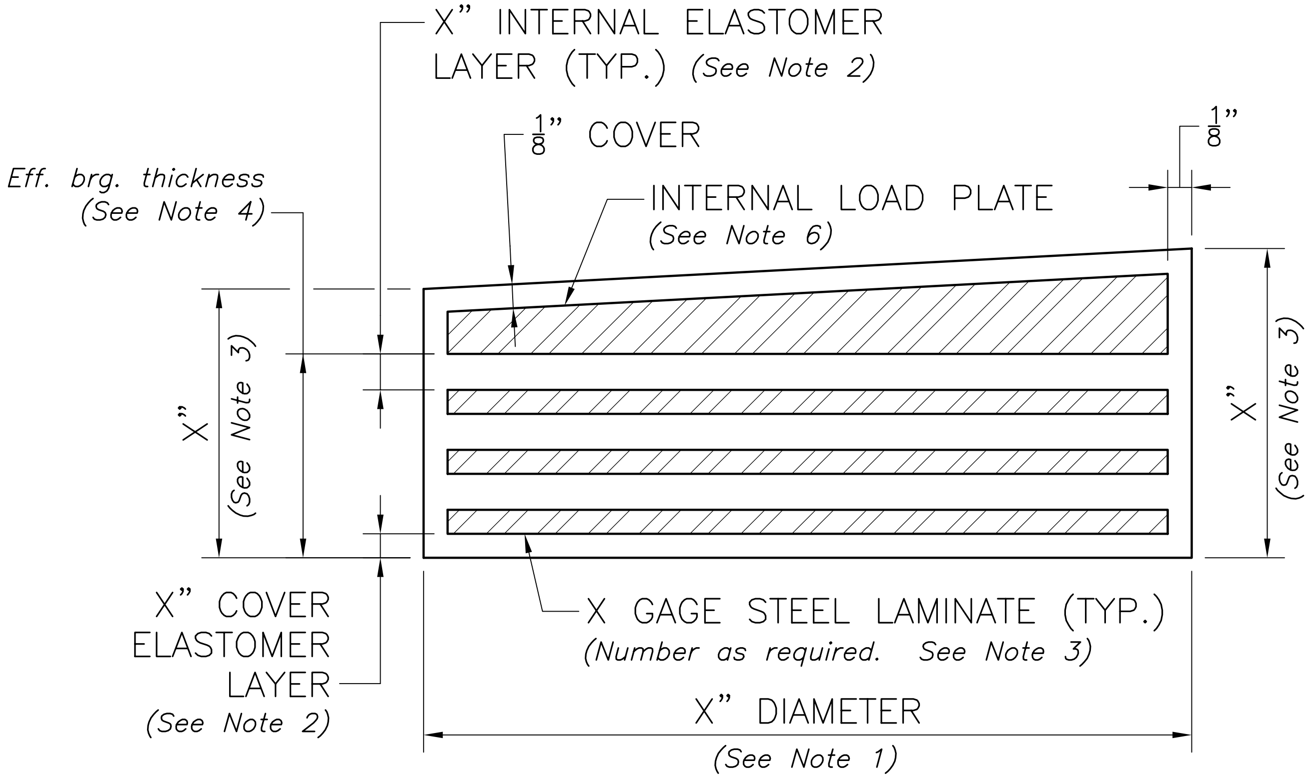
2. PLACE SOLE PLATE ASSEMBLY SO THAT IT IS CENTERED AROUND ANCHOR BOLTS. CENTER THE ELASTOMERIC PAD UNDER THE SOLE PLATE.

3. BEAMS SHALL BE ERECTED WHEN THE AMBIENT TEMPERATURE IS BETWEEN 50 °F AND 77 °F. IF BEAMS ARE ERECTED AT OTHER AMBIENT TEMPERATURES, THEY WILL HAVE TO BE JACKED AND THE SOLE PLATE ASSEMBLY AND ELASTOMERIC BEARINGS RECENTERED WHEN THE TEMPERATURE RETURNS TO THAT RANGE.

4. AFTER THE SOLE PLATE ASSEMBLY IS IN ITS FINAL POSITION, WELD IT TO THE BEAM BOTTOM FLANGE.

5. TEMPERATURE OF STEEL ADJACENT TO ELASTOMER DURING FIELD WELDING SHALL BE KEPT BELOW 250 °F.

6. ANCHOR BOLTS, NUTS, AND WASHERS SHALL CONFORM TO ASTM F 1554 GRADE 105 AND SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 232.



NOTES:

1. ELASTOMER SHALL HAVE A HARDNESS OF XX DUROMETER.

2. STEEL LAMINATES SHALL CONFORM TO ASTM A 1011 GRADE 36 OR HIGHER.

3. THE COMPRESSIVE DESIGN LOAD ON THE BEARING PAD IS XXX KIPS. THE COMPRESSIVE DESIGN STRESS IS THE RESULT OF DIVIDING THE COMPRESSIVE DESIGN LOAD BY THE AREA OF THE PAD AND IS EQUAL TO XXX KSI.

4. TAPERED INTERNAL LOAD PLATE SHALL CONFORM TO AASHTO M 270 GRADE 36.

5. ALL BEARINGS SHALL BE MARKED PRIOR TO SHIPPING. THE MARKS SHALL INCLUDE THE BEARING LOCATION ON THE BRIDGE, AND A $\frac{1}{32}$" DEEP DIRECTION ARROW THAT POINTS UP-STATION. ALL MARKS SHALL BE PERMANENT AND BE VISIBLE AFTER BEARING IS INSTALLED.

ELASTOMERIC BEARING PAD

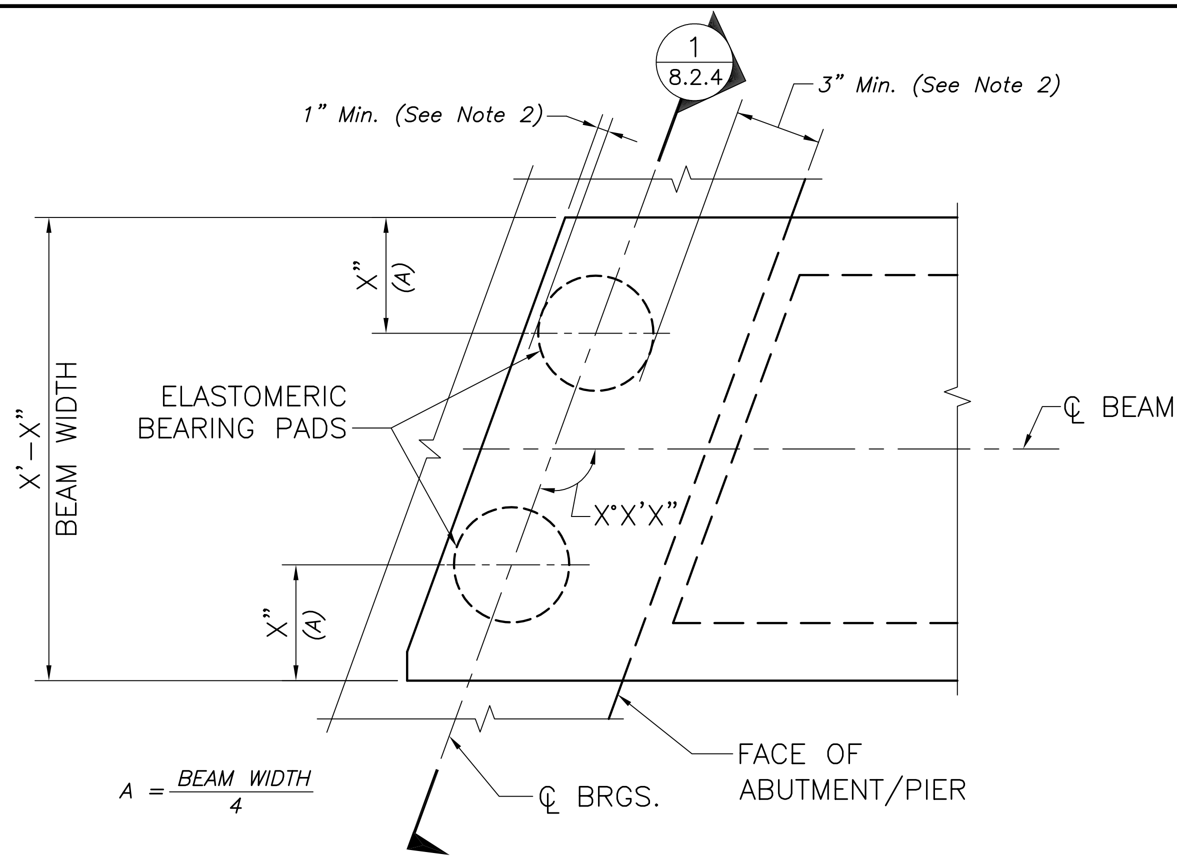
NOT TO SCALE

For Designer Notes see Dwg. No. 8.2.2.

MASS HIGHWAY BRIDGE MANUAL	ELASTOMERIC BEARING PAD STANDARD DETAIL ELASTOMERIC BEARINGS – CONCRETE BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.2.1**

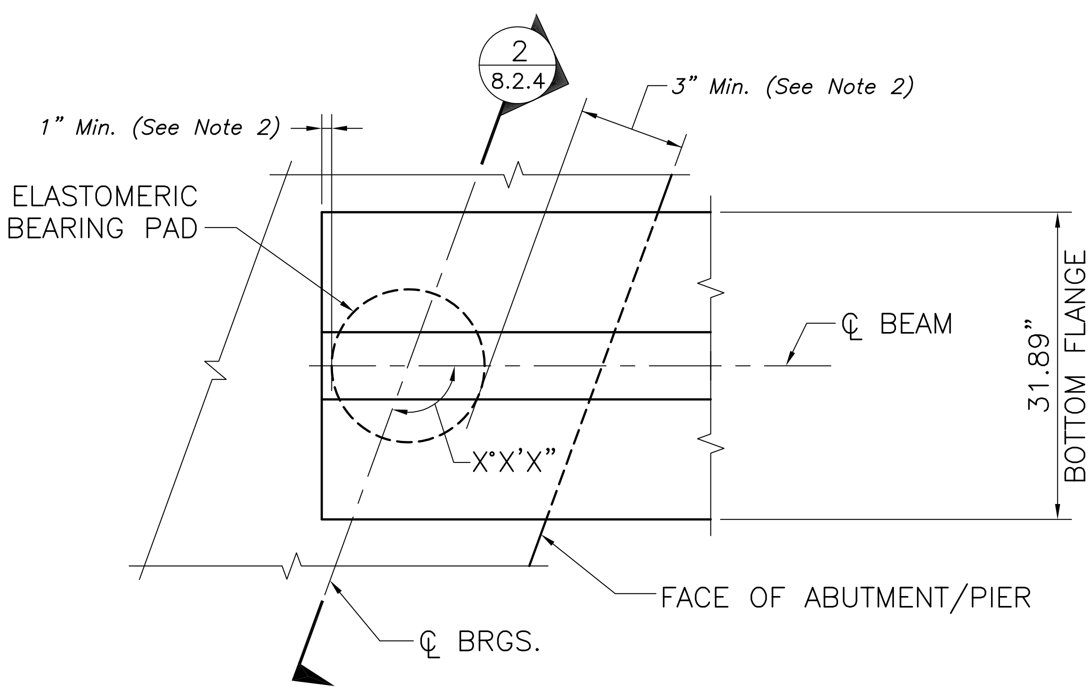
NOTES: (for use with details on Dwg. No. 8.2.1)

1. Bearing diameter shall be set to even increments of 1", for example: 6", 7", etc. For NEBT beams, minimum bearing diameter shall be set at 14" to aid beam stability during erection.
2. A minimum thickness of a single elastomer layer shall be $\frac{1}{4}$". Top and bottom cover layers shall be no thicker than 70% of the individual internal layer.
3. Steel laminates shall have a minimum thickness of 11 gage ($\frac{1}{8}$"). Thickness of steel laminates in inches shall be used to calculate total bearing thickness.
4. Use only the elastomer layers below the tapered load plate for design. See Chapter 3, Part I of the Bridge Manual for bearing design requirements.
5. All bearings on any substructure unit shall have the same nominal compressive stiffness and shall be set level, except for adjacent beam bridges.
6. Provide tapered internal load plate if slope of beam bottom flange due to roadway grade and camber exceeds 1%, and provide detail of tapered internal load plate as shown on Dwg. No. 8.2.5. Otherwise, omit load plate, and delete Notes 4 and 5.



PLAN *(BOX BEAMS)*

SCALE: $\frac{3}{4}$" = 1'–0"



PLAN *(NEBT BEAMS)*

SCALE: $\frac{3}{4}$" = 1'–0"

For Designer Notes see Dwg. No. 8.2.5.

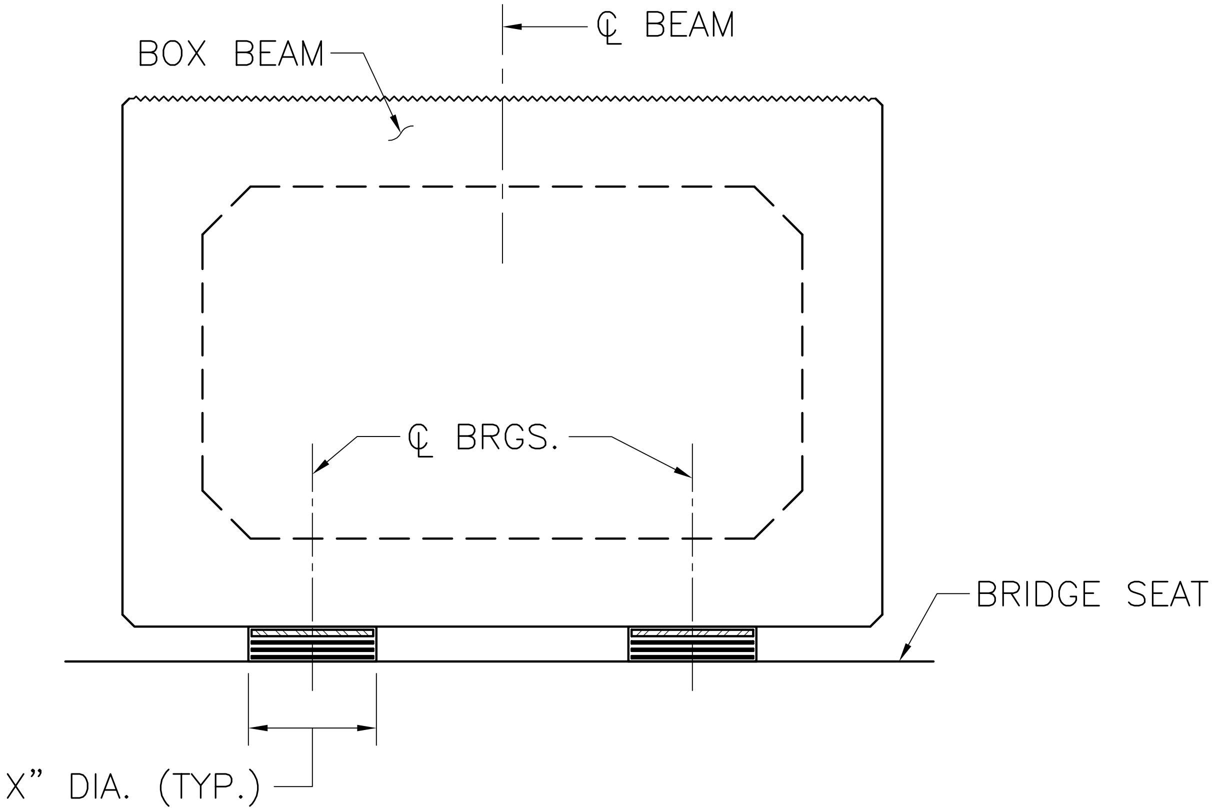
MASS HIGHWAY BRIDGE MANUAL

ELASTOMERIC BEARING PAD TYPICAL PLAN VIEW

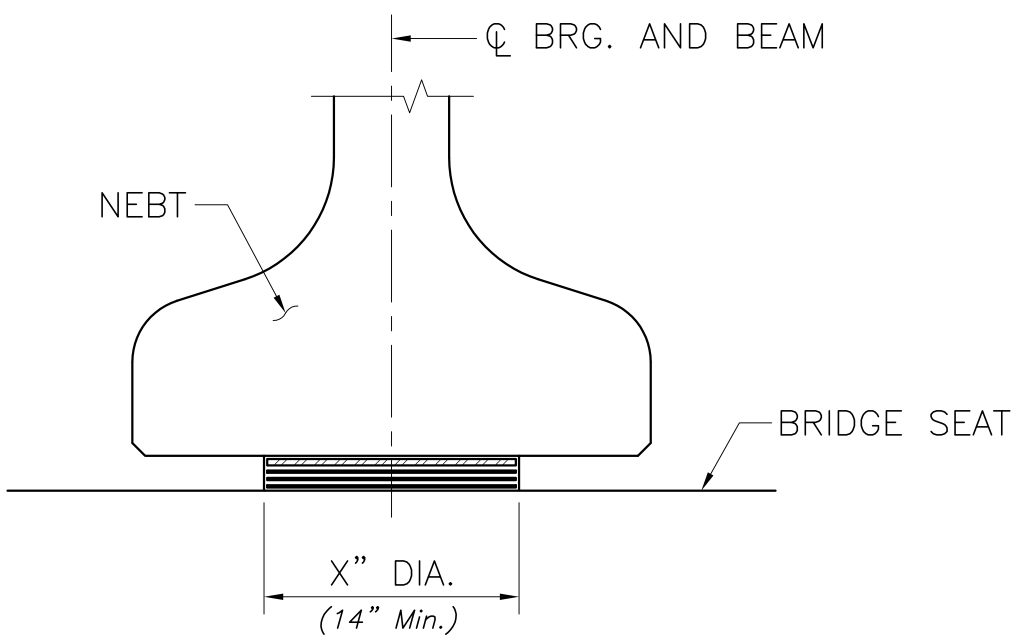
ELASTOMERIC BEARINGS – CONCRETE BEAMS

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **8.2.3**

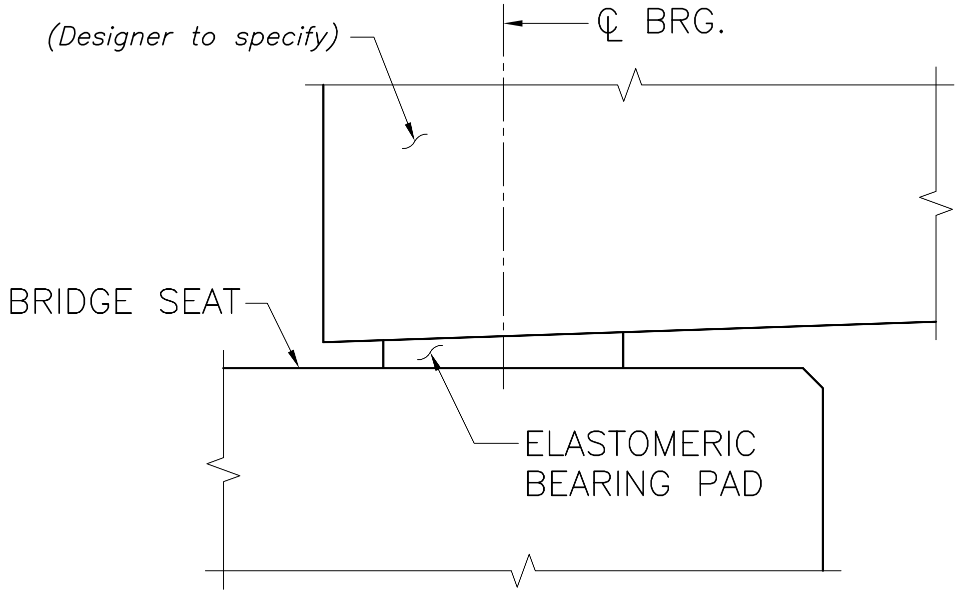


SECTION 1
SCALE: 1" = 1'-0"

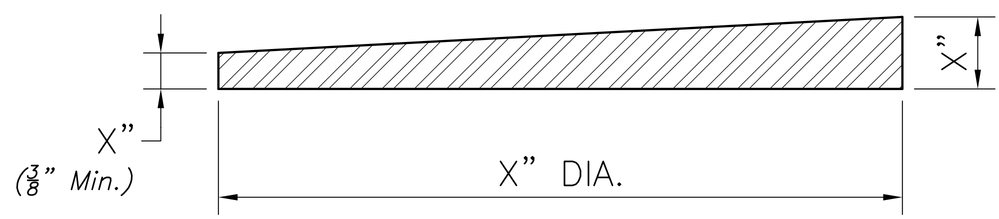


SECTION 2
SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	ELASTOMERIC BEARING PAD TYPICAL SECTION	DATE OF ISSUE MAY 2005
	ELASTOMERIC BEARINGS – CONCRETE BEAMS	DRAWING NUMBER **8.2.4**



ELEVATION
SCALE: 1" = 1'–0"

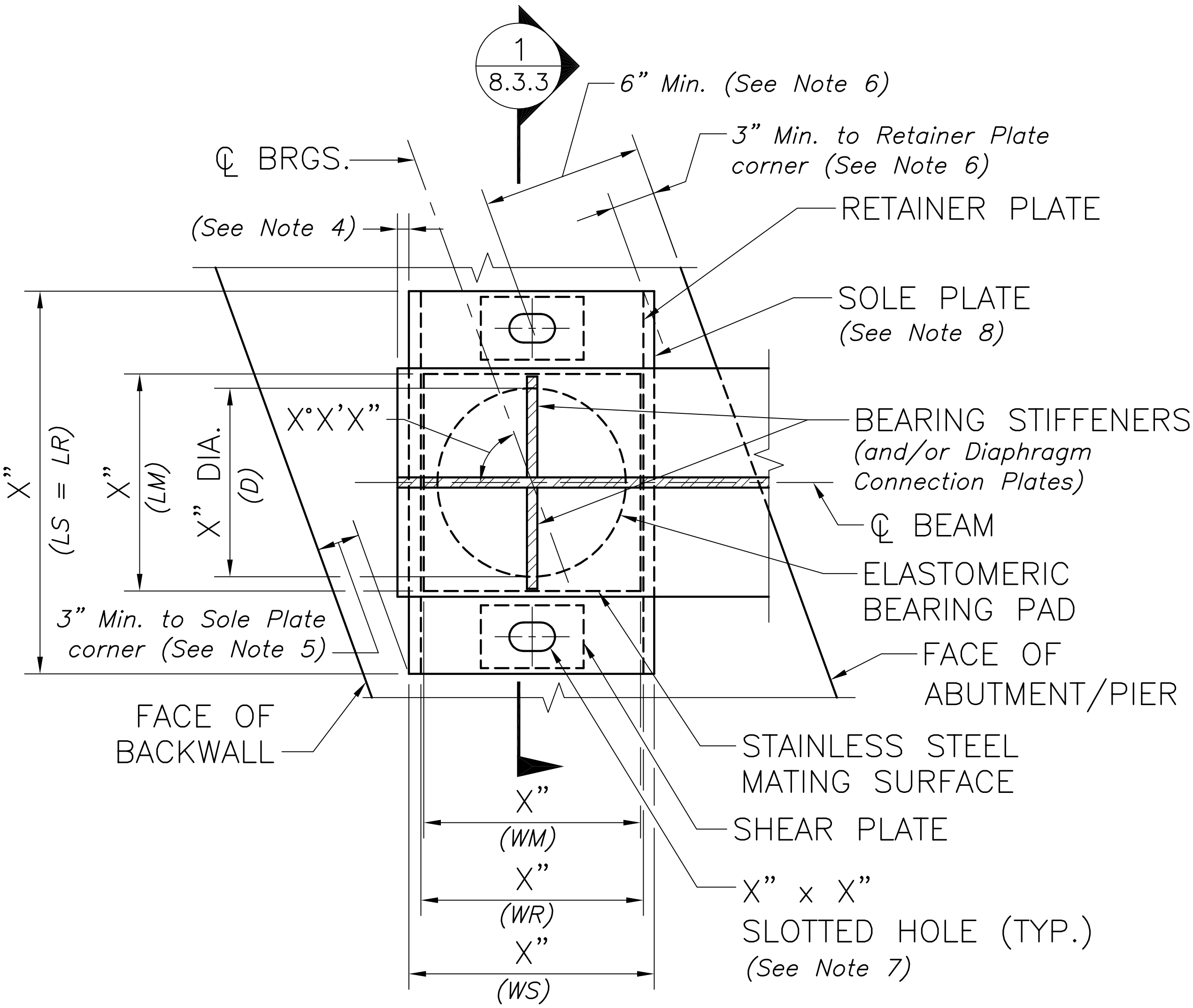


INTERNAL LOAD PLATE DETAIL
SCALE: 3" = 1'–0"

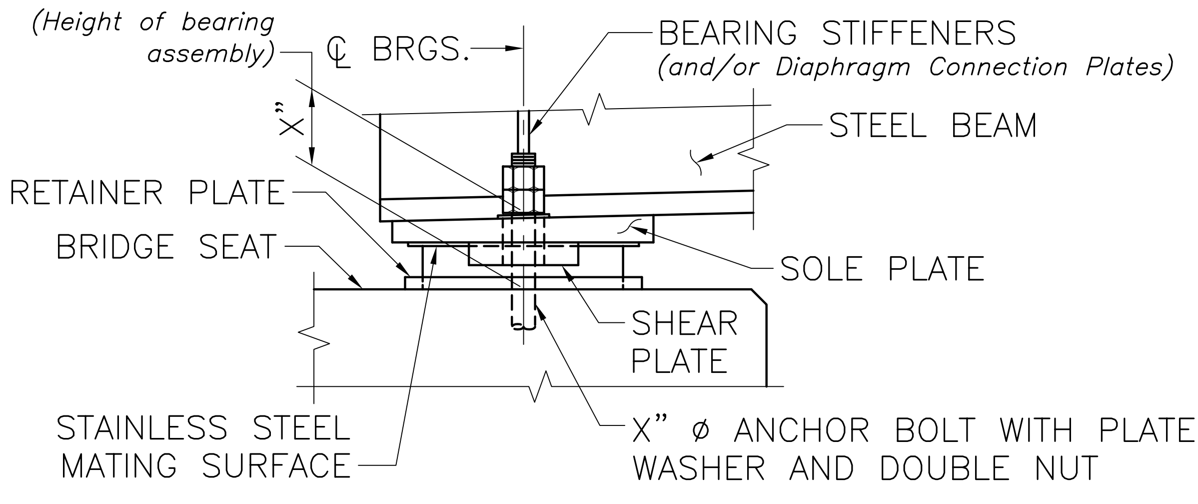
NOTES:

1. *These notes are to be used with plan views on Dwg. No. 8.2.3.*
2. *Depending on the bearing pad size, the width of the bridge seat and the length of the beam may have to be increased to maintain the specified clearances.*
3. *See Chapters 3, 4 and 6 of Part II of the Bridge Manual for additional guidelines on locating elastomeric bearings and calculating bridge seat elevations for adjacent or spread box beams and NEBT's.*

MASS HIGHWAY BRIDGE MANUAL	ELEVATION VIEW, LOAD PLATE DETAIL AND DESIGNER NOTES ELASTOMERIC BEARINGS – CONCRETE BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.2.5**



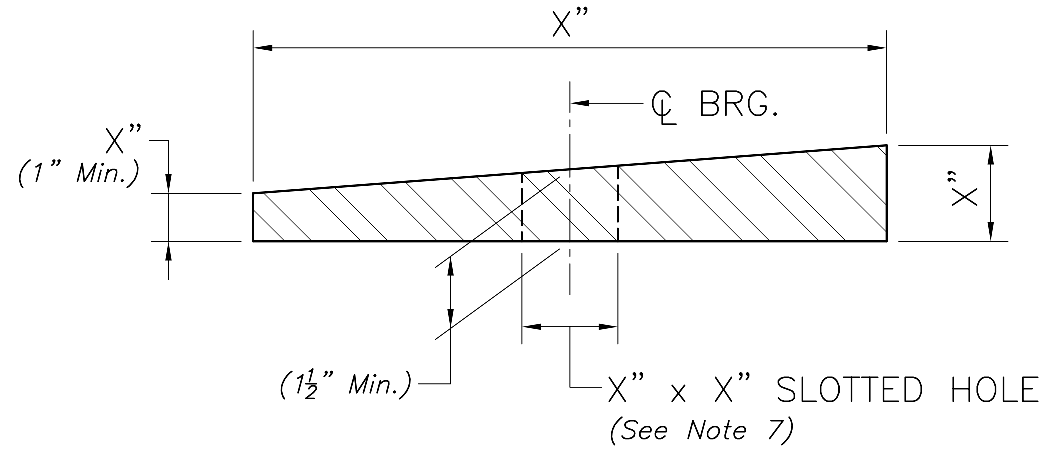
PLAN
SCALE: 1" = 1'-0"



ELEVATION
SCALE: 1" = 1'-0"

For Designer Notes see Dwg. No. 8.3.2.

MASS HIGHWAY BRIDGE MANUAL	STANDARD BEARING ASSEMBLY PLAN AND ELEVATION SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.1**



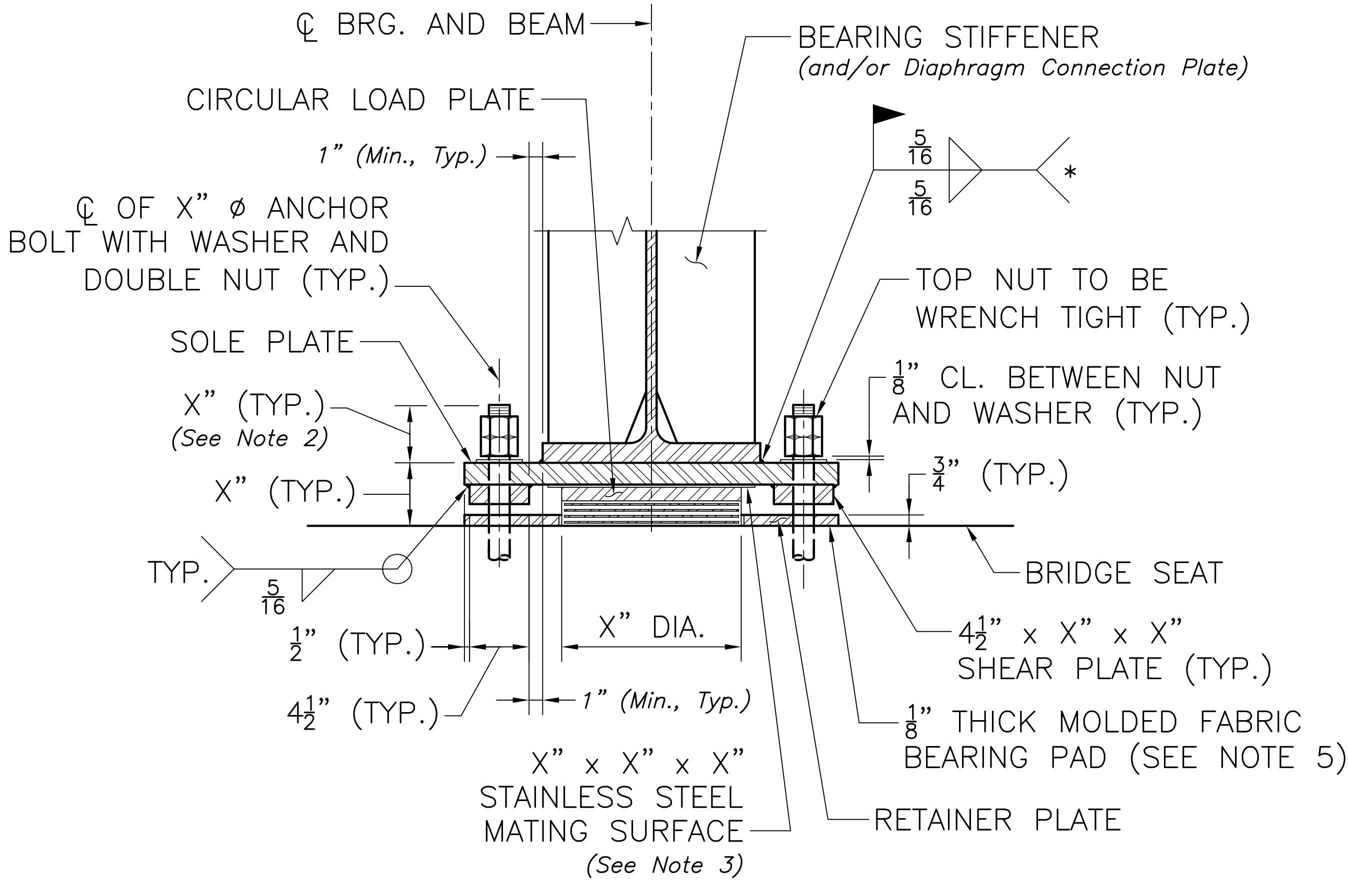
SOLE PLATE DETAIL

SCALE: 3" = 1'–0"

NOTES:

1. These notes are to be used with the details on Dwg. No. 8.3.1.
2. This type of sliding bearing shall be used where it is necessary to minimize the superstructure thermal or seismic forces on the substructure.
3. D = Diameter of Elastomeric Bearing Pad;
   LM = Length of Stainless Steel Mating Surface = D + 2";
   WM = Width of Stainless Steel Mating Surface = D + (calculated total thermal movement range x 1.5), rounded up to nearest ½";
   WS = Width of Sole Plate = WM + 1";
   LS = Length of Sole Plate =
   a) for anchor bolts not exceeding 1½" ø is equal to (LM or width of flange, whichever is greater) + 12";
   b) for anchor bolts greater than 1½" ø it shall be determined by Designer.
4. The end of the beam and sole plate may be flush, however the sole plate cannot extend beyond the beam end. If required, increase the length of beam so that it always stays flush with sole plate.
5. Width of bridge seat may need to be be increased to provide this clearance after the beam reaches its maximum thermal expansion length.
6. Width of bridge seat may need to be increased to maintain these clearances.
7. Size of slotted hole:
   Width = (bolt diameter) x 1.25, rounded up to nearest ¼".
   Length = (calculated thermal movement) x 1.5 + (width of slot), rounded up to nearest ¼".
8. Sole plate must be tapered if slope of beam bottom flange due to roadway grade and camber exceeds 1%. Provide detail of tapered sole plate as shown above.
9. Do not use the bearing assembly shown in Dwg. No. 8.3.3 with the full depth end diaphragms as shown in Section 3.7. Instead, use the bearing assebmbly shown in Dwg. No. 8.3.7.

MASS HIGHWAY BRIDGE MANUAL	SOLE PLATE DETAIL AND DESIGNER NOTES SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.2**



(*) – WELDS SHALL TERMINATE 1/4" FROM EDGE OF PLATE, MASKING AND TOUCH–UP PER STANDARD SPECIFICATIONS.

SECTION 1

SCALE: 1" = 1'–0"

NOTES:

1. *Typical dimensions shown are for anchor bolts no larger than 1½" ø. For bolts of larger diameters these dimensions shall be adjusted accordingly.*
2. *Designer shall calculate this dimension to insure a minimum thread runout of ½". Round up dimension to nearest ½".*
3. *Minimum thickness of stainless steel mating surface shall be 14 gage if the maximum dimension of the surface is less than or equal to 12", otherwise, it shall be equal to 8 gage.*
4. *For Construction Notes and Bearing Installation Notes see Dwg. No. 8.3.4.*

MASS HIGHWAY BRIDGE MANUAL	SECTION SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.3**

These Notes shall be placed on Construction Drawings with details shown on Dwg. No's. 8.3.1, 8.3.2 and 8.3.3.

NOTES:

1. STAINLESS STEEL MATING SURFACE SHALL BE TYPE 304 CONFORMING TO ASTM A 167/A 240 WITH A SURFACE FINISH OF 8 MICRO-INCHES RMS OR BETTER. IT SHALL BE WELDED WITH AN ALL-AROUND WELD TO THE SOLE PLATE SO THAT IT REMAINS FLAT AND IN FULL CONTACT WITH THE SOLE PLATE.

2. STAINLESS STEEL MATING SURFACE SHALL BE PROTECTED FROM SCRATCHES, GOUGES OR OTHER DAMAGE DURING SHIPMENT AND STORAGE.

3. THE SOLE PLATE ASSEMBLY SHALL BE METALIZED, EXCEPT FOR THE STAINLESS STEEL MATING SURFACE AND FOR 1" WIDE STRIPS, WHERE THE SOLE PLATE SHALL BE WELDED TO THE FLANGE. AFTER WELDING, APPLY A GALVANIZING REPAIR PAINT (M7.04.11) WITH A MINIMUM DRY FILM THICKNESS OF 3 MILLS TO THESE STRIPS. THE RETAINER PLATE SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 111.

4. STEEL SOLE PLATE, SHEAR PLATES AND RETAINER PLATE SHALL CONFORM TO AASHTO M 270 GRADE 36.

5. MOLDED FABRIC BEARING PAD SHALL CONFORM TO M9.16.2 AND SHALL BE CUT TO THE SAME SHAPE AS THE RETAINER PLATE. ELASTOMERIC BEARING PAD MUST SIT ON CONCRETE AND NOT ON FABRIC PAD.

6. ANCHOR BOLTS, NUTS, AND WASHERS SHALL CONFORM TO ASTM F 1554 GRADE 105 AND SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 232.

BEARING INSTALLATION NOTES:

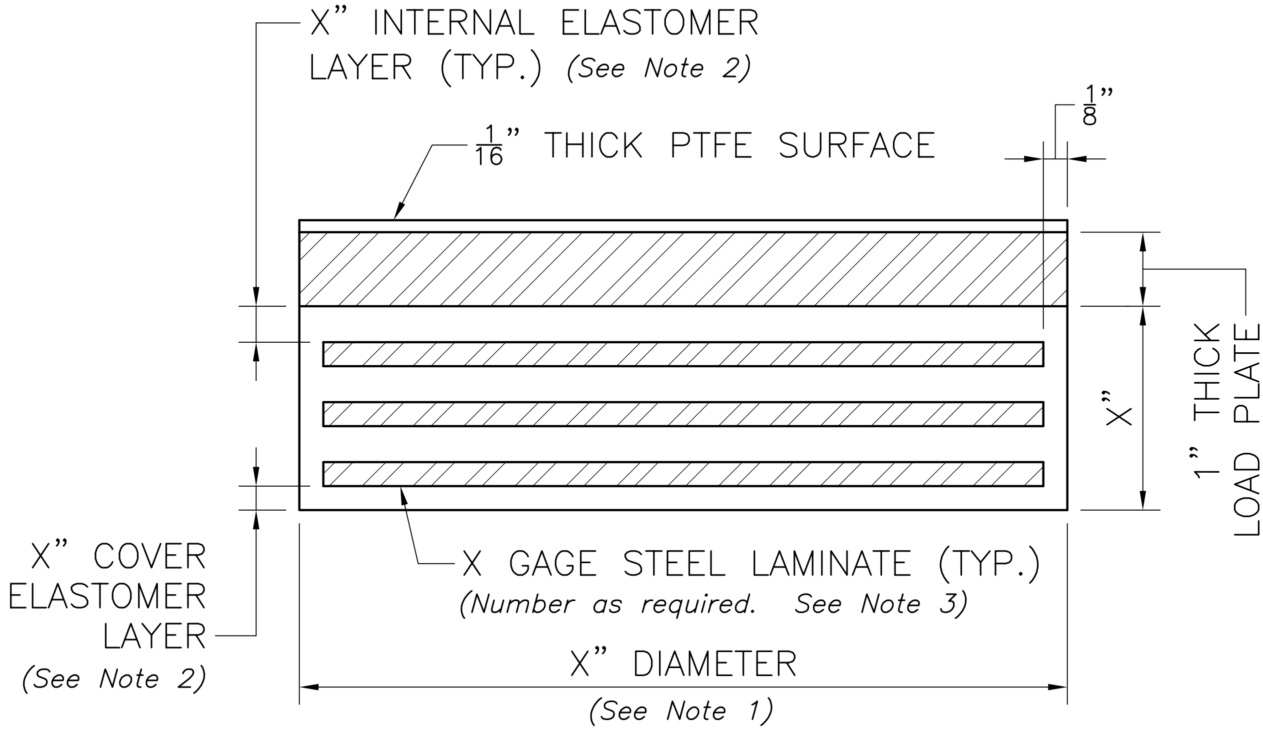
1. INSTALL RETAINER PLATE AND ELASTOMERIC BEARING PAD.

2. POSITION SOLE PLATE ASSEMBLY ON ELASTOMERIC BEARING PAD SO THAT THE SOLE PLATE IS CENTERED ON ANCHOR BOLTS @ 50 °F. ADJUST THE SOLE PLATE FOR ACTUAL AMBIENT TEMPERATURE AT BEAM ERECTION AS FOLLOWS: FOR EVERY 10 °F ABOVE/BELOW 50 °F MOVE SOLE PLATE X" *(Designer to calculate and specify)* TOWARD/AWAY FROM FACE OF ABUTMENT OR PIER.

3. ERECT BEAM TAKING CARE NOT TO DISLODGE SOLE PLATE.

4. AFTER BEAM HAS BEEN ERECTED, WELD SOLE PLATE TO THE BEAM BOTTOM FLANGE.

MASS HIGHWAY BRIDGE MANUAL	CONSTRUCTION NOTES AND BEARING INSTALLATION NOTES SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **8.3.4**



NOTES:

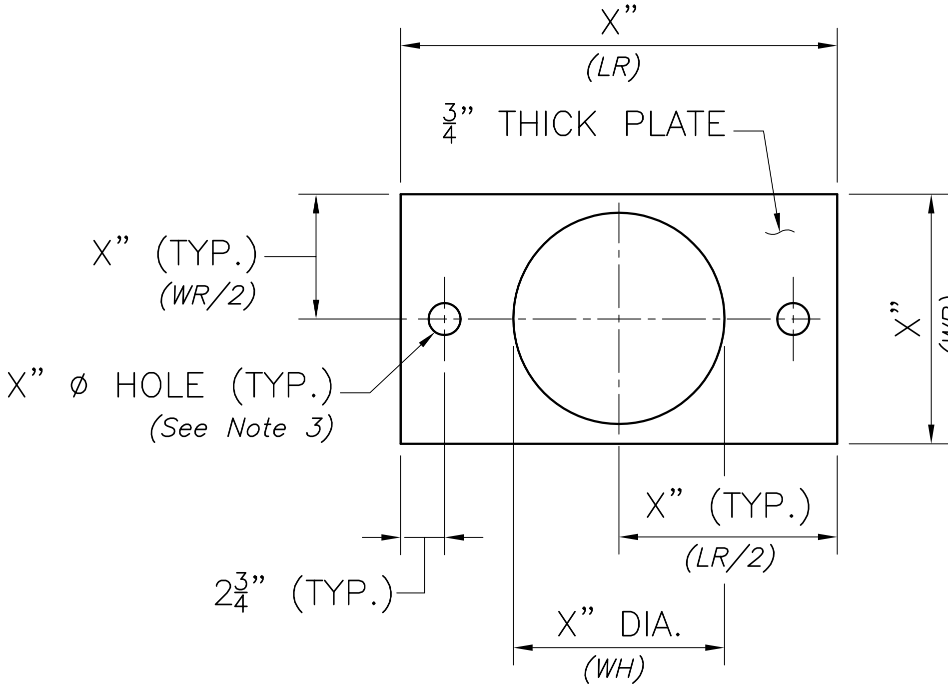
1. ELASTOMER SHALL HAVE A HARDNESS OF XX DUROMETER.
2. STEEL LAMINATES SHALL CONFORM TO ASTM A 1011 GRADE 36.
3. STEEL LOAD PLATE SHALL CONFORM TO AASHTO M 270 GRADE 36.
4. LOAD PLATE SHALL BE VULCANIZED TO THE ELASTOMERIC BEARING PAD. THE SIDES OF THE LOAD PLATE SHALL BE METALIZED PRIOR TO VULCANIZATION.
5. PTFE SURFACE SHALL BE FABRICATED AS UNFILLED SHEET AND SHALL BE MADE FROM PTFE RESIN ALONE. IT SHALL CONTAIN DIMPLES TO ACT AS A RESERVOIR FOR LUBRICANT *(If required by design)*.
6. THE MAXIMUM COEFFICIENT OF FRICTION BETWEEN THE PTFE AND STAINLESS STEEL MATING SURFACE SHALL BE XX AT 68 °F.

ELASTOMERIC BEARING PAD

NOT TO SCALE

For Designer Notes see Dwg. No. 8.3.6.

MASS HIGHWAY BRIDGE MANUAL	ELASTOMERIC BEARING PAD DETAIL SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.5**



RETAINER PLATE DETAIL

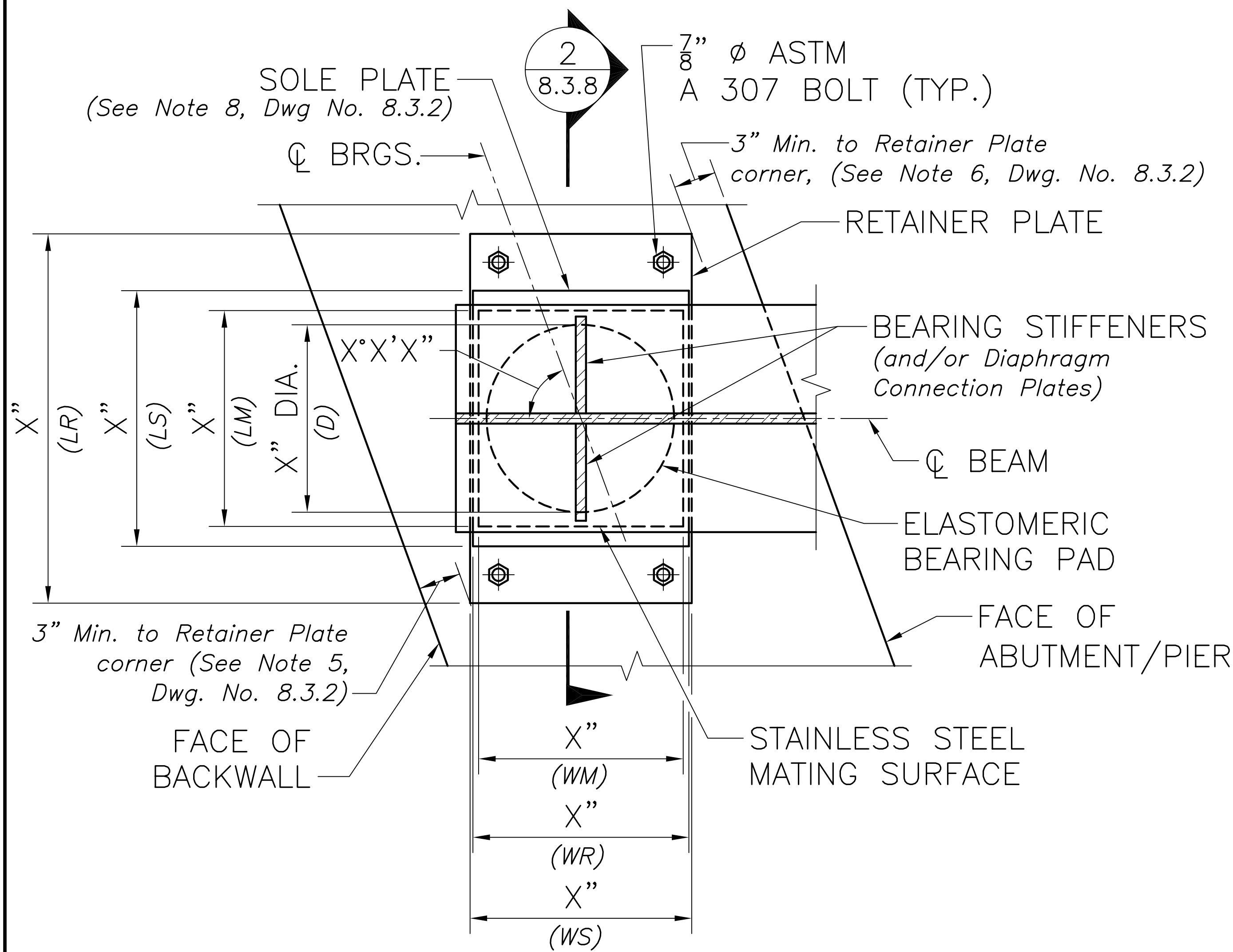
SCALE: 1" = 1'-0"

NOTES:

1. *Retainer plate shall be used to prevent elastomeric bearing pad from walking.*
2. *WH = D + $\frac{1}{2}$";*
   WR = D + 2$\frac{1}{2}$";
   For anchor bolts not exceeding 1$\frac{1}{2}$" ø, LR = LS = (LM or width of flange, whichever is greater) + 12";
   For anchor bolts greater than 1$\frac{1}{2}$" ø, LR shall be determined by Designer.
3. *Diameter of hole = (bolt diameter x 1.25), rounded up to the nearest $\frac{1}{4}$".*

NOTES: (for use with details on Dwg. No. 8.3.5)

1. *Bearing diameters shall be set to even increments of 1", for example: 6", 7", etc.*
2. *A minimum thickness of a single elastomer layer shall be $\frac{1}{4}$". Bottom cover layer shall be no thicker than 70% of the individual internal layer.*
3. *Steel laminates shall have a minimum thickness of 11 gage ($\frac{1}{8}$"). Thickness of steel laminates in inches shall be used to calculate total bearing thickness.*
4. *All bearings on any substructure unit shall have the same nominal compressive stiffness.*
5. *Elastomeric bearing pads shall have a constant thickness and shall be set level.*
6. *The use of unfilled PTFE is preferred because it provides a lower coefficient of friction over filled PTFE. The use of dimples with or without lubricant will also affect the coefficient of friction. The Designer shall specify all of these variables in the Construction Notes as well as the coefficient of friction used in the design.*
7. *See Chapter 3, Part I of the Bridge Manual for additional information and bearing design requirements.*



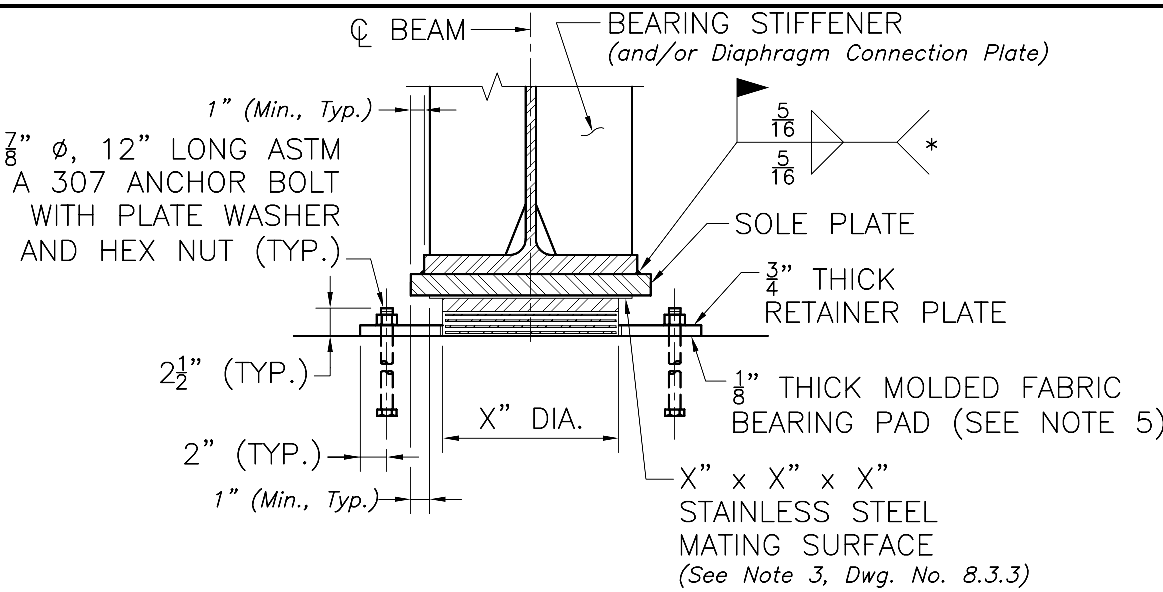
PLAN

SCALE: 1" = 1'–0"

NOTES:

1. *This alternate type of sliding bearing shall be used where the bearings are not required to provide lateral restraint to the superstructure.*
2. *D = Diameter of Elastomeric Bearing Pad;*
   LM = Length of stainless Steel Mating Surface = D + 2";
   WM = Width of Stainless Steel Mating Surface = D + (calculated total thermal movement range x 1.5), rounded up to the nearest $\frac{1}{2}$";
   LS = Length of Sole Plate = (LM or width of bottom flange, whichever is greater) + 2";
   WS = Width of Sole Plate = WM + 1";
   LR = Length of Retainer Plate = LS + 8";
   WR = Width of Retainer Plate = D + 2$\frac{1}{2}$".
3. *See Dwg. No. 8.3.2 for additional applicable Designer Notes.*

MASS HIGHWAY BRIDGE MANUAL	BEARING WITHOUT ANCHOR BOLTS – PLAN SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.7**



(*) – WELDS SHALL TERMINATE 1/4" FROM EDGE OF PLATE, MASKING AND TOUCH–UP PER STANDARD SPECIFICATIONS.

NOTES:

1. STAINLESS STEEL MATING SURFACE SHALL BE TYPE 304 CONFORMING TO ASTM A 167/A 240 WITH A SURFACE FINISH OF 8 MICRO–INCHES RMS OR BETTER. IT SHALL BE WELDED WITH AN ALL–AROUND WELD TO THE SOLE PLATE SO THAT IT REMAINS FLAT AND IN FULL CONTACT WITH THE SOLE PLATE.

2. STAINLESS STEEL MATING SURFACE SHALL BE PROTECTED FROM SCRATCHES, GOUGES OR OTHER DAMAGE DURING SHIPMENT AND STORAGE.

3. THE SOLE PLATE ASSEMBLY SHALL BE METALIZED, EXCEPT FOR THE STAINLESS STEEL MATING SURFACE AND FOR 1" WIDE STRIPS, WHERE THE SOLE PLATE SHALL BE WELDED TO THE FLANGE. AFTER WELDING, APPLY A GALVANIZING REPAIR PAINT (M7.04.11) WITH A MINIMUM DRY FILM THICKNESS OF 3 MILLS TO THESE STRIPS. THE RETAINER PLATE SHALL BE HOT–DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 111.

4. STEEL SOLE AND RETAINER PLATES SHALL CONFORM TO AASHTO M 270 GRADE 36.

5. MOLDED FABRIC BEARING PAD SHALL CONFORM TO M9.16.2 AND SHALL BE CUT TO THE SAME SHAPE AS THE RETAINER PLATE. ELASTOMERIC BEARING PAD MUST SIT ON CONCRETE AND NOT ON FABRIC PAD.

6. BOLTS, PLATE WASHERS AND NUTS SHALL BE HOT–DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 232.

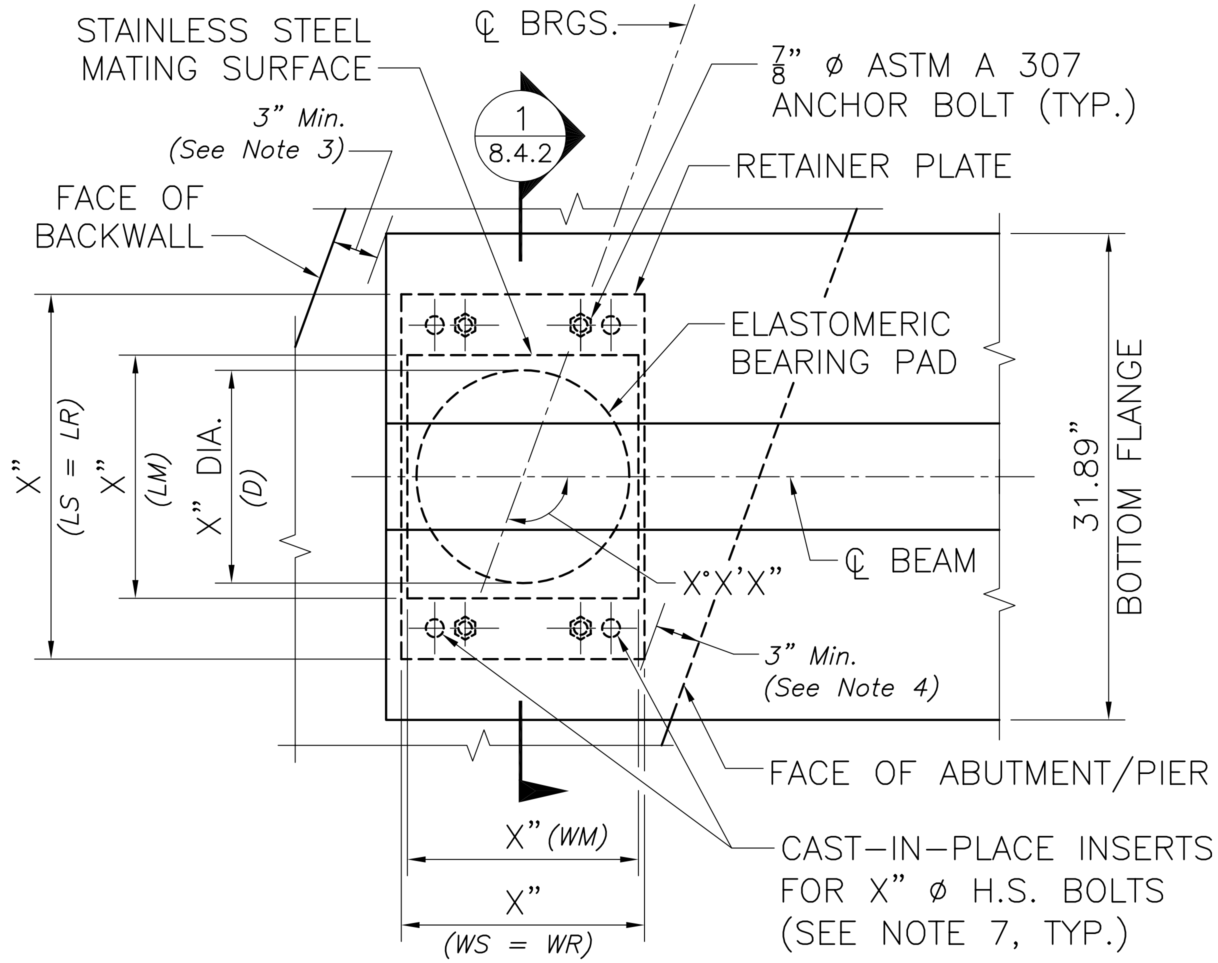
SECTION 2

SCALE: 1" = 1'–0"

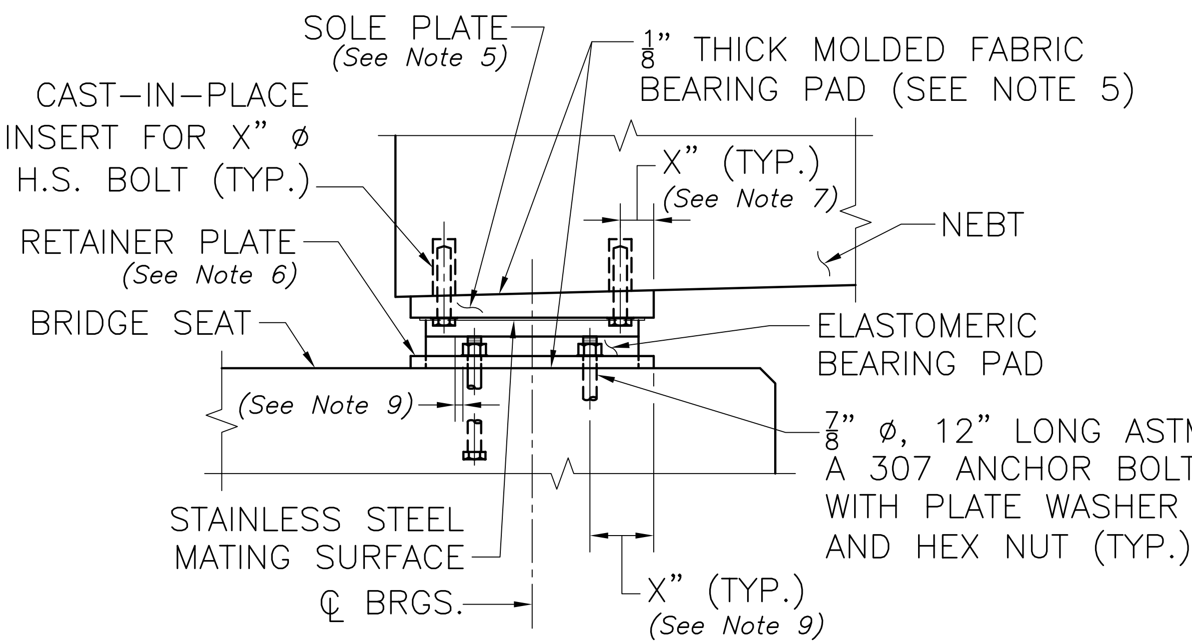
NOTE:

Modify sole and retainer plates as required by Dwg's No. 8.3.7 and 8.3.8, and provide details, as shown on Dwg. No's. 8.3.2 and 8.3.6, respectively.

MASS HIGHWAY BRIDGE MANUAL	BEARING WITHOUT ANCHOR BOLTS – SECTION SLIDING BEARINGS – STEEL BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.3.8**



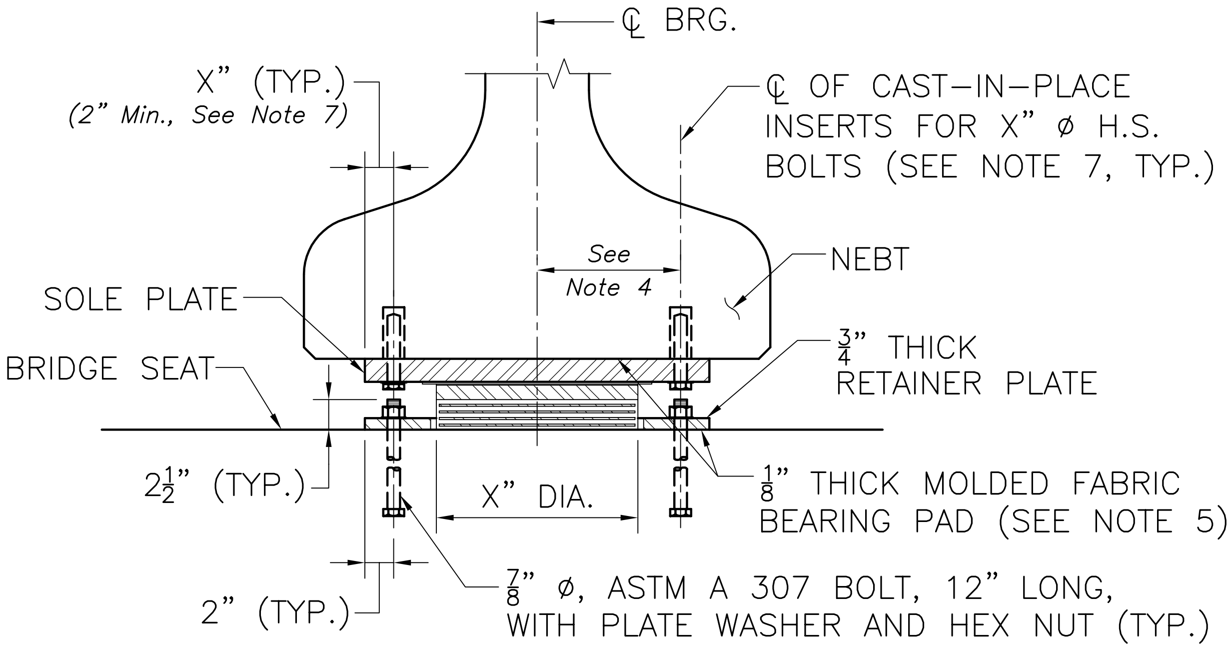
PLAN
SCALE: 1" = 1'-0"



ELEVATION
SCALE: 1" = 1'-0"

For Designer Notes see Dwg. No. 8.4.3.

MASS HIGHWAY BRIDGE MANUAL	STANDARD BEARING ASSEMBLY PLAN AND ELEVATION SLIDING BEARINGS – NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.4.1**



NOTES:

1. STAINLESS STEEL MATING SURFACE SHALL BE TYPE 304 CONFORMING TO ASTM A 167/A 240 WITH A SURFACE FINISH OF 8 MICRO-INCHES RMS OR BETTER. IT SHALL BE WELDED WITH AN ALL-AROUND WELD TO THE SOLE PLATE SO THAT IT REMAINS FLAT AND IN FULL CONTACT WITH THE SOLE PLATE.

2. STAINLESS STEEL MATING SURFACE SHALL BE PROTECTED FROM SCRATCHES, GOUGES OR OTHER DAMAGE DURING SHIPMENT AND STORAGE.

3. THE SOLE PLATE ASSEMBLY SHALL BE METALIZED, EXCEPT FOR THE STAINLESS STEEL MATING SURFACE. THE RETAINER PLATE SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 111.

4. STEEL SOLE AND RETAINER PLATES SHALL CONFORM TO AASHTO M 270 GRADE 36.

5. MOLDED FABRIC BEARING PAD SHALL CONFORM TO M9.16.2. UNDERNEATH THE RETAINER PLATE IT SHALL BE CUT TO ITS SHAPE. THE BEARING PAD MUST SIT ON CONCRETE AND NOT ON FABRIC PAD.

6. BOLTS, PLATE WASHERS AND NUTS SHALL BE HOT-DIP GALVANIZED IN ACCORDANCE WITH AASHTO M 232.

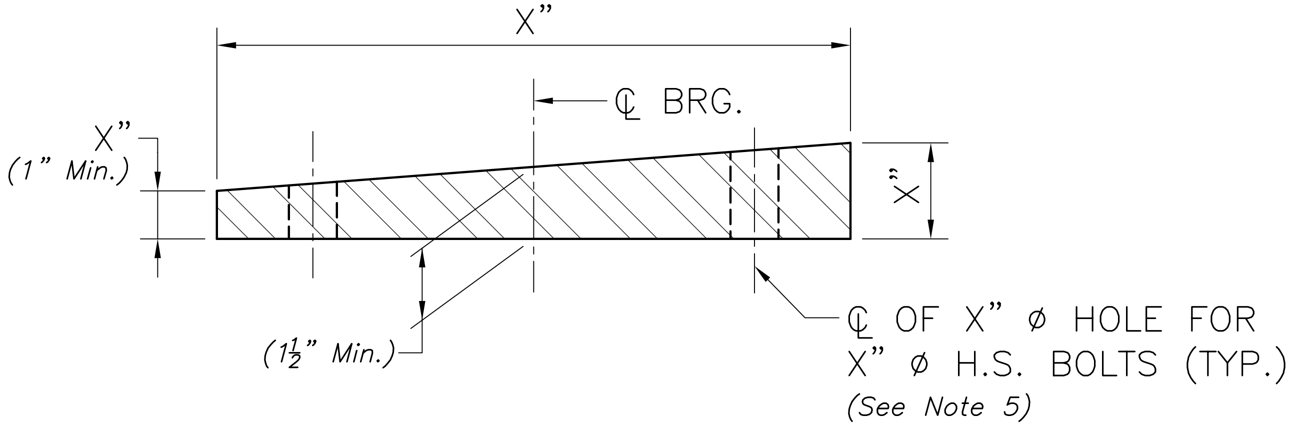
7. CAST-IN-PLACE INSERTS SHALL HAVE AN ULTIMATE SHEAR CAPACITY OF XX KIPS.

SECTION 1

SCALE: 1" = 1'-0"

For Designer Notes see Dwg. No. 8.4.3.

MASS HIGHWAY BRIDGE MANUAL	STANDARD BEARING ASSEMBLY SECTION SLIDING BEARINGS – NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.4.2**



SOLE PLATE DETAIL

SCALE: 3" = 1'−0"

NOTES: (to be used with details shown on Dwg. No.'s 8.4.1 and 8.4.2)

1. *D = Diameter of Elastomeric Bearing Pad;*
   LM = Length of Stainless Steel Mating Surface = D + 2";
   WM = Width of Stainless Steel Mating Surface = D + (calculated total thermal movement range x 1.5), rounded up to the nearest ½";
   LS = Length of Sole Plate = LM + 8";
   WS = Width of Sole Plate = WM + 1";
   LR = Length of Retainer Plate = LS;
   WR = Width of Retainer Plate = WS.
2. *The end of the beam and sole plate may be flush, however the sole plate cannot extend beyond the beam end. If required, increase the length of beam so that it always stays flush with sole plate.*
3. *Width of bridge seat may need to be increased to provide this clearance after the beam reaches its maximum thermal expansion length.*
4. *Width of bridge seat may need to be increased to maintain these clearances.*
5. *Sole plate must be tapered if slope of beam bottom flange due to roadway grade and camber exceeds 1%. Provide detail of tapered sole plate as shown above. Diameter of hole = (bolt diameter x 1.25), rounded up to nearest ¼".*
6. *Modify retainer plate as required by Dwg. No. 8.4.1 and 8.4.2, and provide detail as shown on Dwg. No. 8.3.5.*
7. *Set centerline of cast−in−place inserts on strand location and omit those columns of strands for the specific strand pattern.*
8. *Designer must provide sufficient vertical clearance, which is based on the total height of the bearing assembly, for the bolts securing sole plate, to allow for their complete unscrewing and subsequent removal of the retainer plate and the bearing pad.*
9. *Designer must also provide sufficient horizontal clearance after maximum thermal movements between the centerlines of the cast−in−place inserts and the nuts securing retainer plate to avoid their interference during possible removal of the retainer plate and the bearing pad.*

MASS HIGHWAY BRIDGE MANUAL	SOLE PLATE DETAIL AND DESIGNER NOTES SLIDING BEARINGS − NEBT BEAMS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **8.4.3**

NOTES:

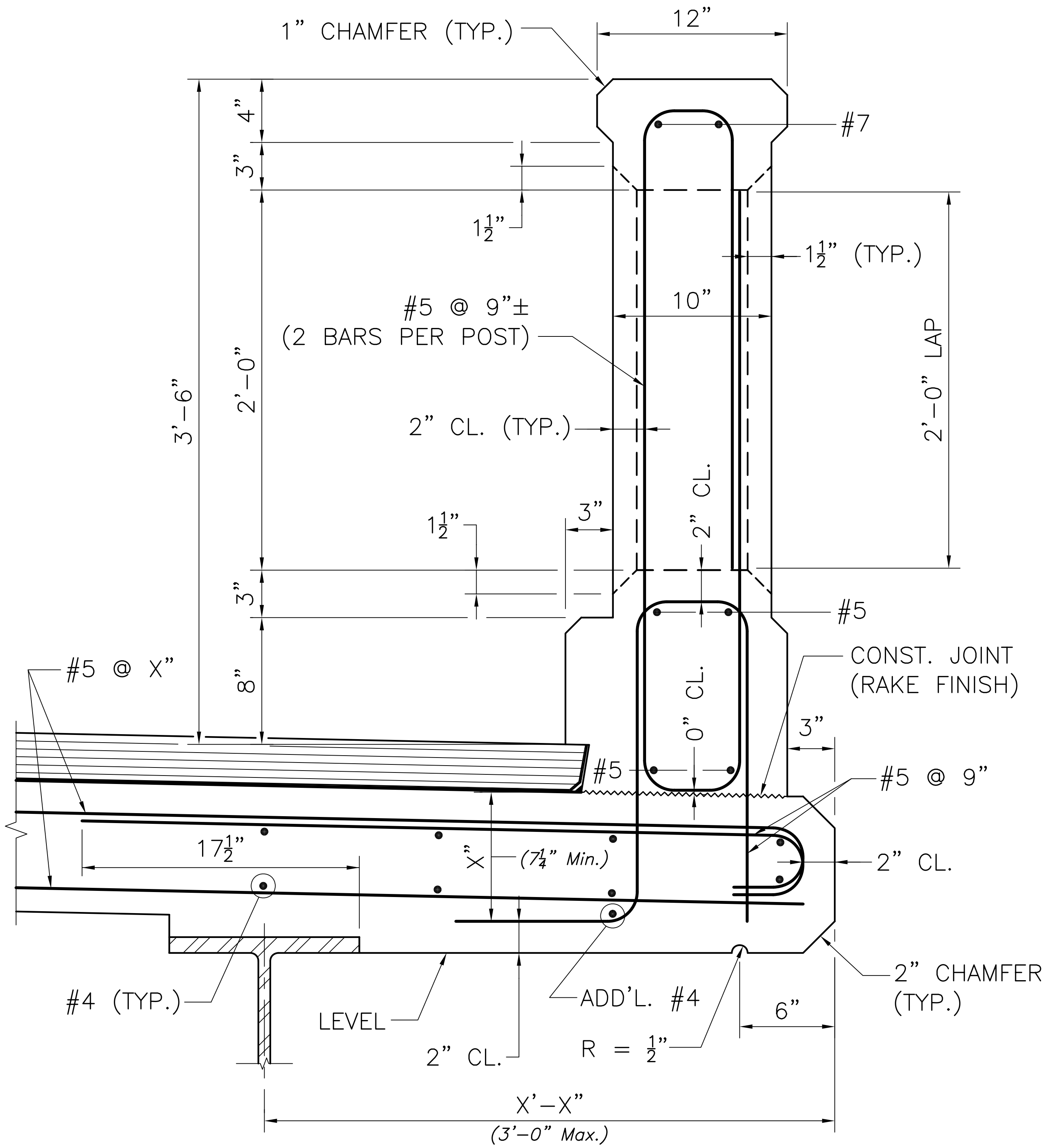
1. Railings and barriers are referenced by their material, type code and performance or test level:

   RAILING/BARRIER NAME

   CT–TL2 BARRIER
   S3–TL4 RAIL
   CP–PL2 BARRIER
   CF–PL2 BARRIER
   CF–PL3 BARRIER

2. All concrete for railing/traffic barrier systems, sidewalks and safety curbs shall be 5000 PSI, $\frac{3}{4}$ IN, 685 HP Cement Concrete, except for the CT–TL2 Barrier, which shall be 5000 PSI, $\frac{3}{8}$ IN, 710 HP Cement Concrete and shall be noted on the Construction Drawings. Concrete penetrant is not required for barriers composed of HP cement concrete.
3. Transverse steel in sidewalks and safety curbs shall follow the same direction as the transverse deck steel.
4. Details of railings for separated precast concrete box/deck beam bridges are similar to the details for the steel beam bridges, except that the maximum overhang shall be 2'–6" from the outside edge of the precast beam.
5. The details of the dowel arrangement for the attachment of the sidewalk slab to precast adjacent beam bridges are shown in Section 3 of Chapter 4.
6. The minimum depth of slab for the overhanging sidewalk is 11". All overhanging sidewalks have been pre–designed for utility loads up to 250 lb/ft that are centered in the overhang. The minimum depth of slab for the roadway deck (outside the exterior beam) is $9\frac{1}{4}$" at the location of the embedded reinforcement.
7. If the decks are less than the stated minimum thicknesses or exceed the maximum overhang, the designer is responsible for determining the appropriate reinforcement in the deck and sidewalk slabs and the embedment of the barrier and rail attachments.
8. The unit weights of the unmodified rails and barriers are as follows:

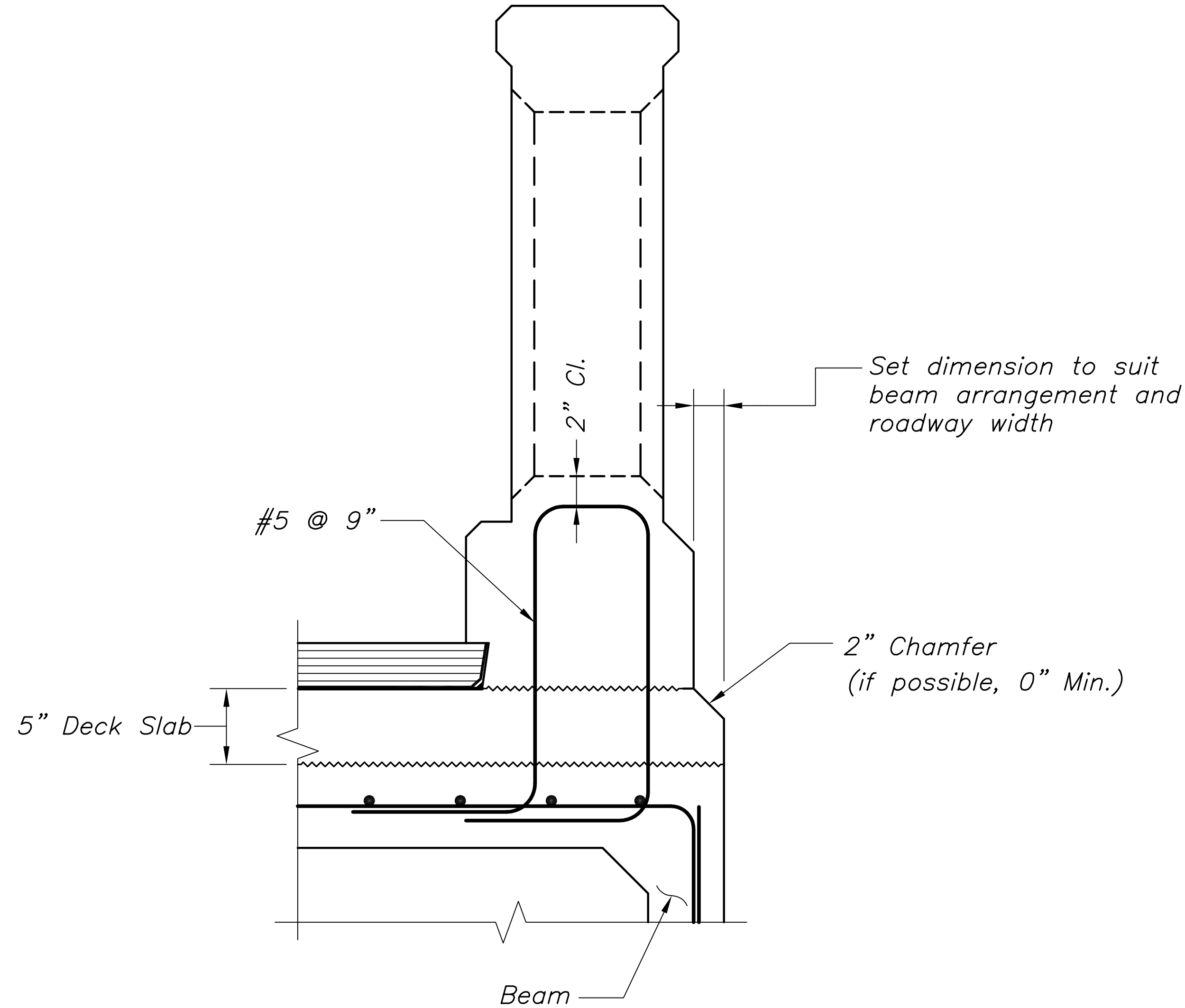
CT–TL2 at sidewalk:	344 lb/ft (between pilasters)
CT–TL2 pilaster (16" long) at sidewalk:	600 lb/each
CT–TL2 at safety curb:	426 lb/ft
CT–TL2 pilaster (16" long) at safety curb:	673 lb/each
S3–TL4 at sidewalk:	90 lb/ft
S3–TL4 at safety curb:	85 lb/ft
CP–PL2 at sidewalk:	410 lb/ft
CP–PL2 at safety curb:	438 lb/ft
CF–PL2:	466 lb/ft
CF–PL3:	659 lb/ft
TYPE I PROTECTIVE SCREEN:	34 lb/ft
TYPE II PROTECTIVE SCREEN:	21 lb/ft
TYPE II ELECTRIFICATION BARRIER:	47 lb/ft



SECTION THRU CT–TL2 BARRIER AT SAFETY CURB

SCALE: 1½" = 1'–0"

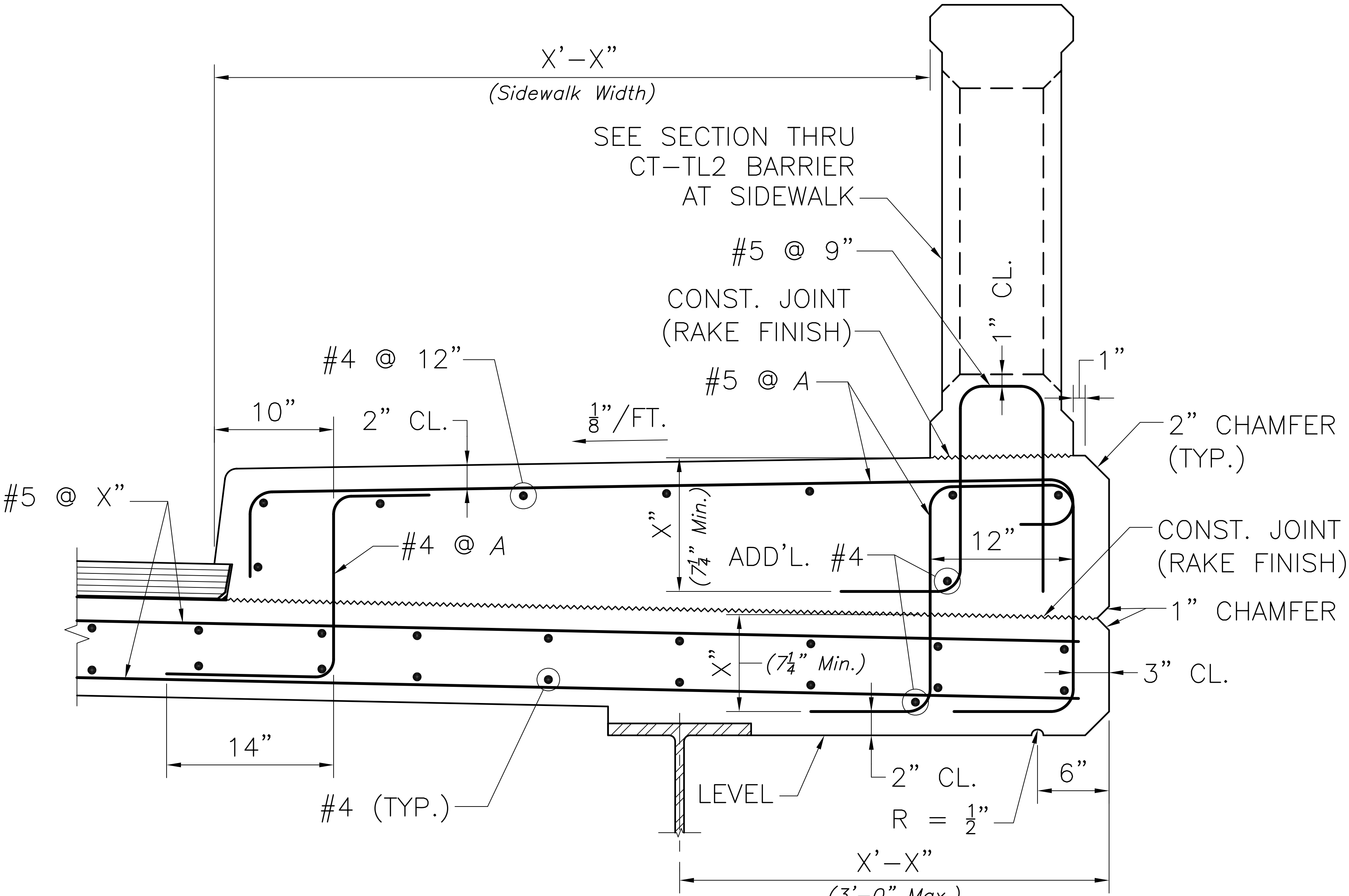
MASS HIGHWAY BRIDGE MANUAL	DETAILS AT SAFETY CURB	DATE OF ISSUE NOVEMBER 2010
	CT–TL2 BARRIER	DRAWING NUMBER **9.2.1**



SECTION THRU CT-TL2 BARRIER

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR ADJACENT BEAM BRIDGES	DATE OF ISSUE MAY 2005
	CT-TL2 BARRIER	DRAWING NUMBER **9.2.2**

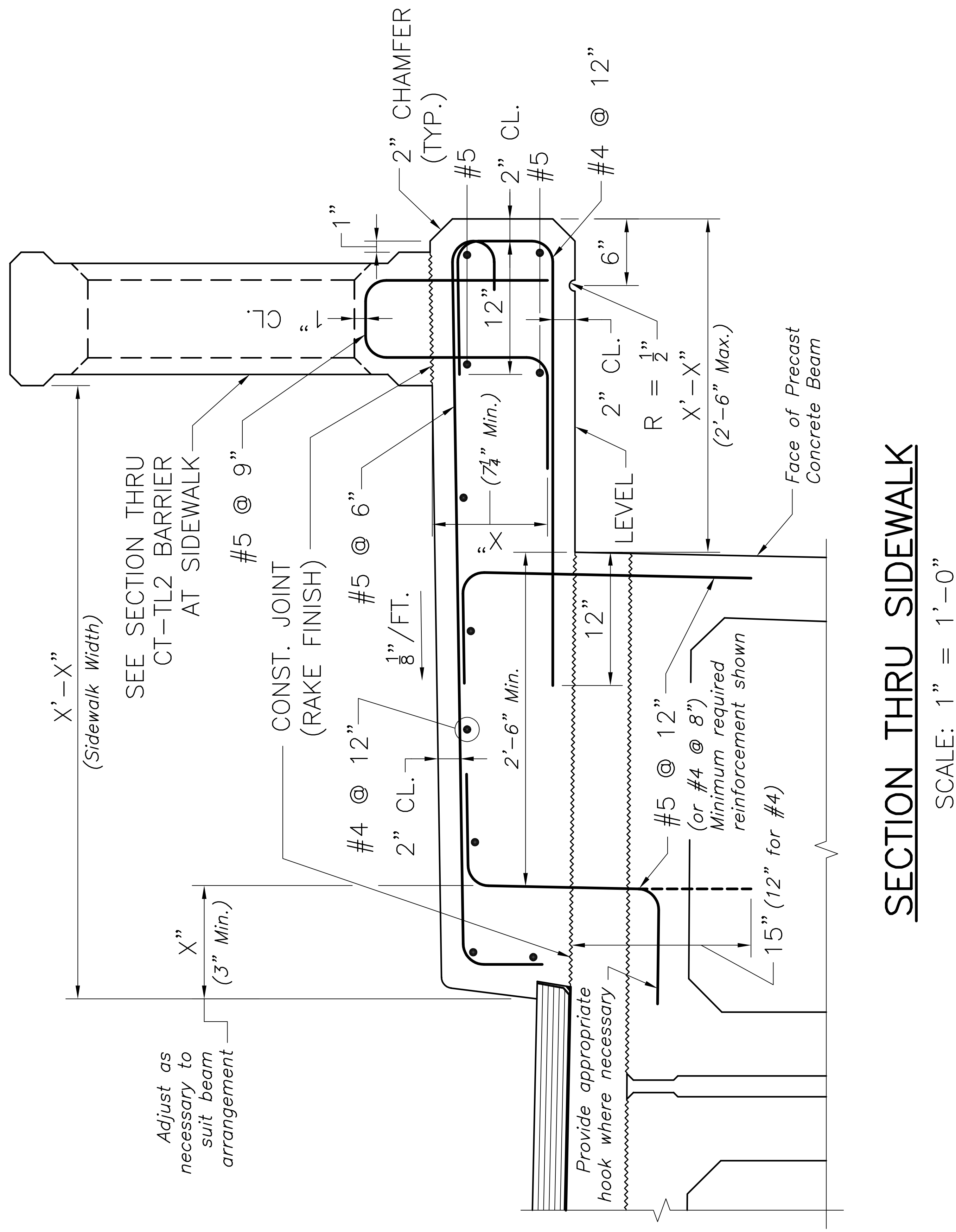


SECTION THRU SIDEWALK

SCALE: 1" = 1'–0"

NOTE:
A = Same spacing as deck slab reinforcement (8 1/2" maximum spacing).

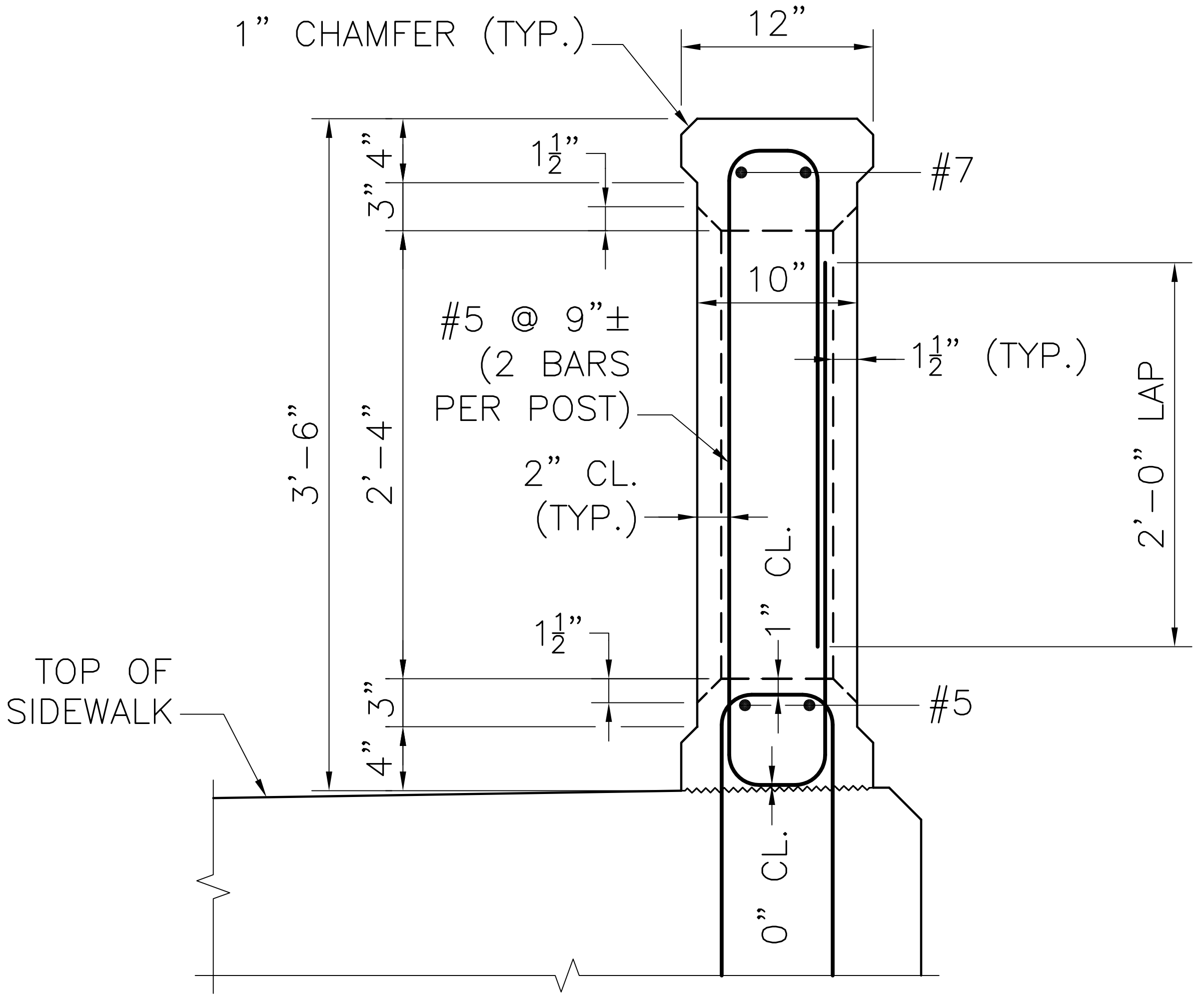
MASS HIGHWAY BRIDGE MANUAL	SECTION THRU SIDEWALK STRINGER BRIDGES CT–TL2 BARRIER	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.2.3**



SECTION THRU SIDEWALK

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	SECTION THRU SIDEWALK ADJACENT BEAM BRIDGES CT–TL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.2.4**



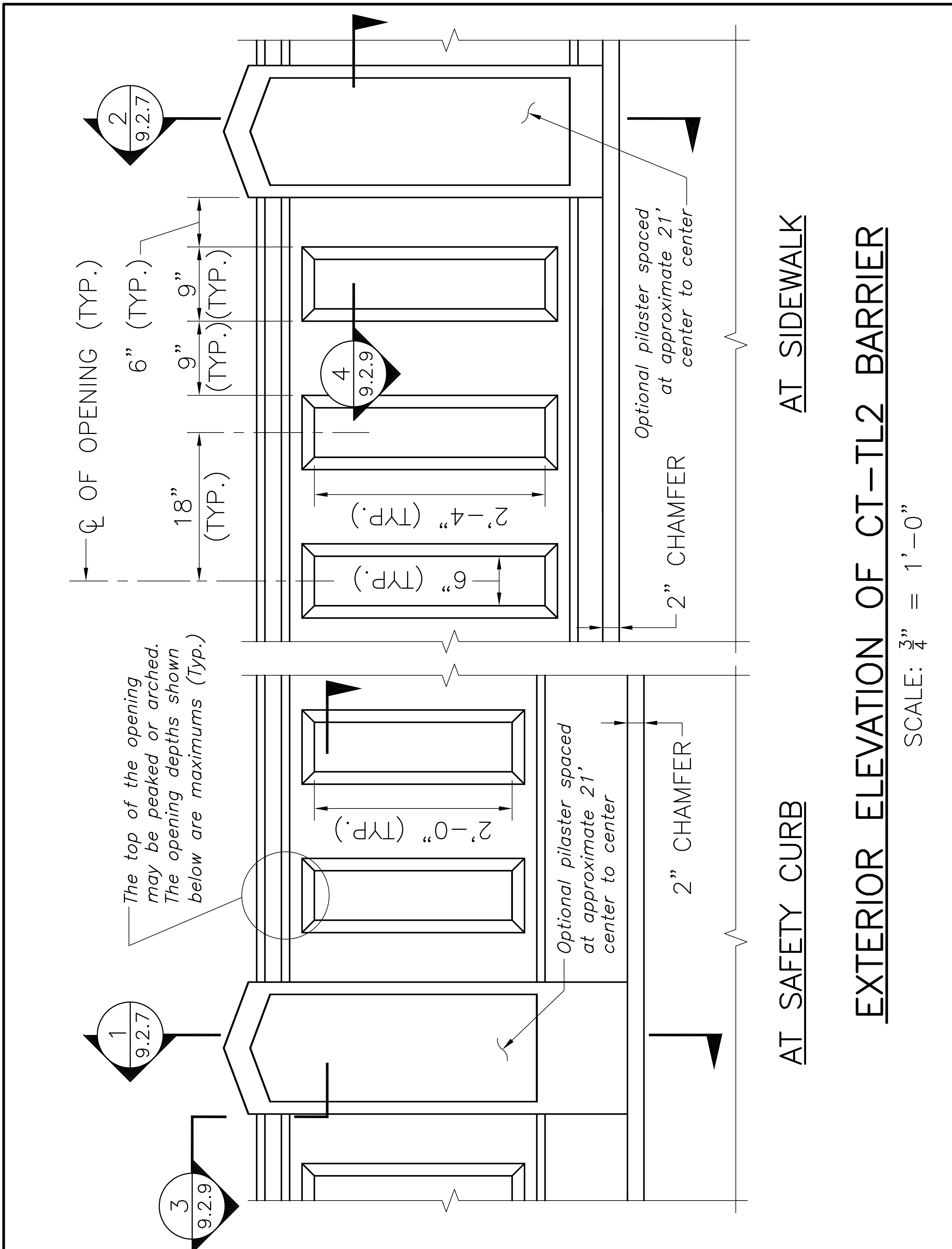
NOTE:

FOR SIDEWALK REINFORCEMENT SEE SECTION THRU SIDEWALK.

SECTION THRU CT–TL2 BARRIER AT SIDEWALK

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	DETAILS AT SIDEWALK	DATE OF ISSUE MAY 2005
	CT–TL2 BARRIER	DRAWING NUMBER **9.2.5**



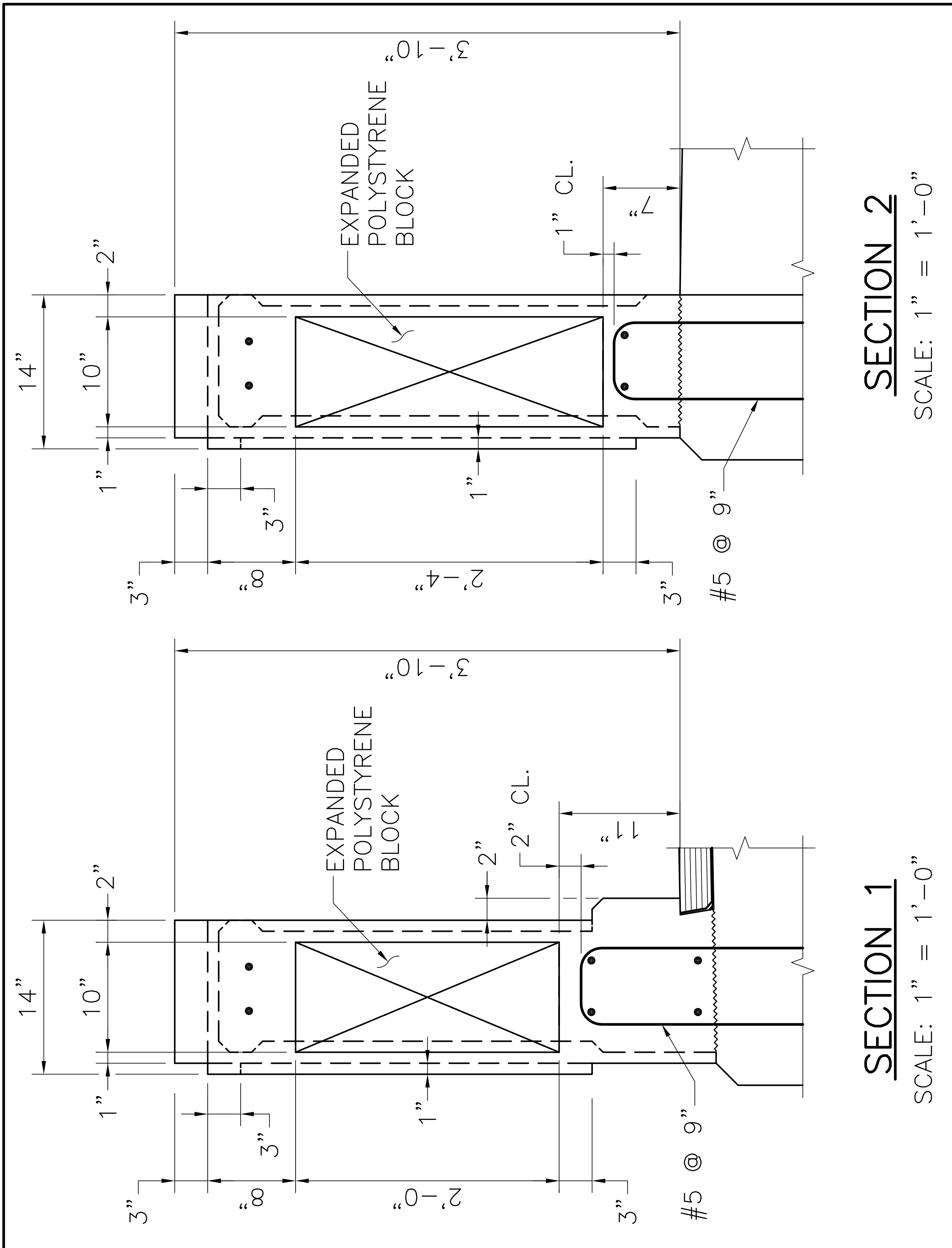
MASS HIGHWAY
BRIDGE MANUAL

ELEVATION OF BARRIER

CT–TL2 BARRIER

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
9.2.6



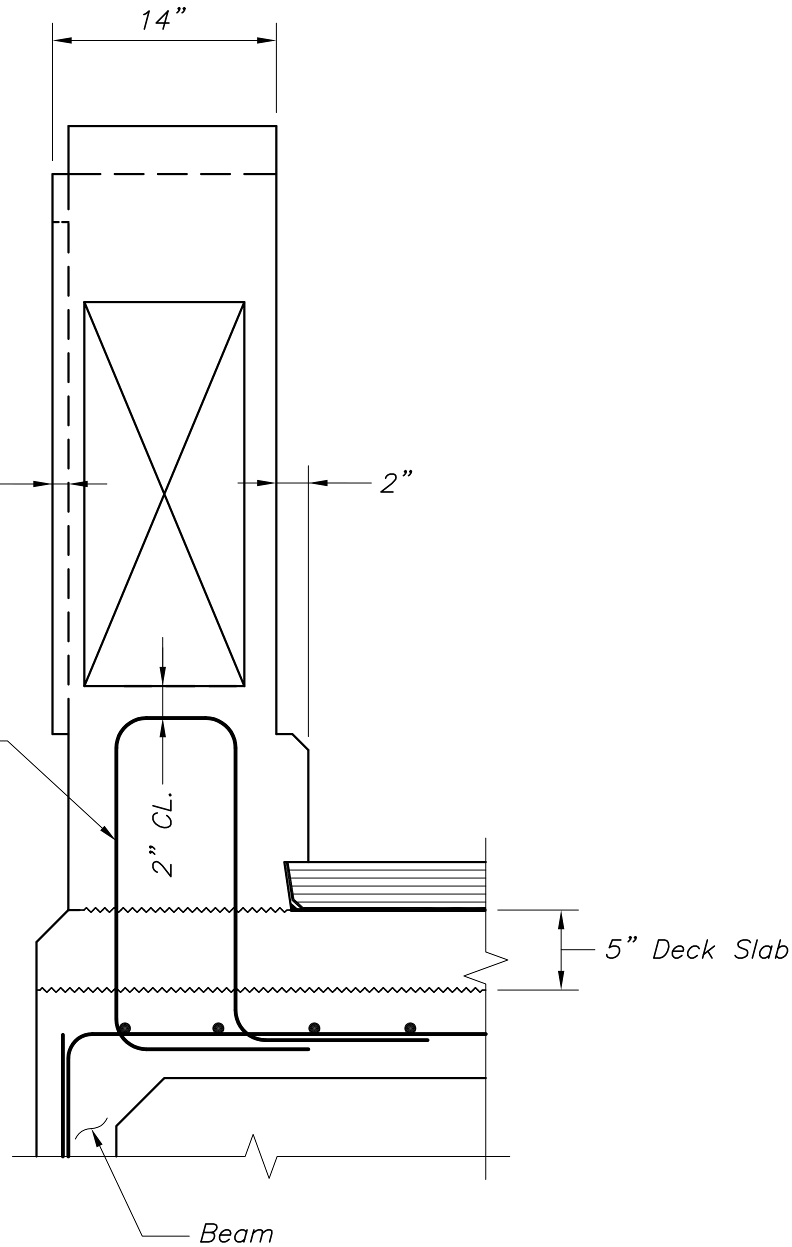
MASS HIGHWAY
BRIDGE MANUAL

VERTICAL SECTIONS OF OPTIONAL PILASTERS

CT-TL2 BARRIER

DATE OF ISSUE
MAY 2005

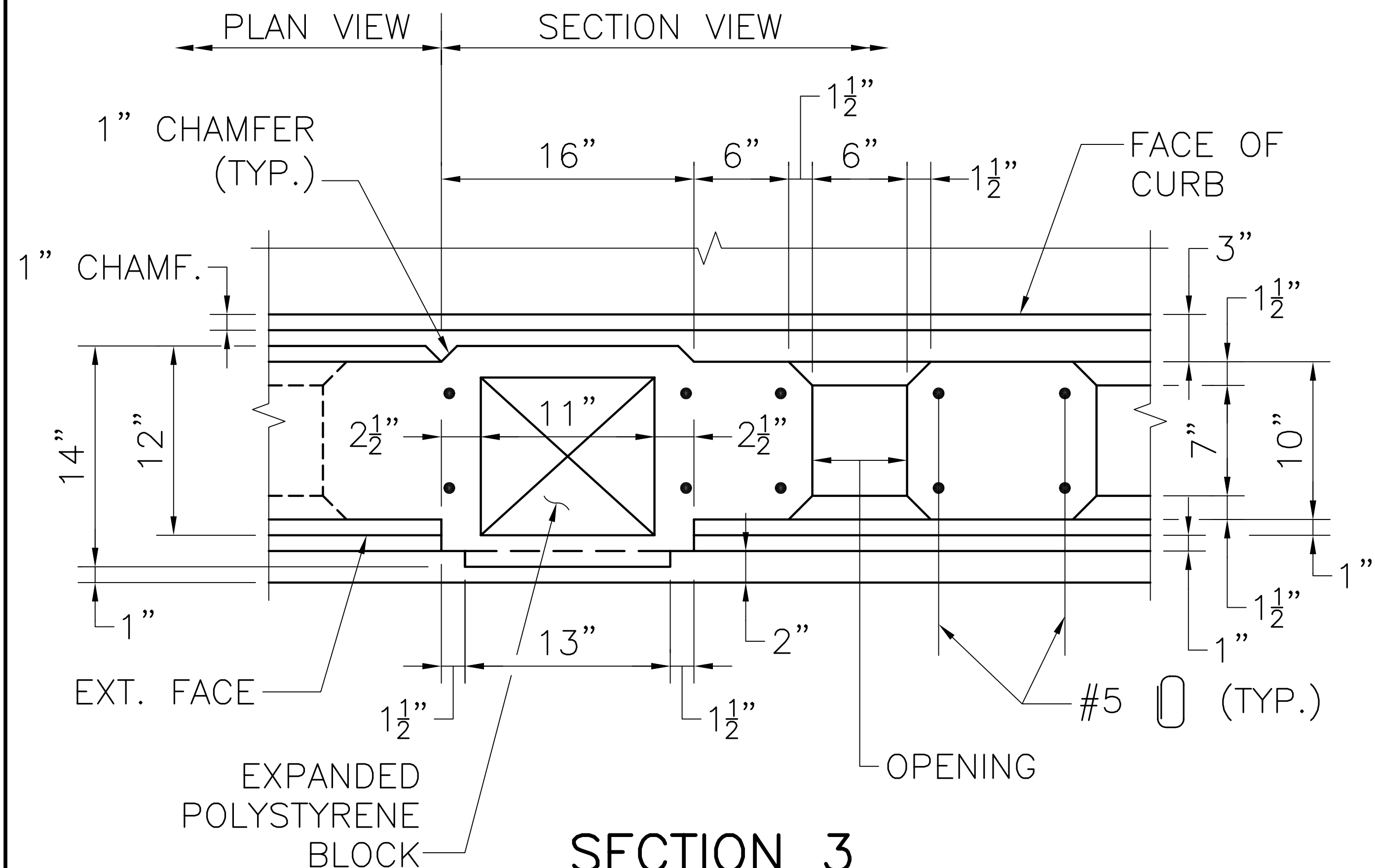
DRAWING NUMBER
9.2.7



VERTICAL SECTION THRU OPTIONAL PILASTER

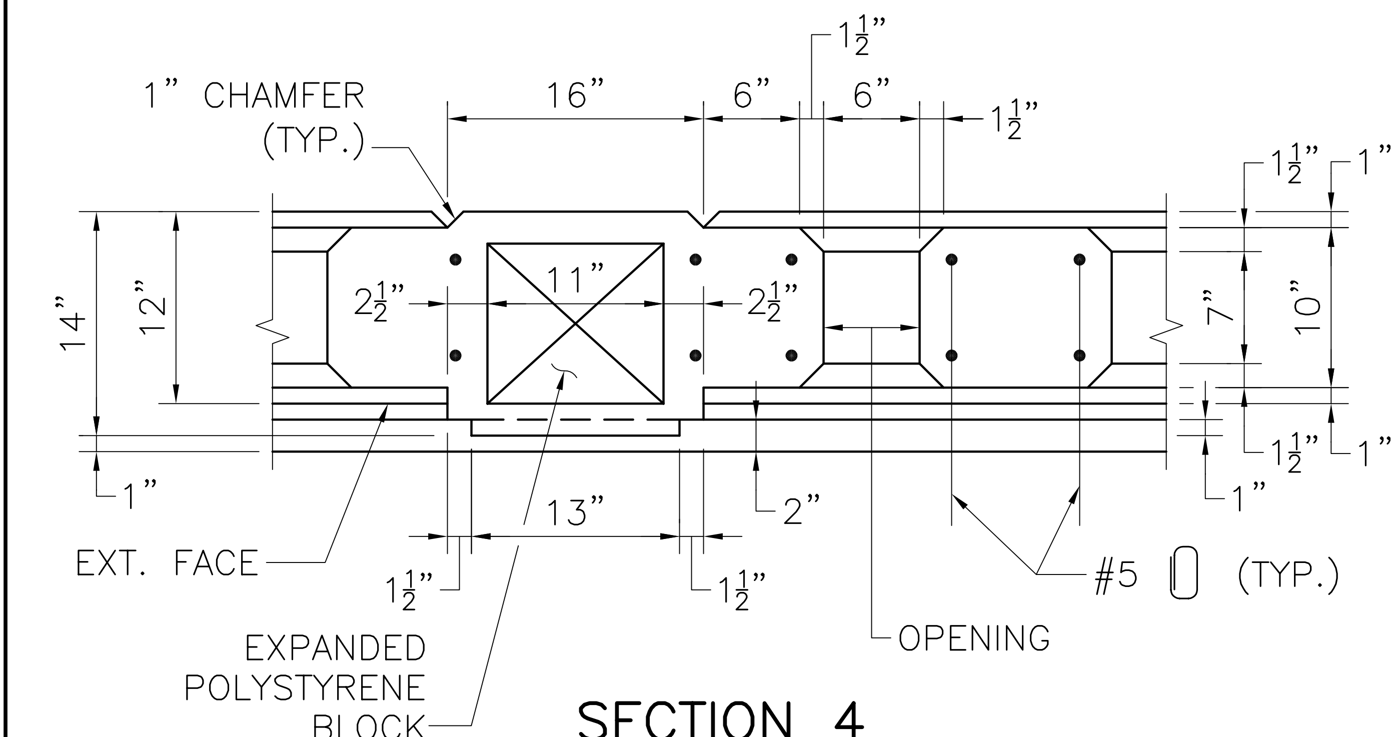
SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR ADJACENT BEAM BRIDGES CT-TL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.2.8**



SECTION 3

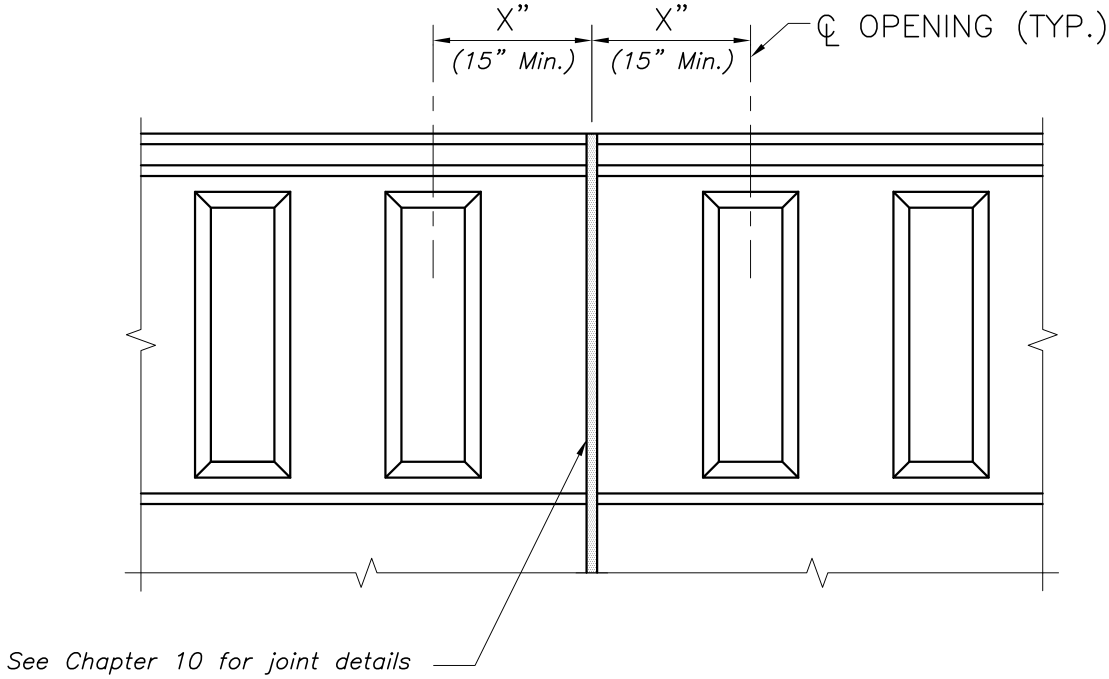
SCALE: 1" = 1'–0"



SECTION 4

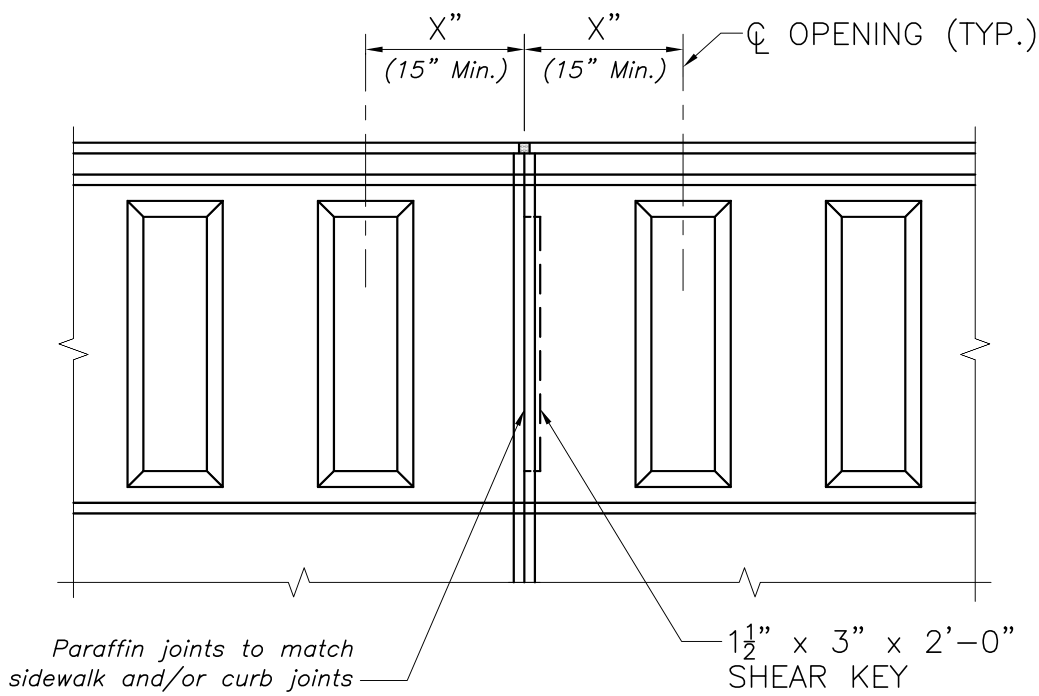
SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	PLAN SECTIONS OF OPTIONAL PILASTERS CT–TL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.2.9**



EXPANSION JOINT

SCALE: $\frac{3}{4}$" = 1'–0"



PARAFFIN JOINT

SCALE: $\frac{3}{4}$" = 1'–0"

NOTE:

Paraffin joints shall be spaced a minimum of 20' and a maximum of 25' over deck and at construction joints on wingwalls.

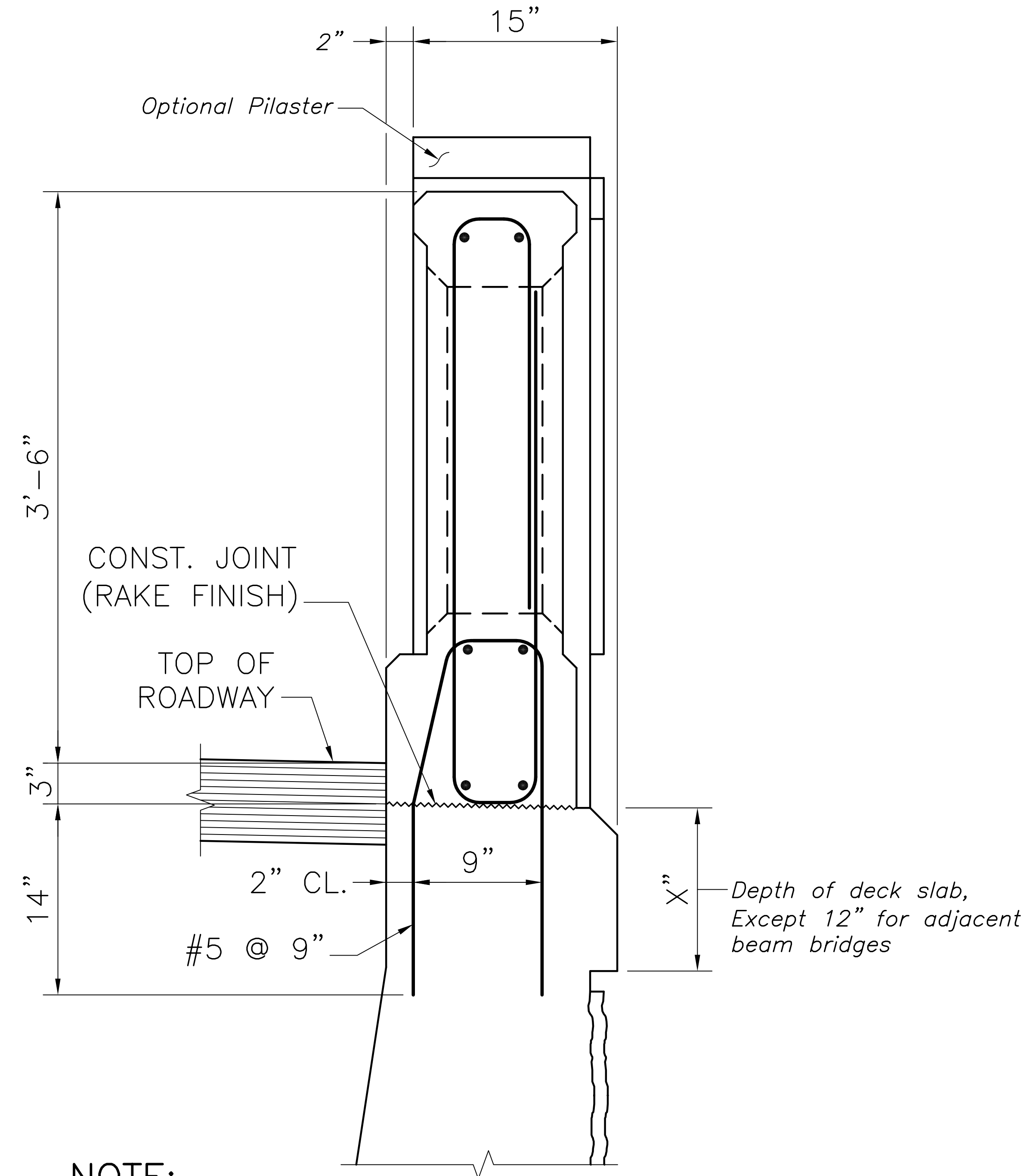
MASS HIGHWAY BRIDGE MANUAL

JOINT DETAILS

CT–TL2 BARRIER

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **9.2.10**



NOTE:

SEE SECTION THRU CT-TL2 BARRIER AT SAFETY CURB FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

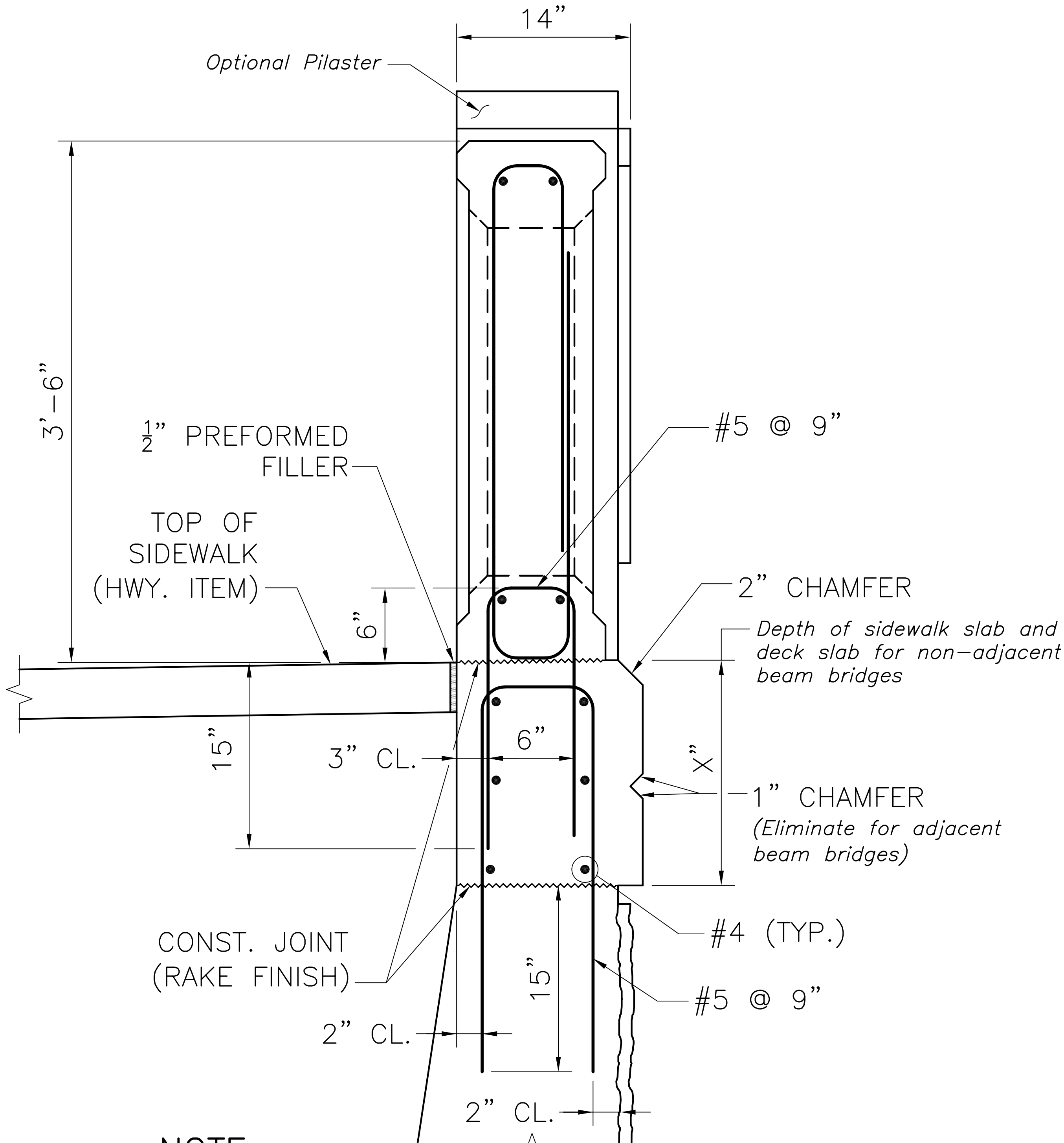
TOP OF U-WINGWALL DETAILS AT SAFETY CURB

SCALE: 1" = 1'-0"

NOTE:

Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U-WINGWALL DETAILS AT SAFETY CURB CT-TL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.2.11**



NOTE:

SEE SECTION THRU CT–TL2 AT SIDEWALK FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

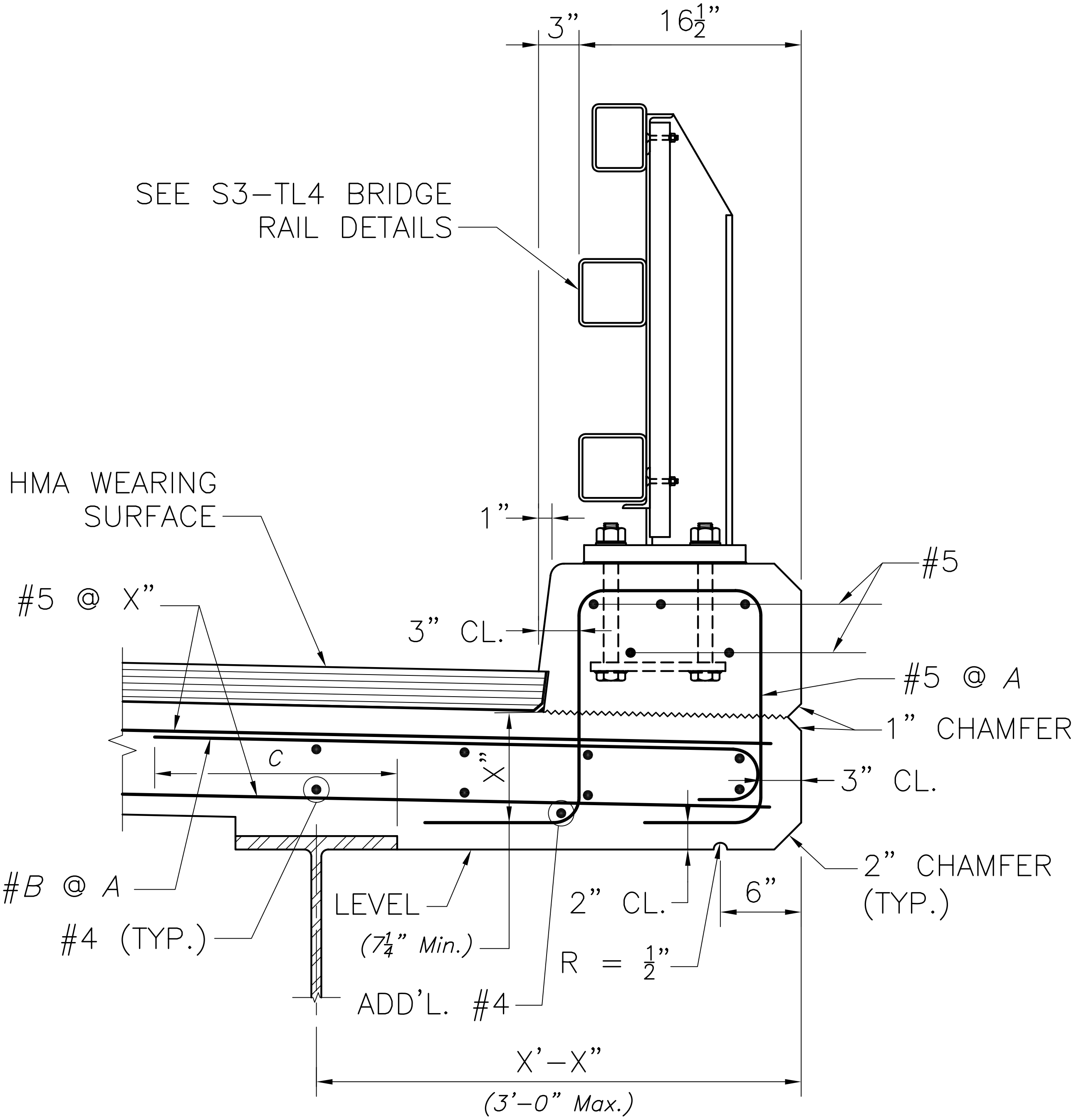
TOP OF U–WINGWALL DETAILS AT SIDEWALK

SCALE: 1" = 1'–0"

NOTE:

Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U–WINGWALL DETAILS AT SIDEWALK CT–TL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.2.12**



SECTION THRU SAFETY CURB

SCALE: 1" = 1'–0"

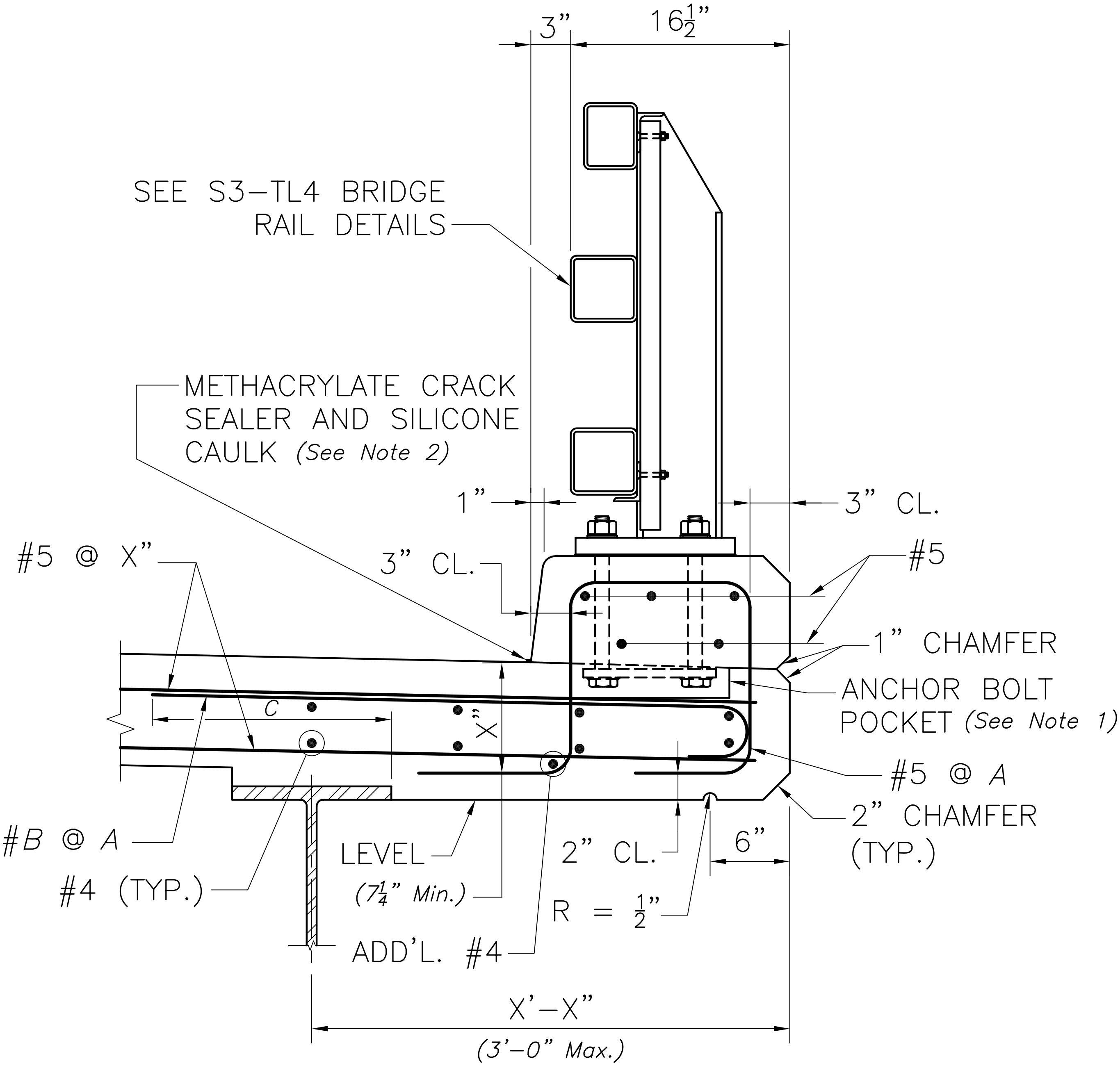
NOTES:

A = Same spacing as deck slab reinforcement (8½" maximum spacing).

B = #4 for design deck slab = 8½", 9" and 9½"
#5 for design deck slab = 8"

C = 13" for #4 bar
18" for #5 bar

MASS HIGHWAY BRIDGE MANUAL	SAFETY CURB SECTION BRIDGES W/HMA SURFACE S3–TL4 RAIL	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **9.3.1**



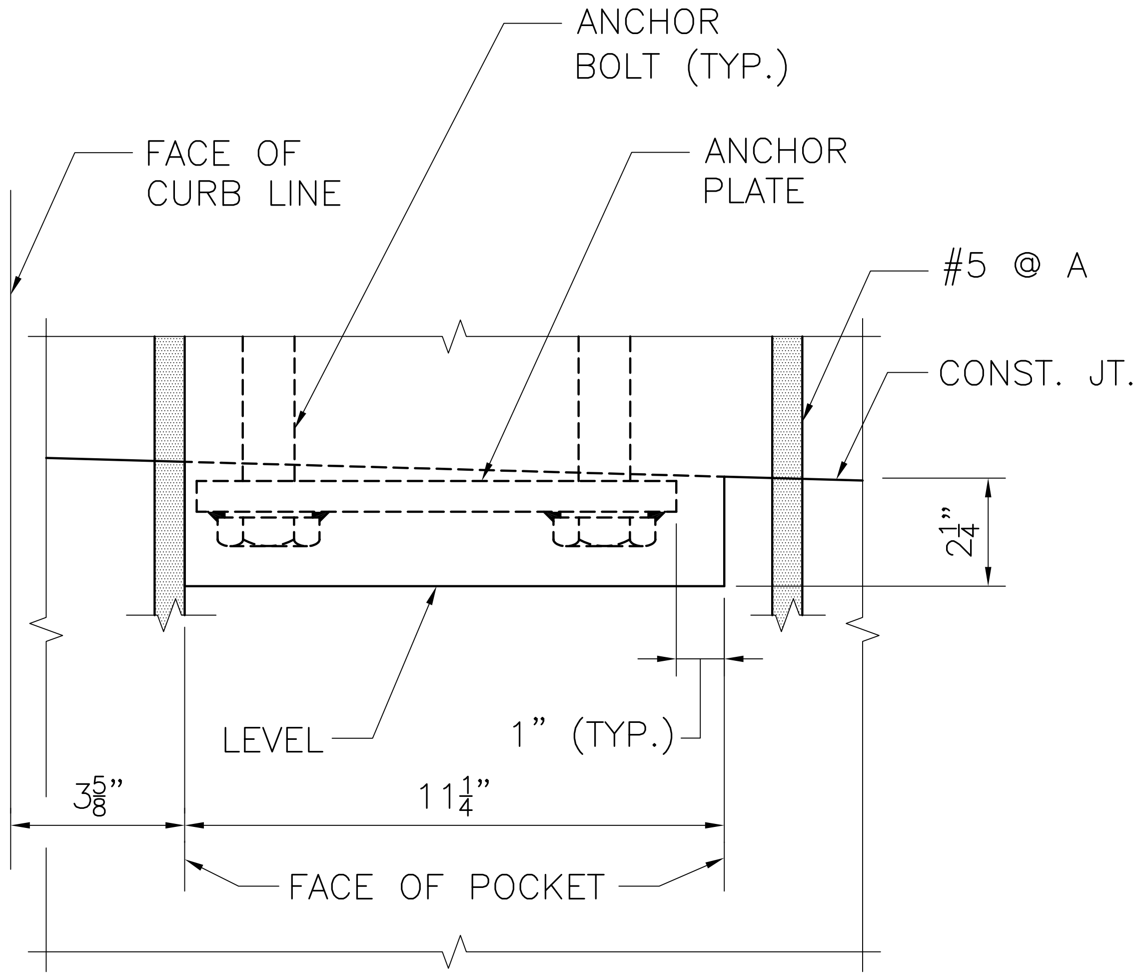
SECTION THRU SAFETY CURB

SCALE: 1" = 1'–0"

NOTES:

1. *See Dwg. No. 9.3.3 for Details of Anchor Bolt Pocket.*
2. *See Dwg. No. 9.8.2 for Details of Curb Treatment.*
3. *See Dwg. No. 9.3.1 for other Designer Notes.*

MASS HIGHWAY BRIDGE MANUAL	SAFETY CURB SECTION EXPOSED DECK BRIDGES S3–TL4 RAIL	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **9.3.2**



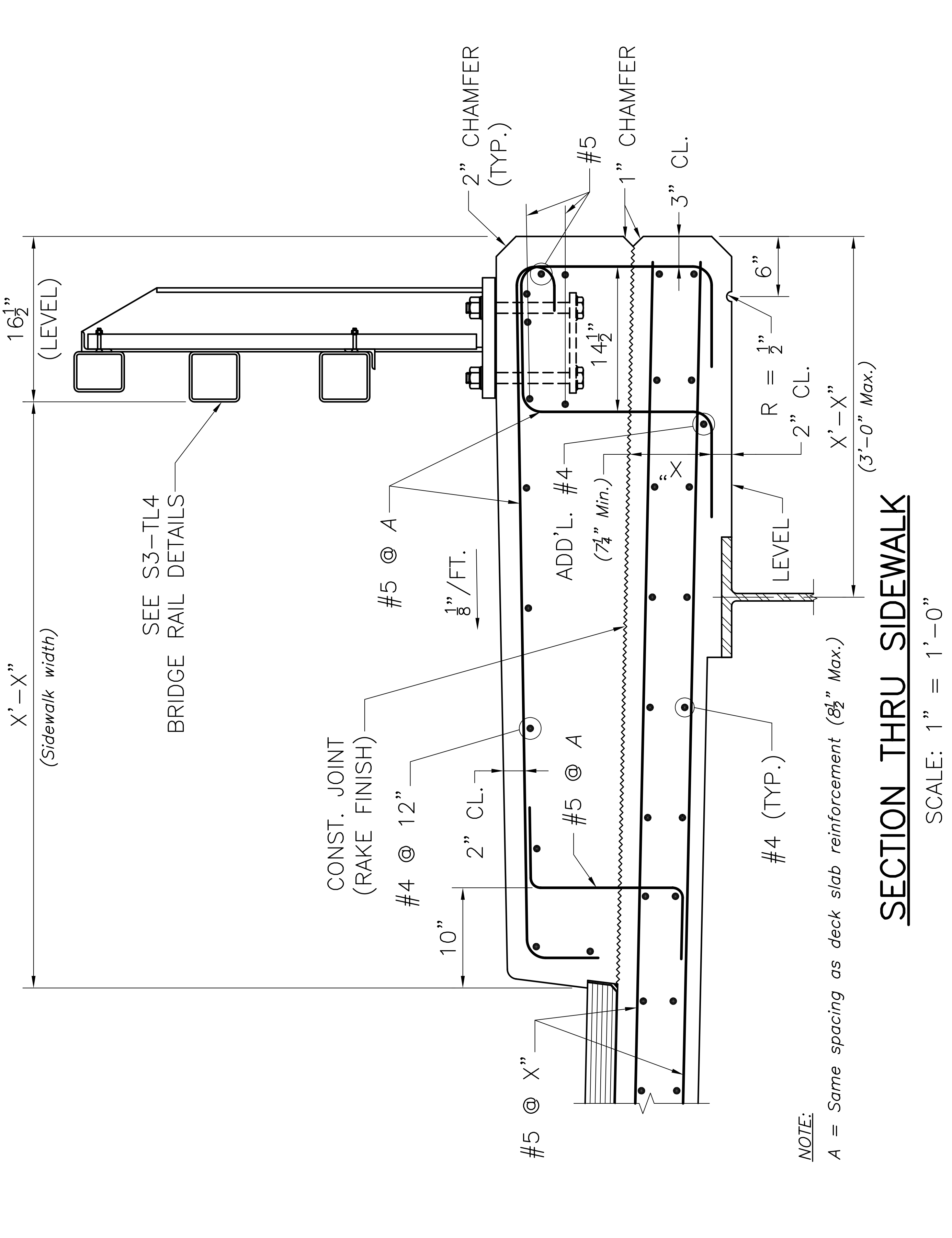
NOTE:

PROVIDE 15¾" LONG, 11¼" WIDE, 2¼" DEEP POCKET IN THE DECK SLAB AT THE LOCATION OF EACH RAIL POST AT SAFETY CURB ONLY.

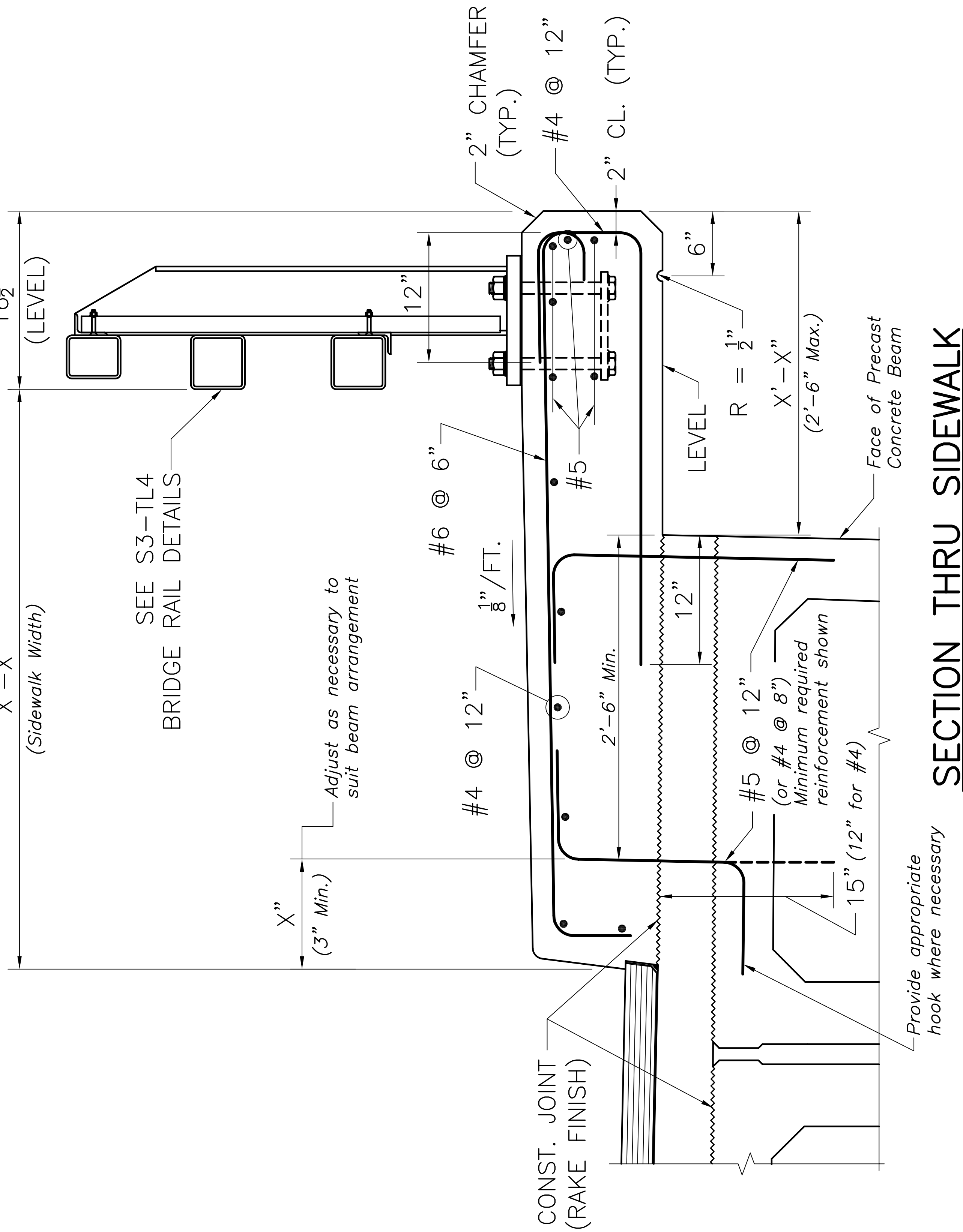
ANCHOR BOLT POCKET AT SAFETY CURB

SCALE: 3" = 1'-0"

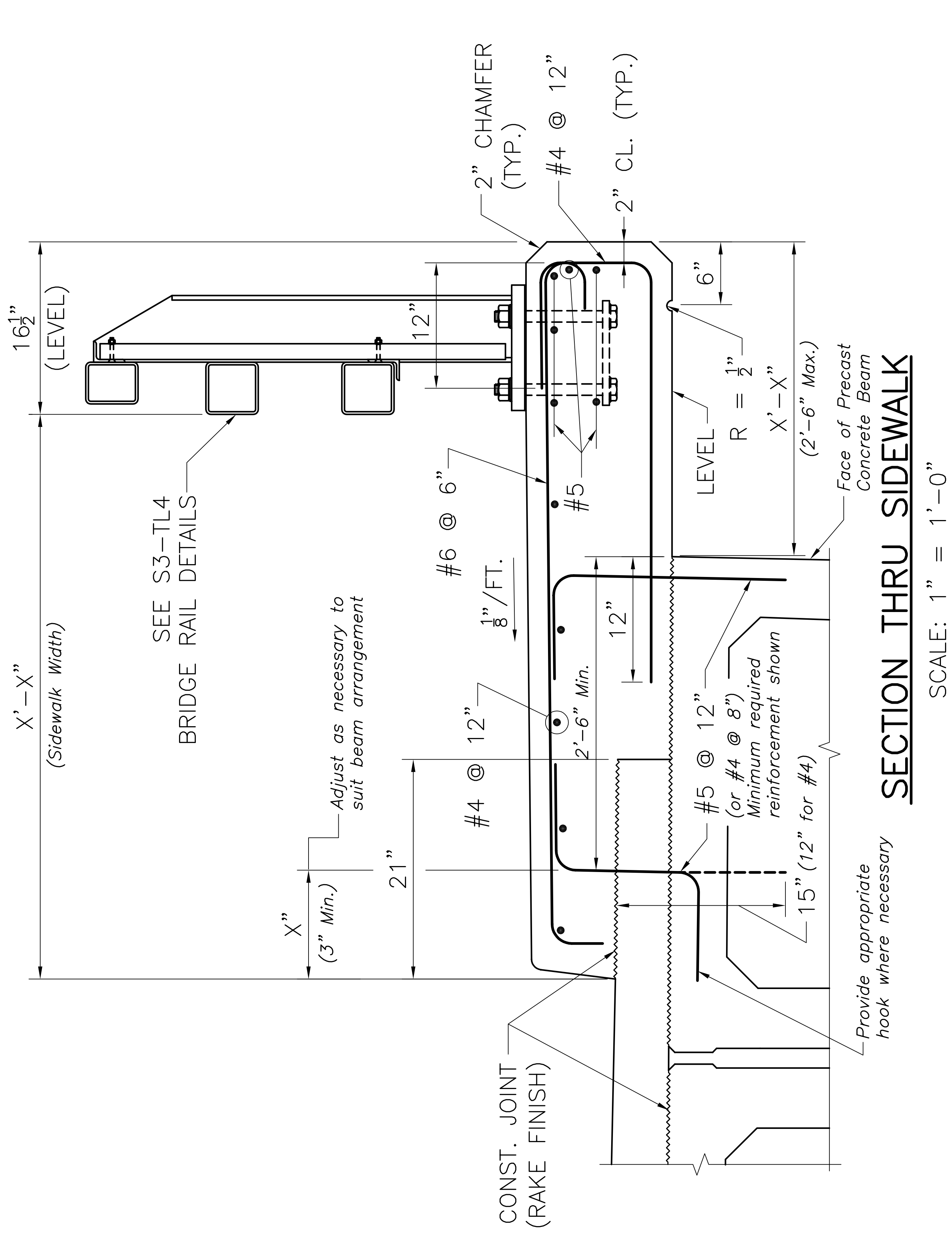
MASS HIGHWAY BRIDGE MANUAL	ANCHOR BOLT POCKET EXPOSED DECK BRIDGES S3-TL4 RAIL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.3.3**



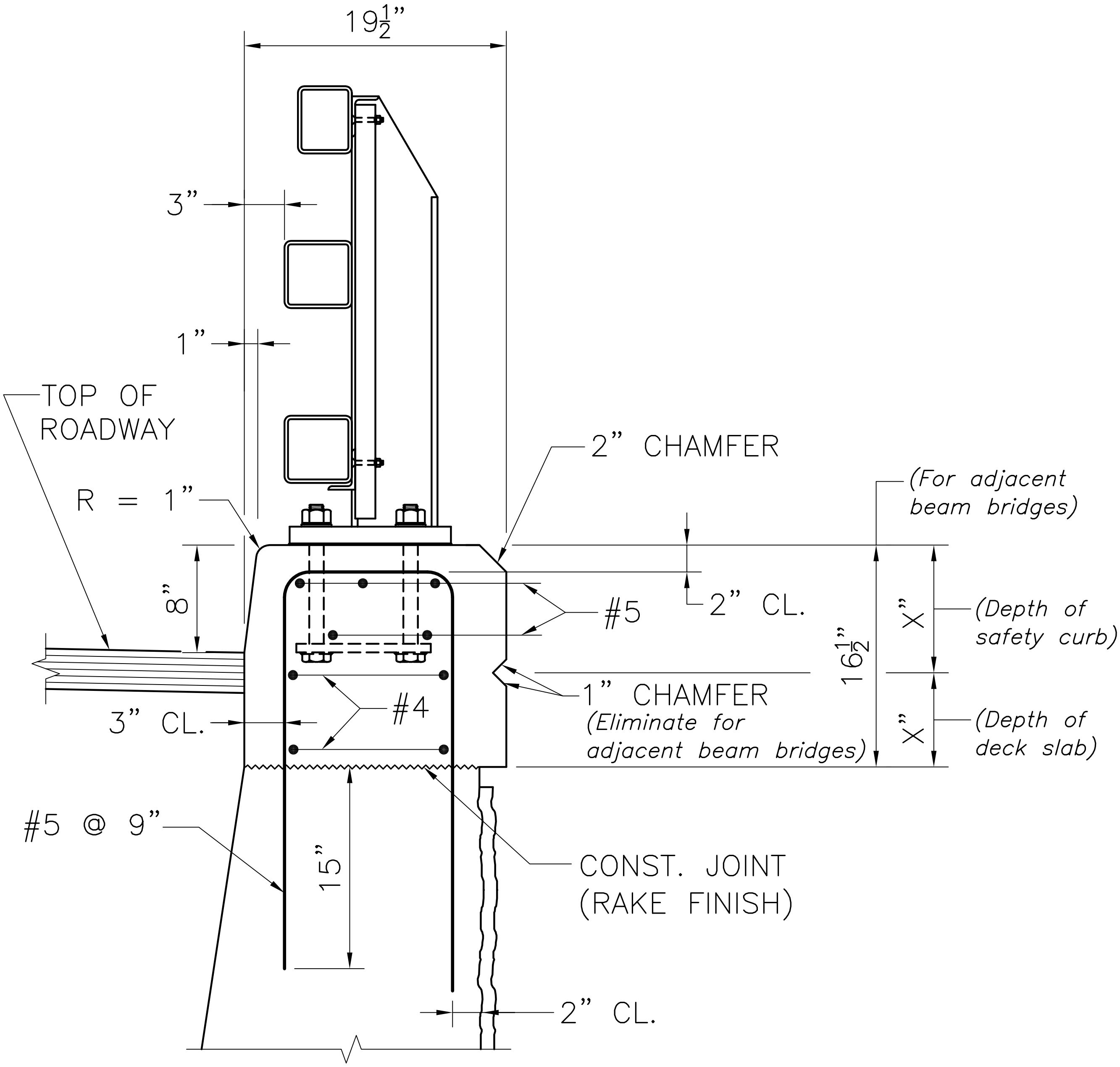
MASS HIGHWAY BRIDGE MANUAL	SECTION THRU SIDEWALK STRINGER BRIDGES S3–TL4 RAIL	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.3.4**



MASS HIGHWAY BRIDGE MANUAL	SDWK. SECTION, ADJACENT BEAMS, HMA W.S. S3–TL4 RAIL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.3.5**



MASS HIGHWAY BRIDGE MANUAL	SDWK. SECTION, ADJACENT BEAMS, EXPOSED DECK S3–TL4 RAIL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.3.6**



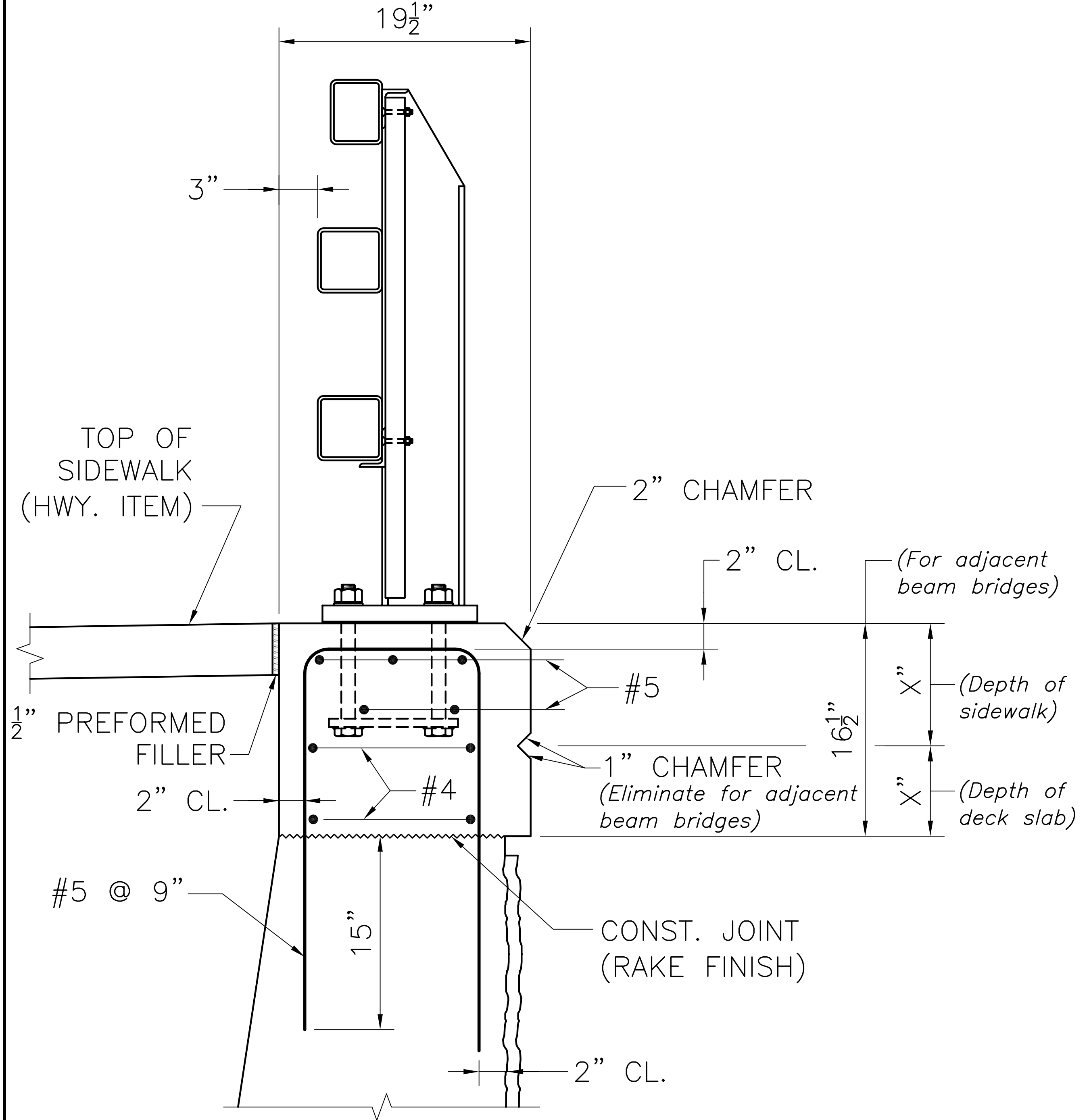
TOP OF U-WINGWALL DETAILS AT SAFETY CURB

SCALE: 1" = 1'-0"

NOTE:

Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U-WINGWALL DETAILS AT SAFETY CURB S3-TL4 RAIL	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.3.7**



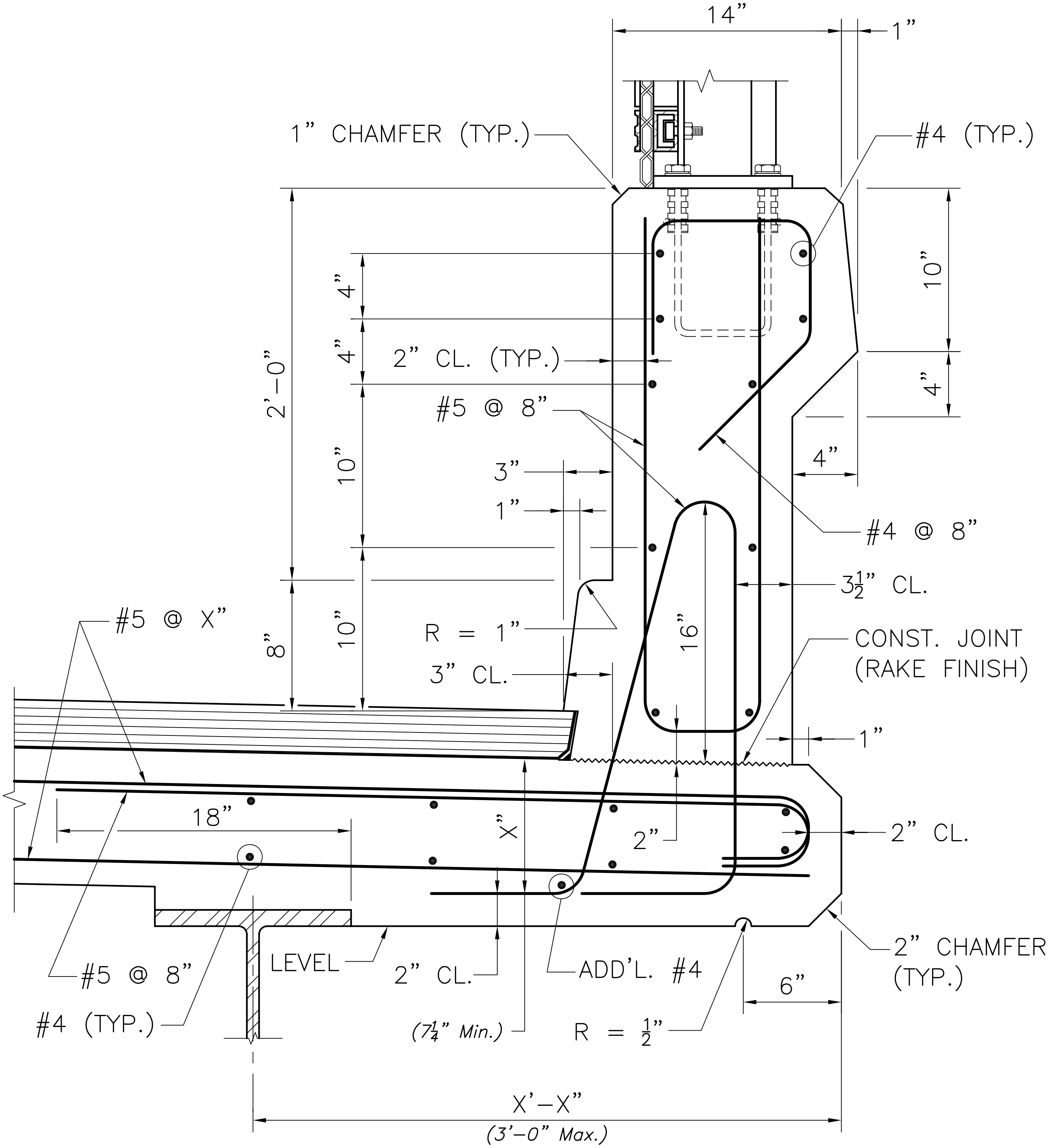
TOP OF U-WINGWALL DETAILS AT SIDEWALK

SCALE: 1" = 1'-0"

NOTE:

Include and label all reinforcement at the top of the wingwall.

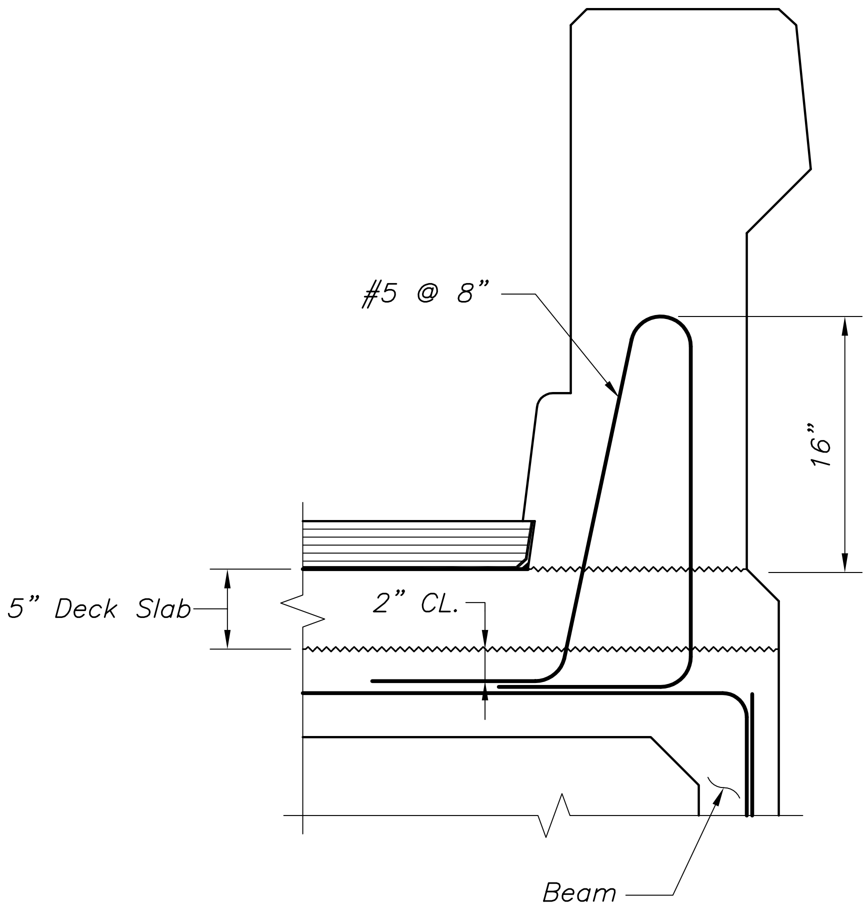
MASS HIGHWAY BRIDGE MANUAL	TOP OF U-WINGWALL DETAILS AT SIDEWALK S3-TL4 RAIL	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **9.3.8**



SECTION THRU CP-PL2 BARRIER AT SAFETY CURB

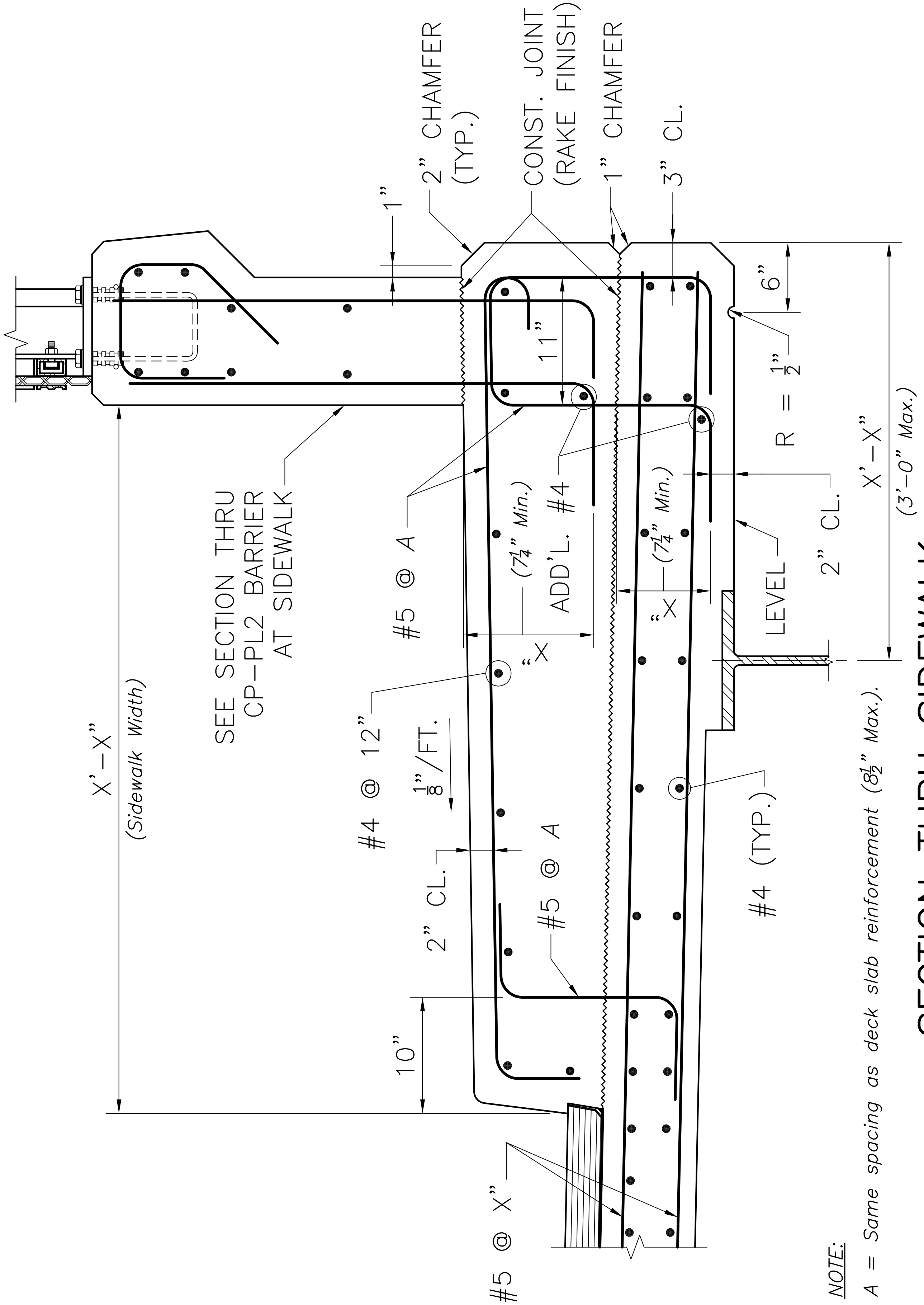
SCALE: 1½" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	DETAILS AT SAFETY CURB	DATE OF ISSUE: NOVEMBER 2010
	CP-PL2 BARRIER	DRAWING NUMBER: 9.4.1



SECTION THRU CP–PL2 BARRIER
AT SAFETY CURB
SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR ADJACENT BEAM BRIDGES CP–PL2 BARRIER	DATE OF ISSUE: MAY 2005 DRAWING NUMBER: **9.4.2**

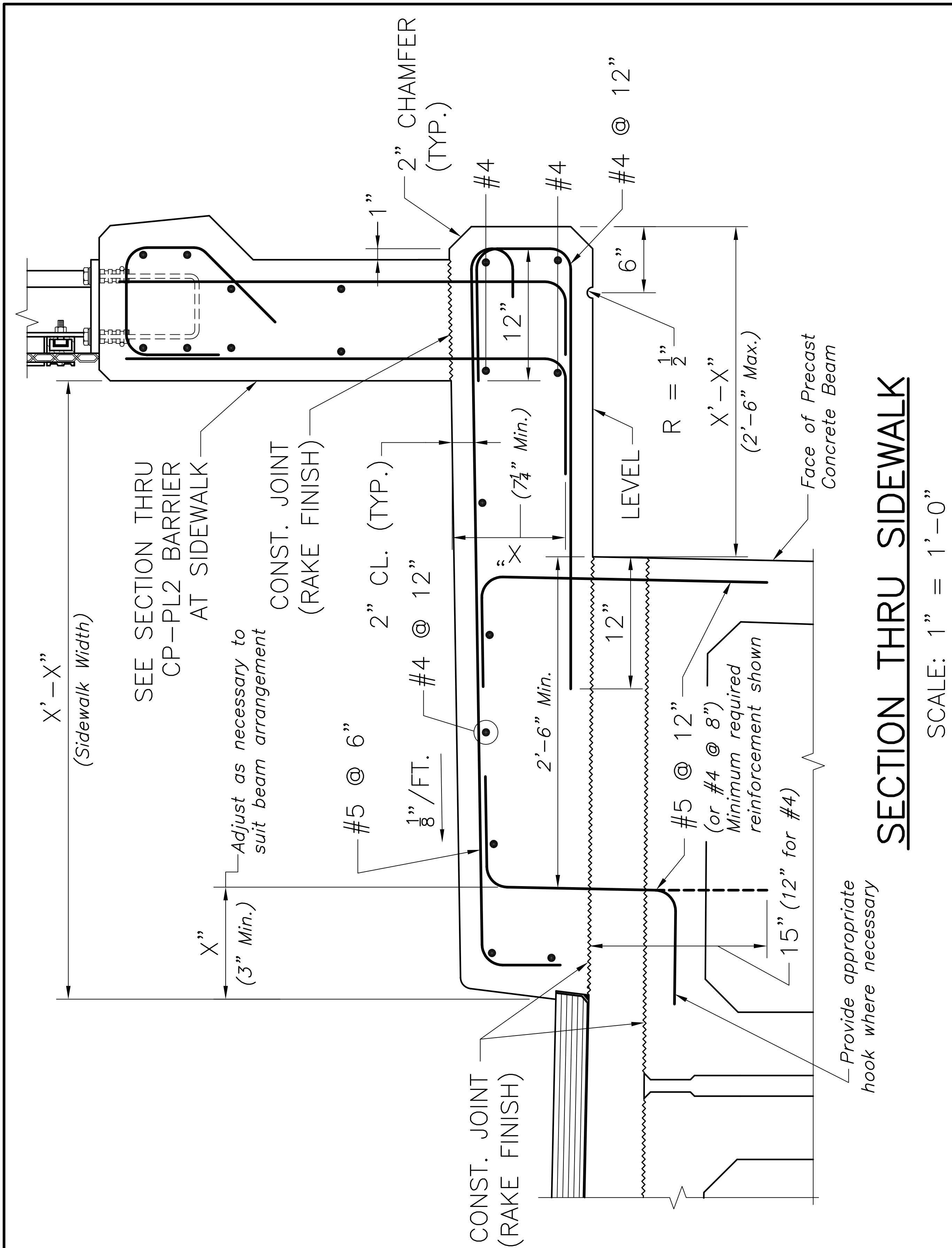


SECTION THRU SIDEWALK

SCALE: 1" = 1'–0"

NOTE: A = Same spacing as deck slab reinforcement (8½" Max.).

MASS HIGHWAY BRIDGE MANUAL	SECTION THRU SIDEWALK STRINGER BRIDGES CP–PL2 BARRIER	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.4.3**



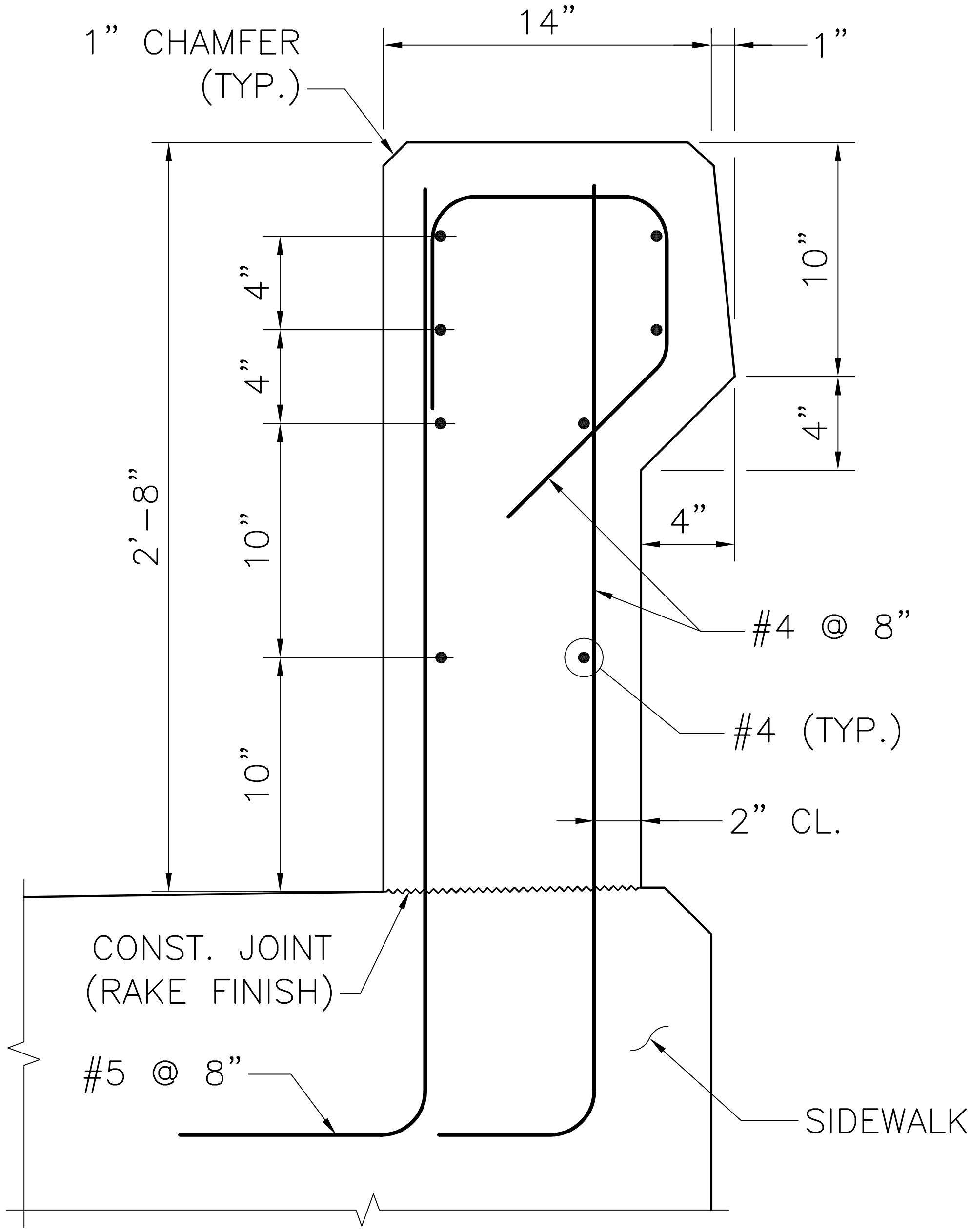
MASS HIGHWAY
BRIDGE MANUAL

SECTION THRU SIDEWALK
ADJACENT BEAM BRIDGES

CP–PL2 BARRIER

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
9.4.4



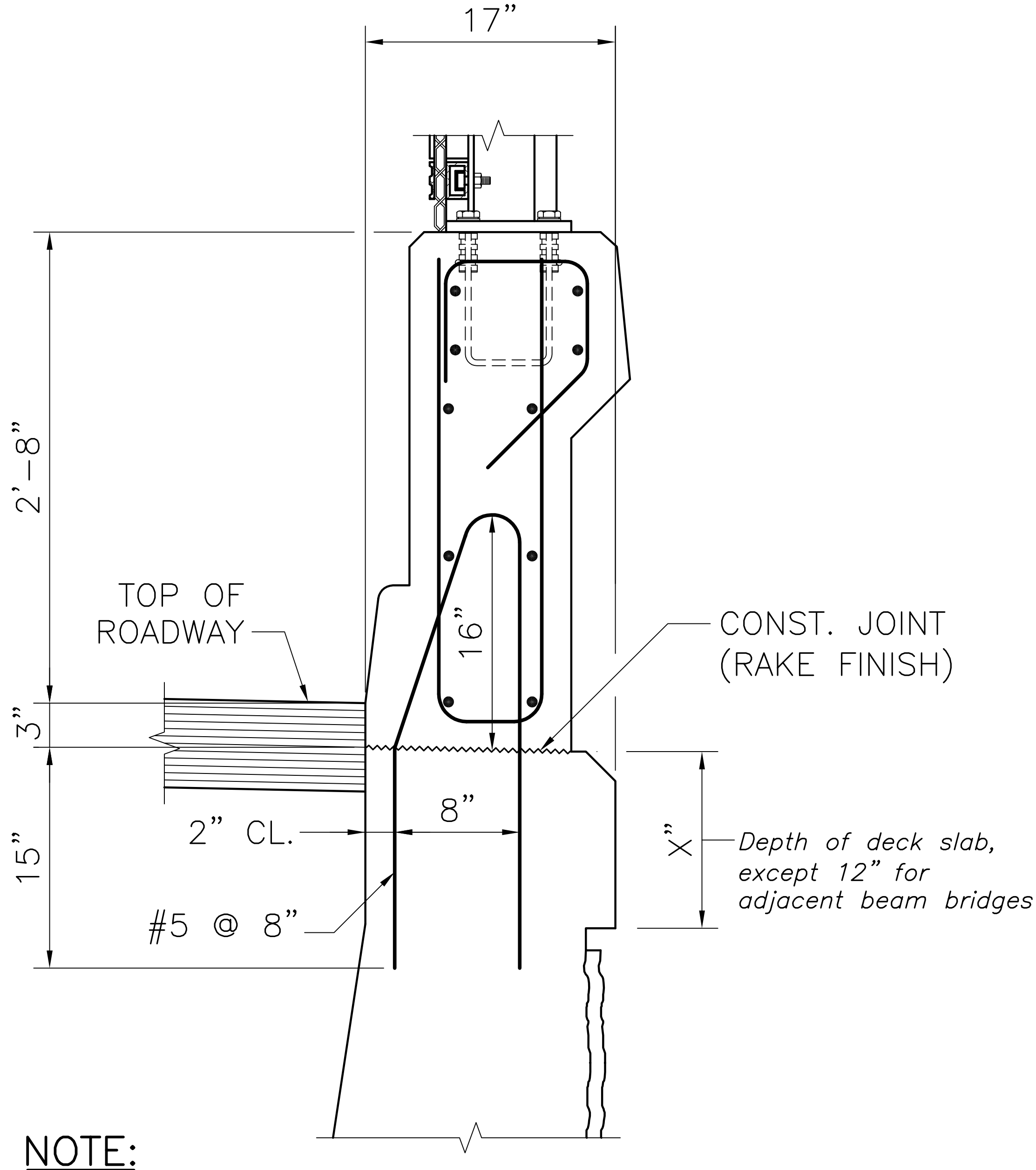
NOTE:

FOR SIDEWALK REINFORCEMENT SEE SECTION THRU SIDEWALK.

SECTION THRU CP-PL2 BARRIER AT SIDEWALK

SCALE: $1\frac{1}{2}$" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	DETAILS AT SIDEWALK	DATE OF ISSUE MAY 2005
	CP-PL2 BARRIER	DRAWING NUMBER 9.4.5



NOTE:

SEE SECTION THRU CP-PL2 BARRIER AT SAFETY CURB FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

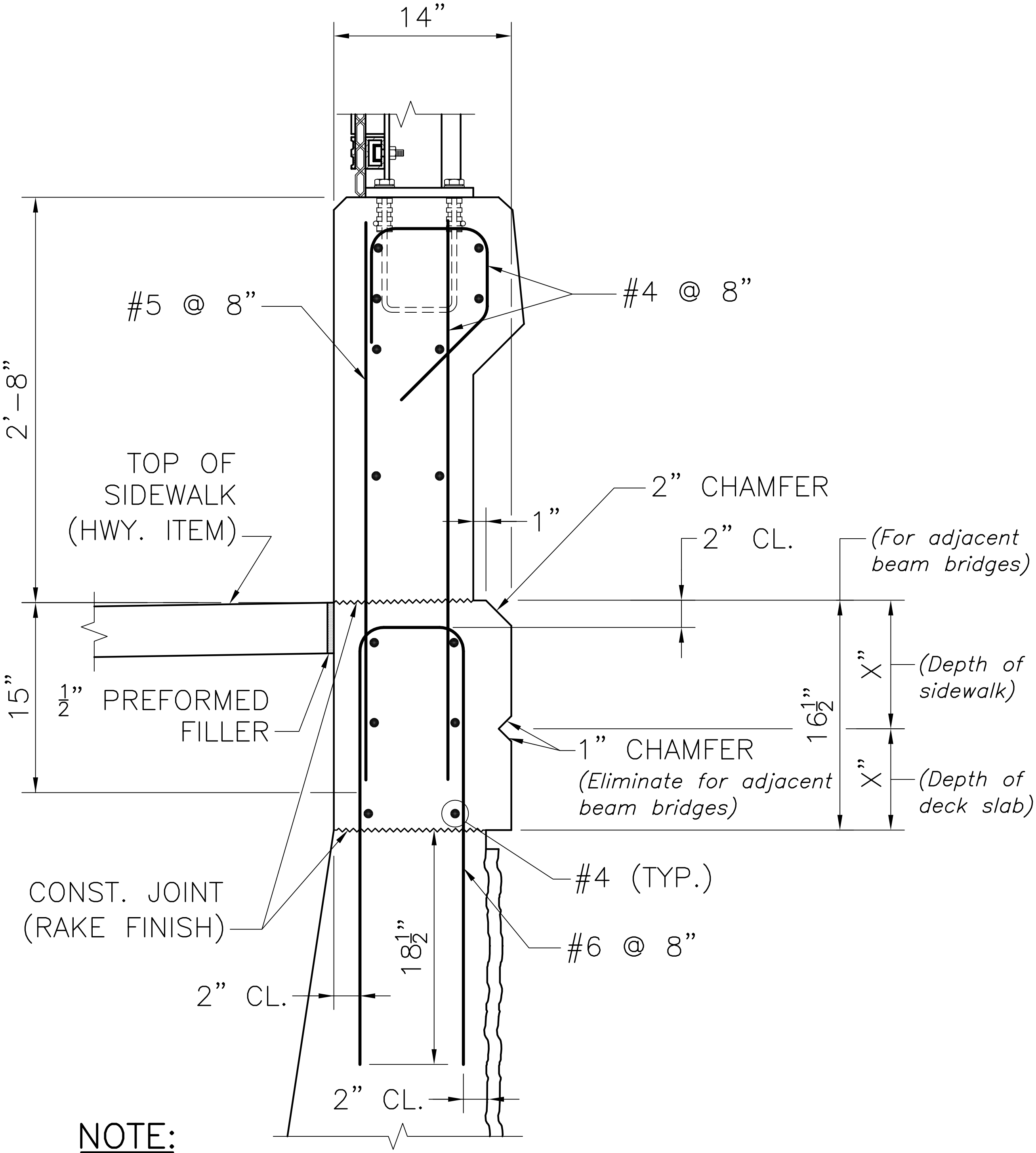
TOP OF U-WINGWALL DETAILS AT SAFETY CURB

SCALE: 1" = 1'-0"

NOTE:

Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U-WINGWALL DETAILS AT SAFETY CURB CP-PL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.4.6**



NOTE:

SEE SECTION THRU CP-PL2 BARRIER AT SIDEWALK FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

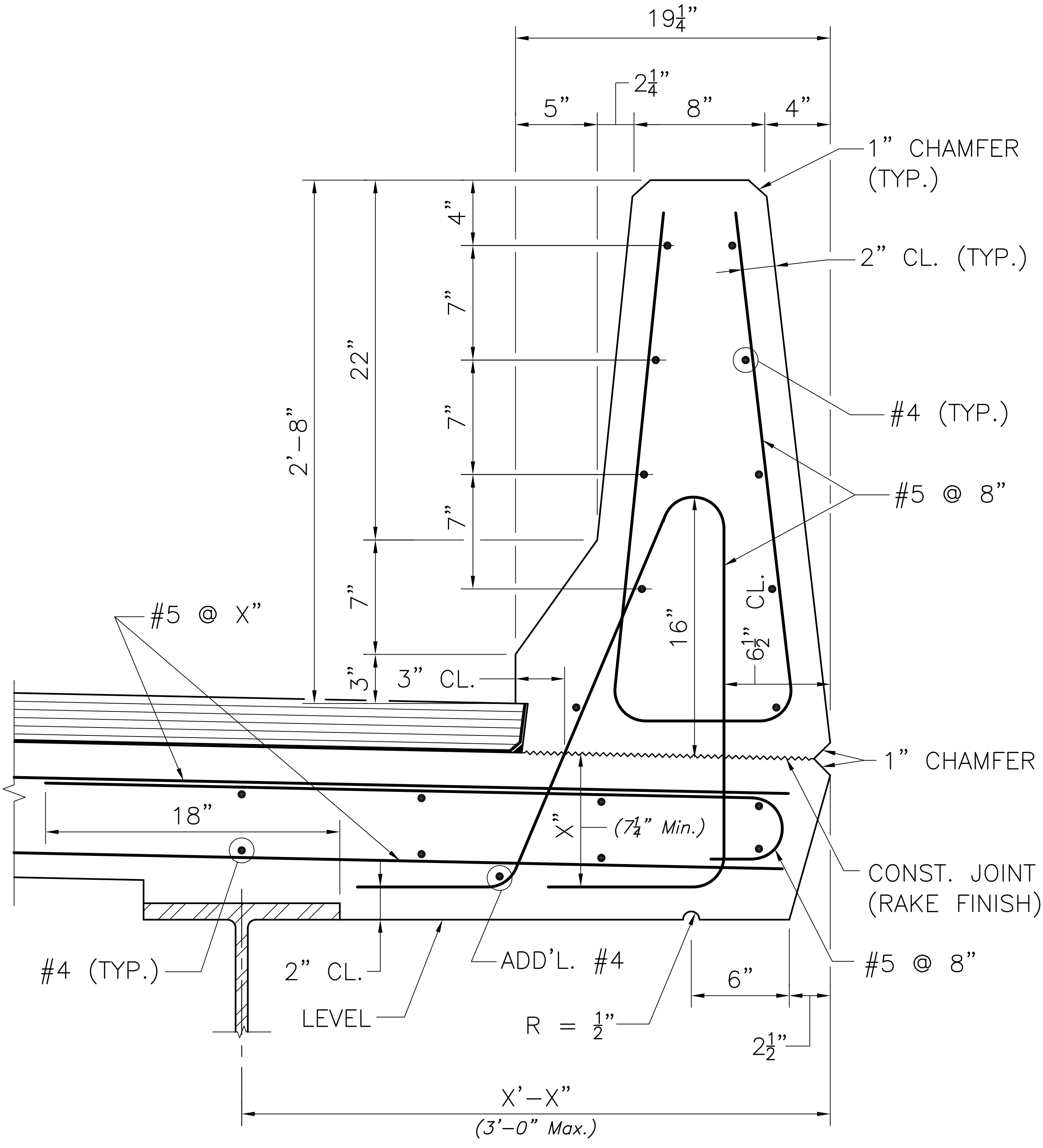
NOTE:

Include and label all reinforcement at the top of the wingwall.

TOP OF U-WINGWALL DETAILS AT SIDEWALK

SCALE: 1" = 1'-0"

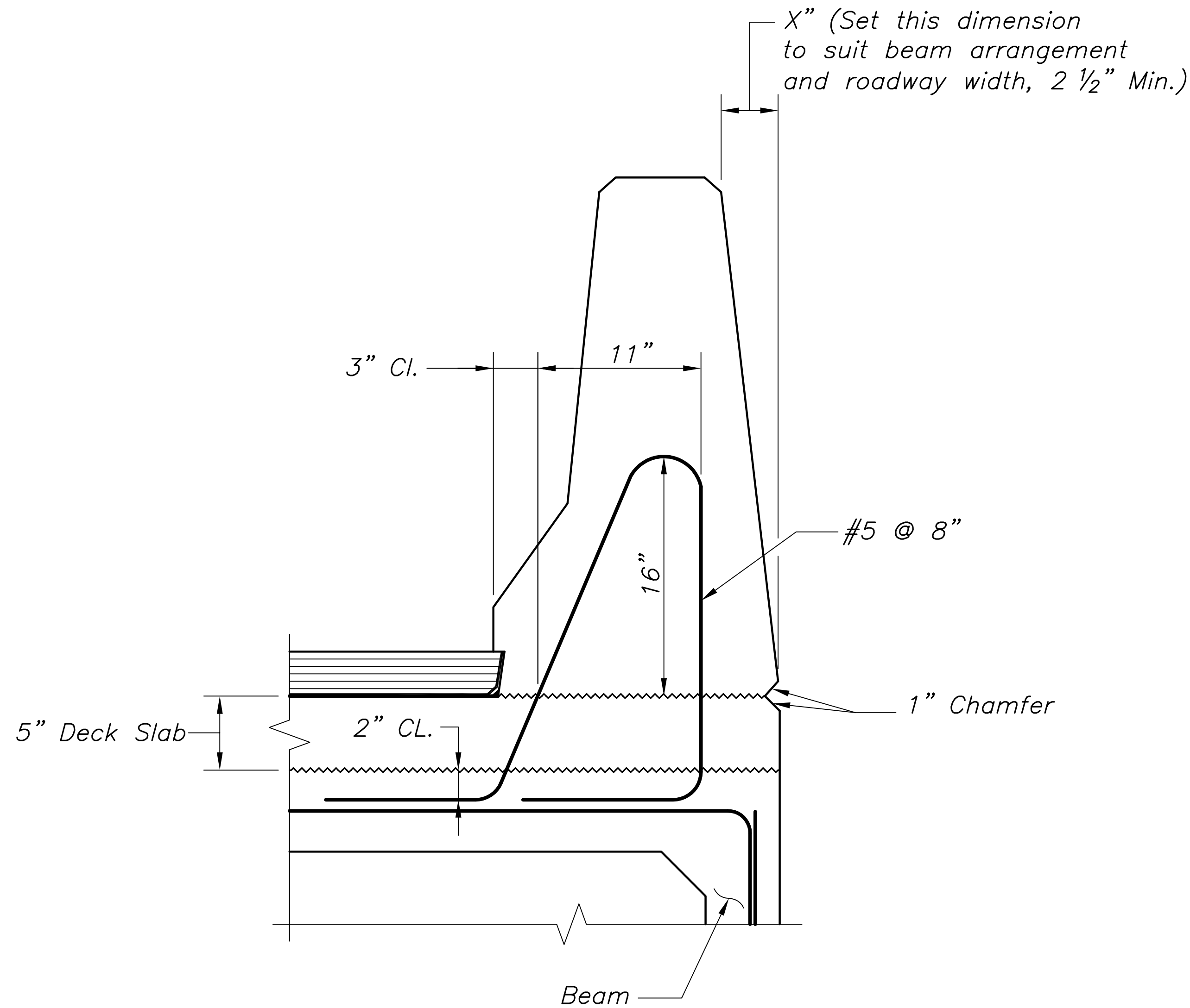
MASS HIGHWAY BRIDGE MANUAL	TOP OF U-WINGWALL DETAILS AT SIDEWALK CP-PL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.4.7**



SECTION THRU CF-PL2 BARRIER

SCALE: 1½" = 1'-0"

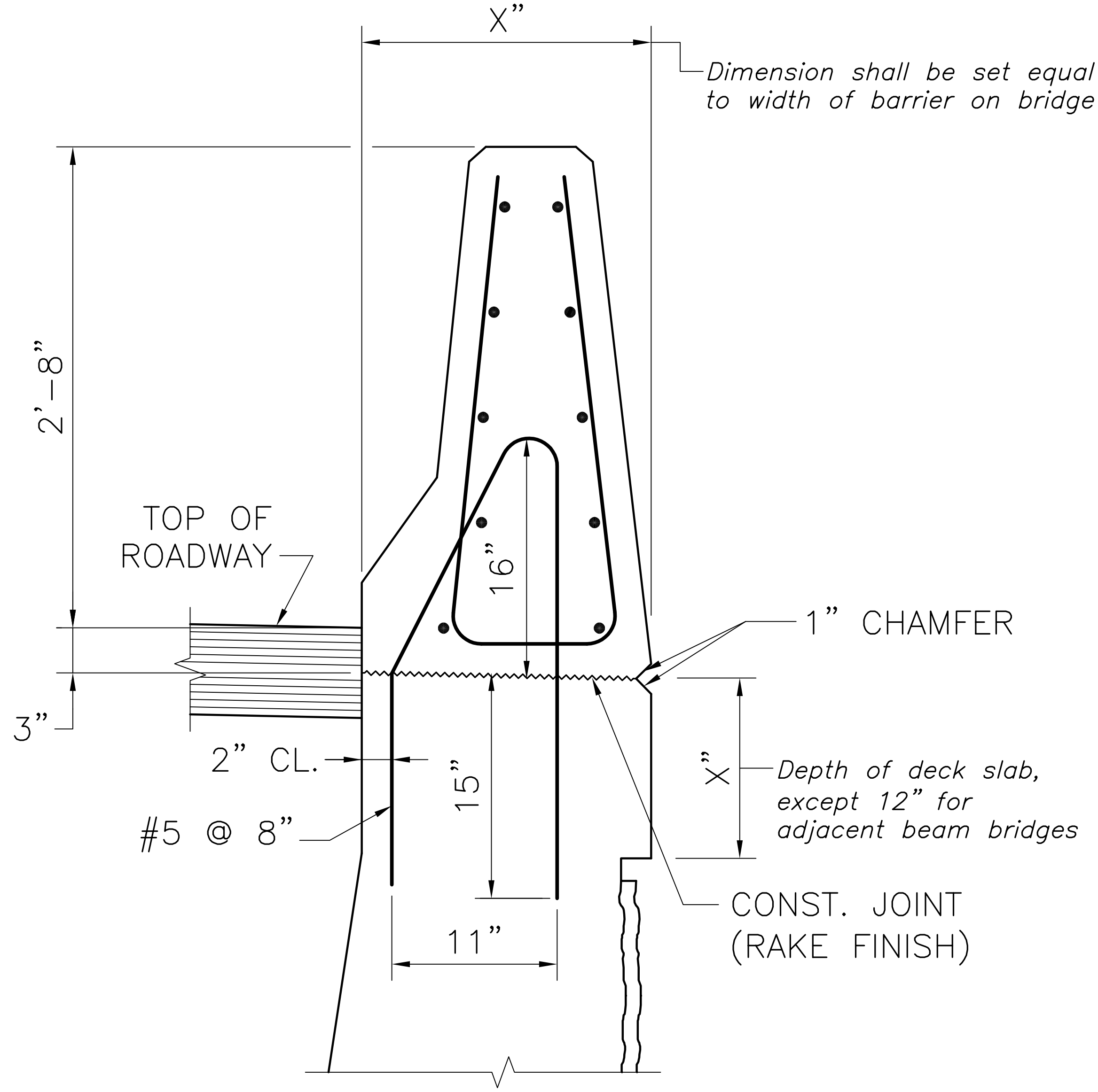
MASS HIGHWAY BRIDGE MANUAL	TYPICAL SECTION	DATE OF ISSUE NOVEMBER 2010
	CF-PL2 BARRIER	DRAWING NUMBER **9.5.1**



SECTION THRU CF–PL2 BARRIER

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR ADJACENT BEAM BRIDGES CF–PL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.5.2**



NOTE:

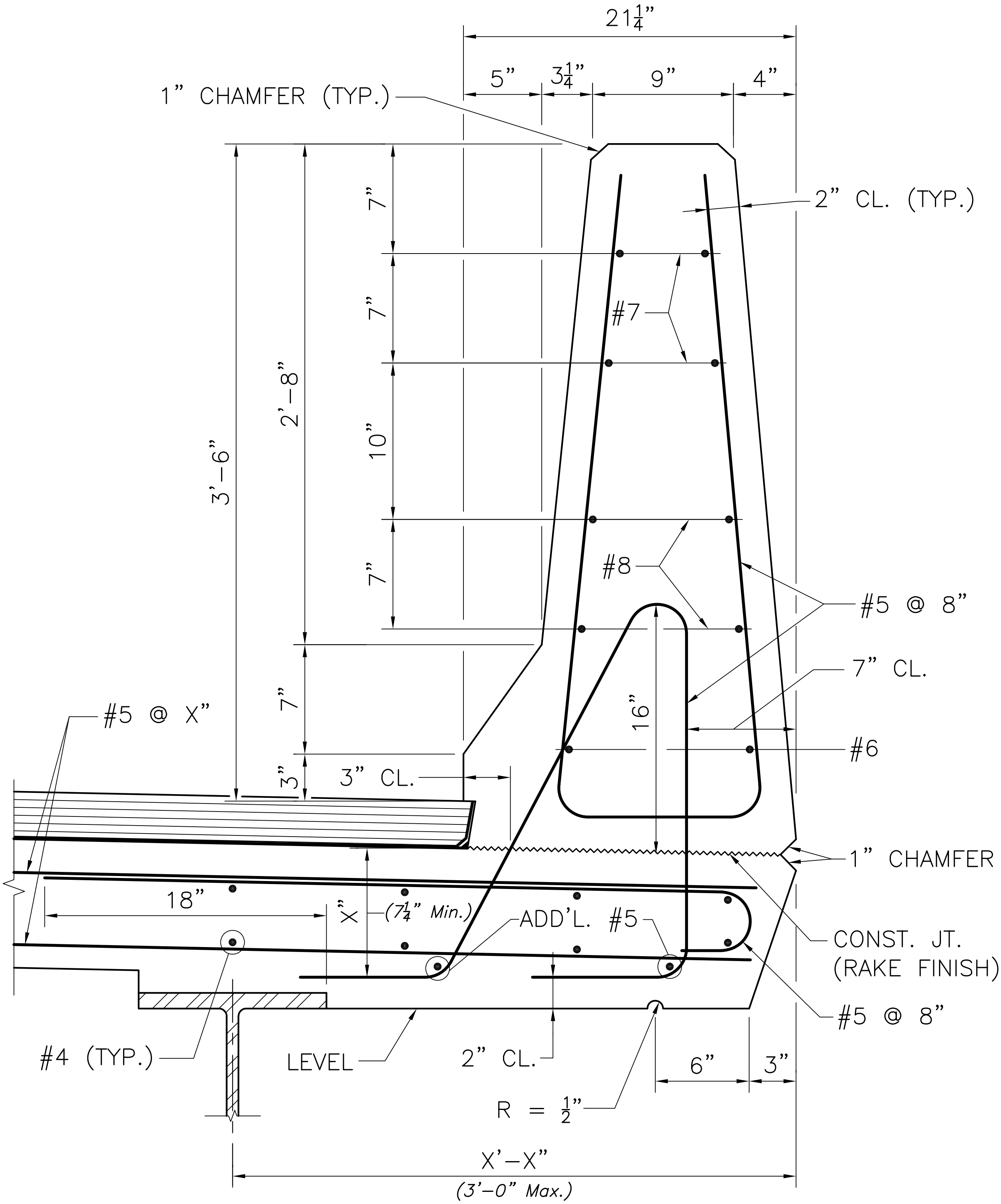
SEE SECTION THRU CF–PL2 BARRIER FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

TOP OF U–WINGWALL DETAILS

SCALE: 1" = 1'–0"

NOTE:
Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U–WINGWALL DETAILS CF–PL2 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.5.3**



SECTION THRU CF-PL3 BARRIER

SCALE: 1½" = 1'-0"

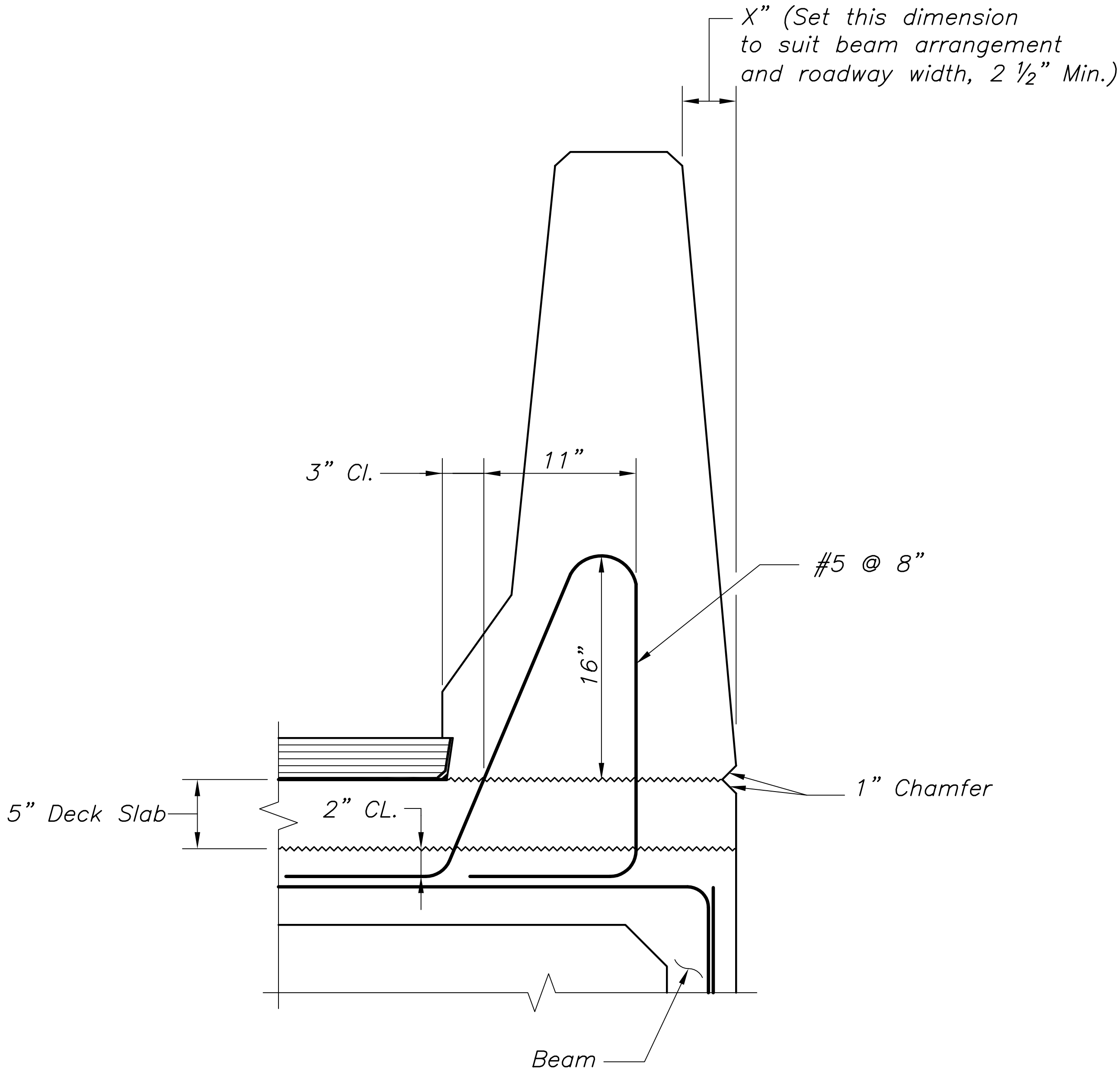
MASS HIGHWAY BRIDGE MANUAL

TYPICAL SECTION

CF-PL3 BARRIER

DATE OF ISSUE
NOVEMBER 2010

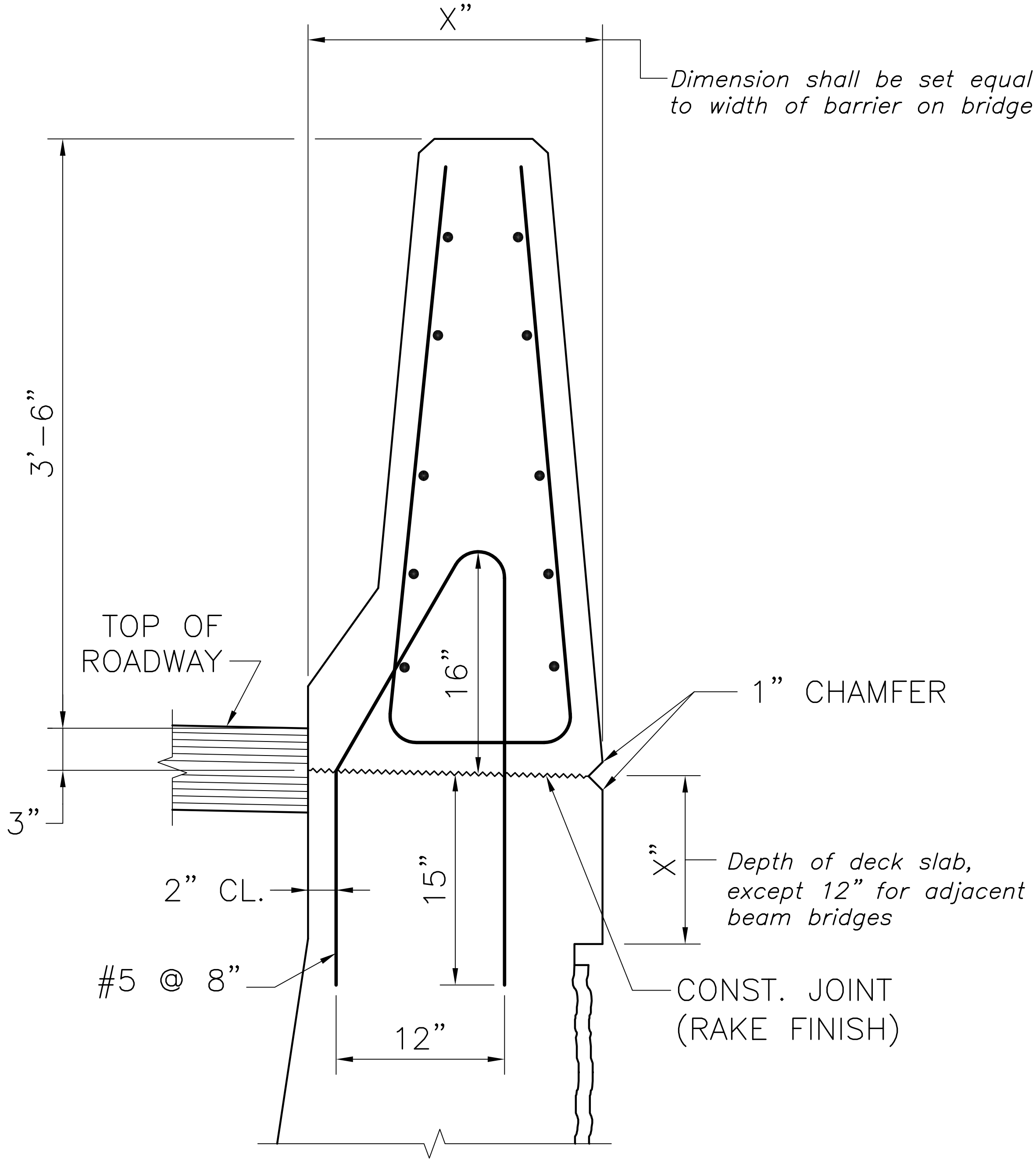
DRAWING NUMBER
9.6.1



SECTION THRU CF–PL3 BARRIER

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	MODIFICATIONS FOR ADJACENT BEAM BRIDGES CF–PL3 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER 9.6.2



NOTE:

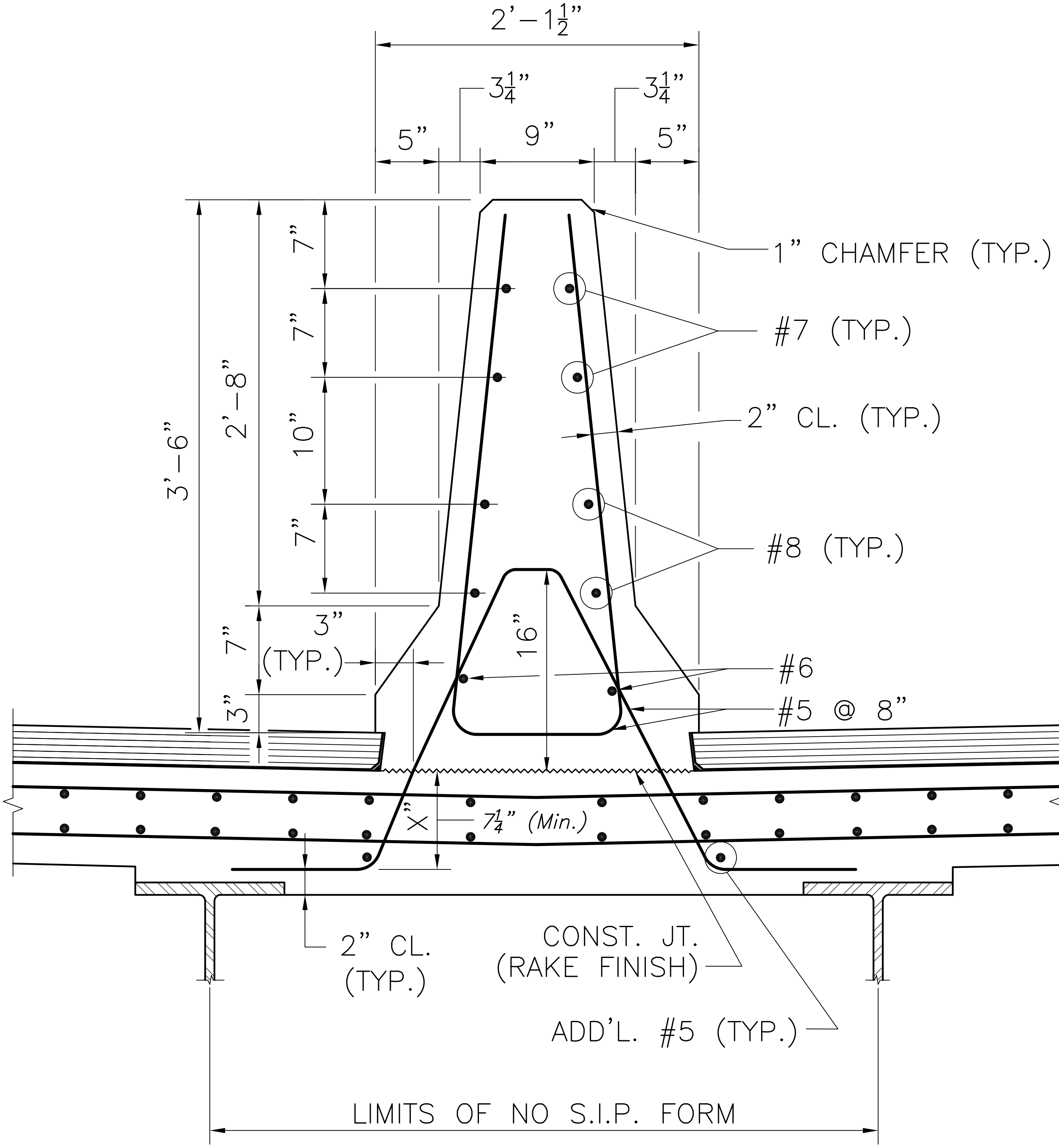
SEE SECTION THRU CF–PL3 BARRIER FOR DIMENSIONS AND REINFORCEMENT NOT SHOWN HERE.

TOP OF U–WINGWALL DETAILS

SCALE: 1" = 1'–0"

NOTE:
Include and label all reinforcement at the top of the wingwall.

MASS HIGHWAY BRIDGE MANUAL	TOP OF U–WINGWALL DETAILS CF–PL3 BARRIER	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.6.3**



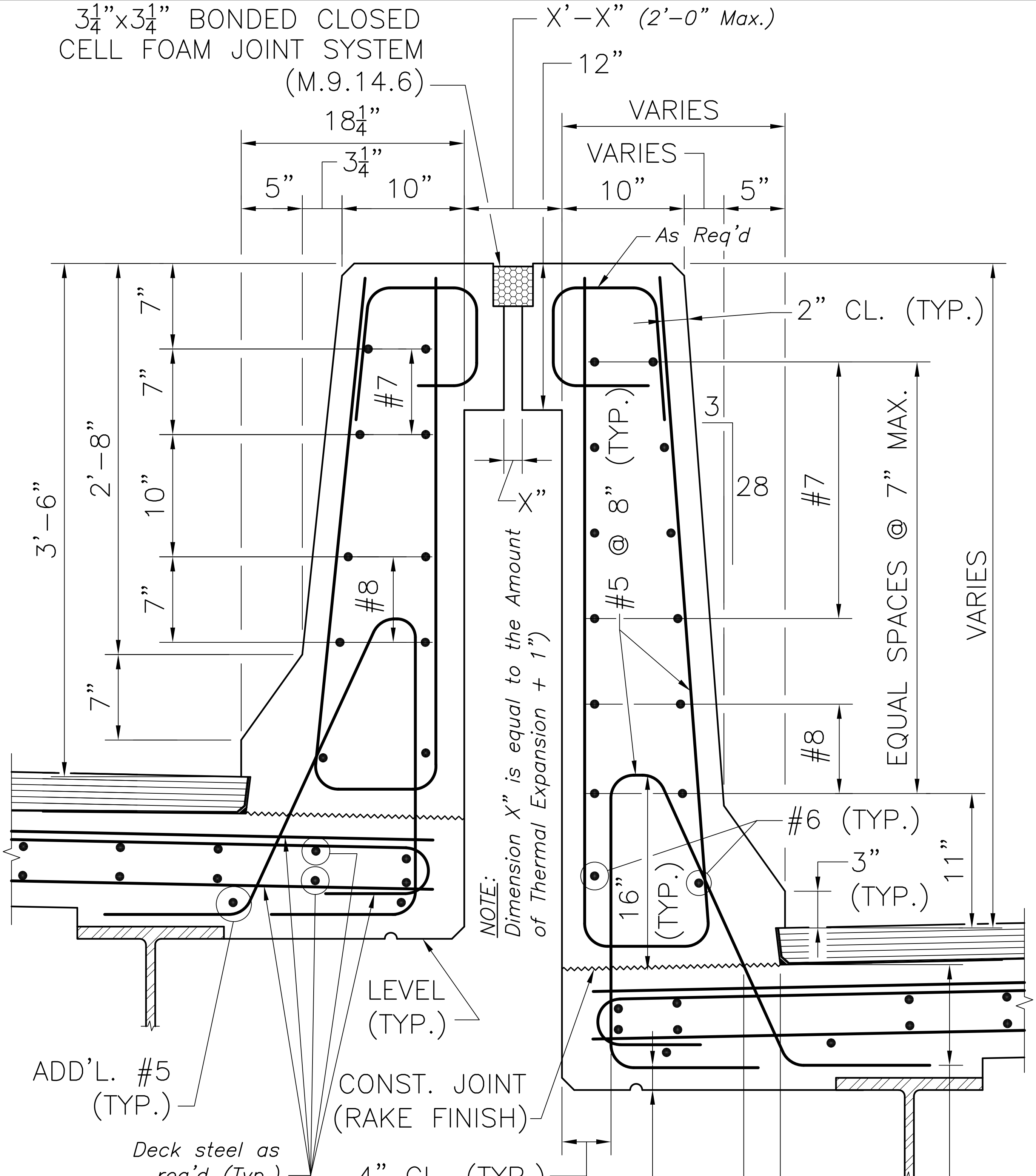
CF–PL3 MEDIAN BARRIER

SCALE: 1" = 1'–0"

NOTE:

CF–PL2 Barrier similar, except modify details to be consistent with Dwg. No. 9.5.1.

MASS HIGHWAY BRIDGE MANUAL	DOUBLE FACE MEDIAN BARRIER CF–PL3 MEDIAN BARRIER	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.7.1**



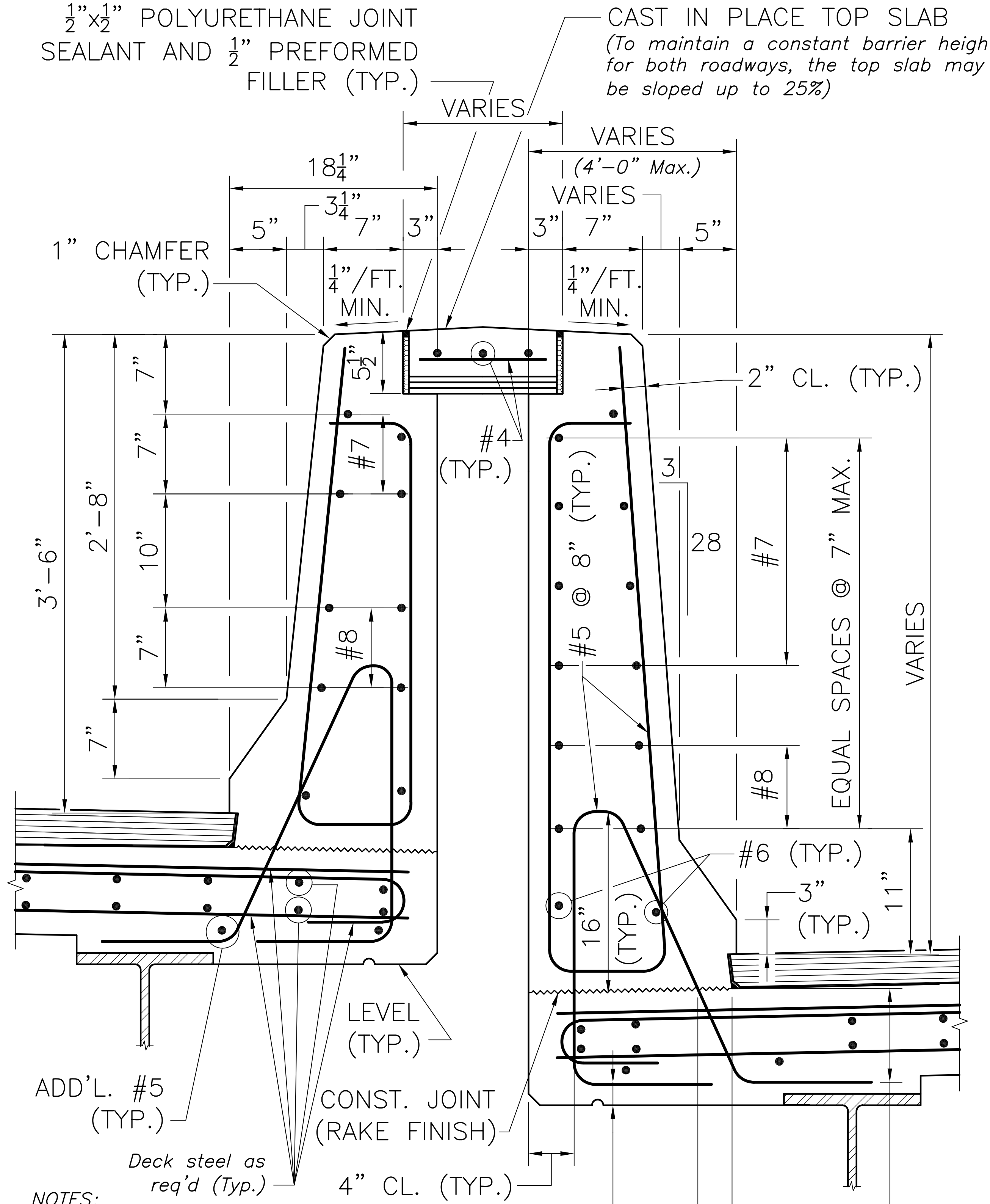
NOTES:

1. *CF–PL2 Barrier similar, except modify details to be consistent with Dwg. No. 9.5.1.*
2. *Refer to Dwg. No. 9.6.1 for deck overhang limits.*

CF–PL3 MEDIAN BARRIER

SCALE: 1" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SINGLE FACE MEDIAN BARRIER WITH JOINT SYSTEM CF–PL3 MEDIAN BARRIER	DATE OF ISSUE: NOVEMBER 2010 DRAWING NUMBER: **9.7.2**



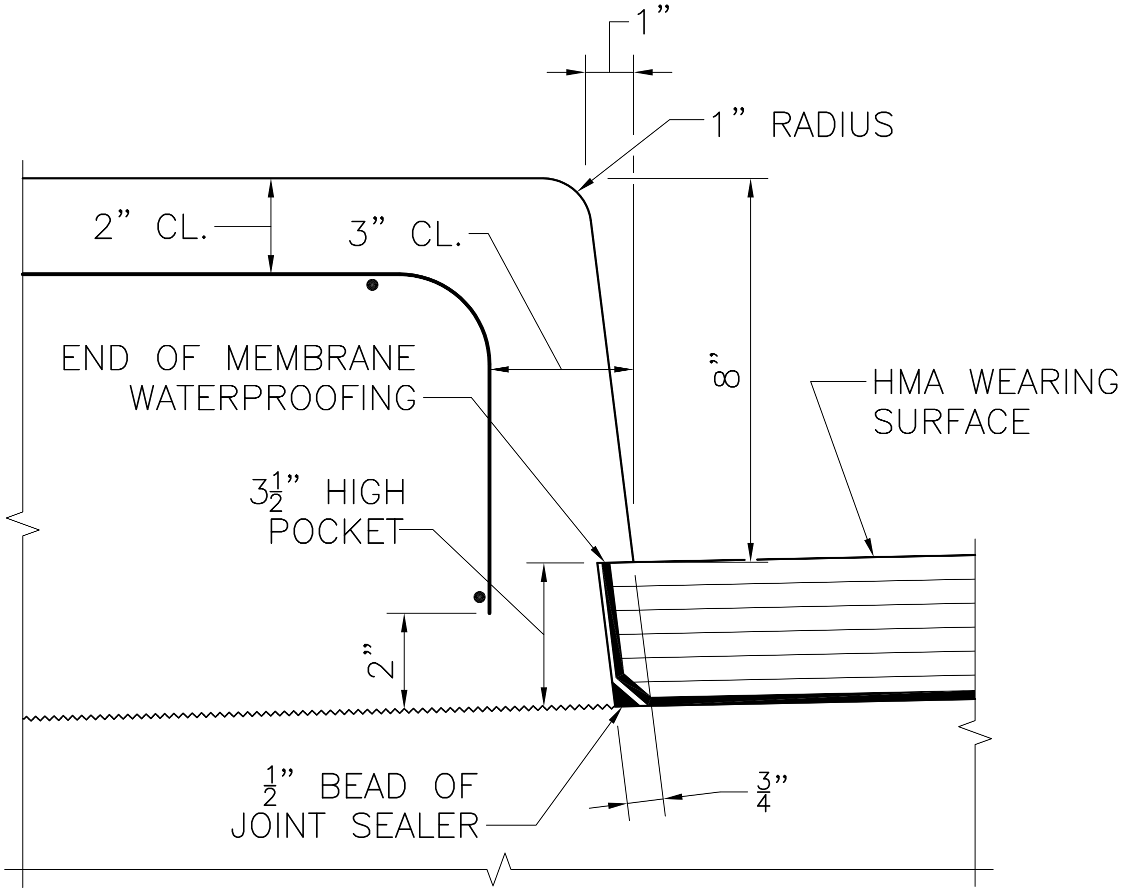
NOTES:

1. CF-PL2 Barrier similar, except modify details to be consistent with Dwg. No. 9.5.1.
2. Refer to Dwg. No. 9.6.1 for deck overhang limits.

CF-PL3 MEDIAN BARRIER

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	SINGLE FACE MEDIAN BARRIER WITH TOP SLAB CF-PL3 MEDIAN BARRIER	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.7.3**



NOTES:

1. TURN MEMBRANE UP INTO 3½" HIGH POCKET.

2. DIMENSIONS AT THE FACE OF CURB ARE THE SAME FOR THE SAFETY CURB.
   (Add this note for bridges with S3–TL4 metal bridge rail only)

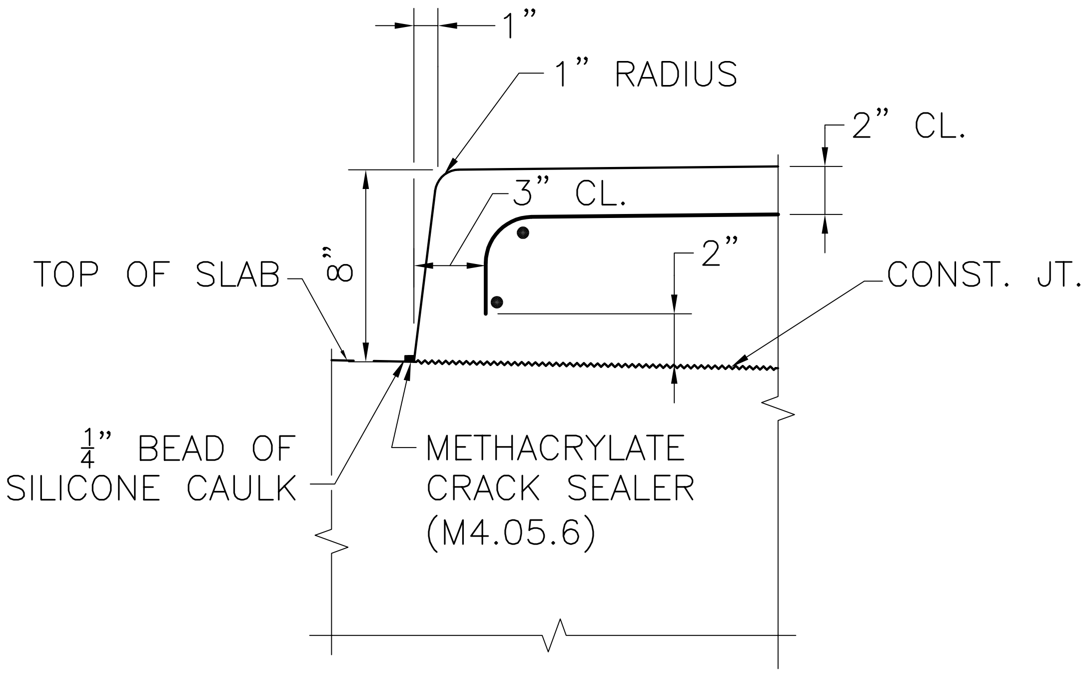
FACE OF SIDEWALK CURB DETAILS

SCALE: 3" = 1'–0"

NOTE:

For bridges with a variable depth HMA wearing surface, eliminate Note 1 and omit the height of pocket dimension on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK CURB DETAILS BRIDGES WITH HMA W.S. CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.8.1**



NOTES:

1. METHACRYLATE CRACK SEALER SHALL BE APPLIED AFTER SIDEWALK OR SAFETY CURB/BARRIER CURING PERIOD IS COMPLETE AND IN ACCORDANCE WITH REQUIREMENTS OF MANUFACTURER AND THE STANDARD SPECIFICATIONS.

2. BEFORE SEALING, THE CONCRETE AT THE INTERFACE OF DECK AND CURB SHALL BE SWEPT CLEAN AND BLOWN OFF USING OIL FREE COMPRESSED AIR IMMEDIATELY PRIOR TO APPLYING THE SEALER.

3. APPLY ¼" HIGH BEAD OF SILICONE CAULKING COMPOUND ABOUT ¼" FROM THE FACE OF CURB.

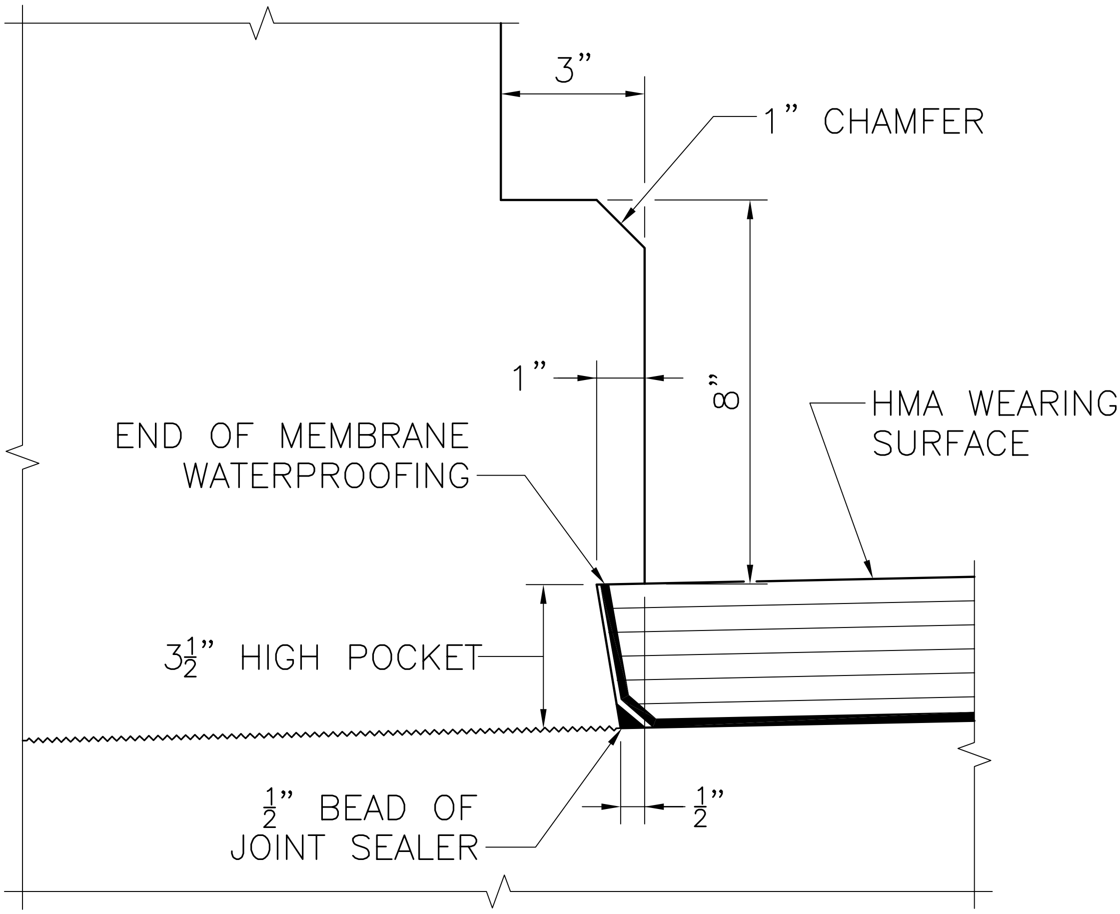
4. METHACRYLATE SHALL THEN BE POURED INTO THE ¼" WIDE GAP BETWEEN THE FACE OF CURB AND THE BEAD OF CAULK.

5. CURB AT SIDEWALK SHOWN. SAFETY CURB IS SIMILAR.

FACE OF CURB DETAILS

SCALE: 1½" = 1'−0"

MASS HIGHWAY BRIDGE MANUAL	FACE OF CURB DETAILS EXPOSED DECK BRIDGES CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.8.2**



NOTE:

TURN MEMBRANE UP INTO $3\frac{1}{2}$" HIGH POCKET.

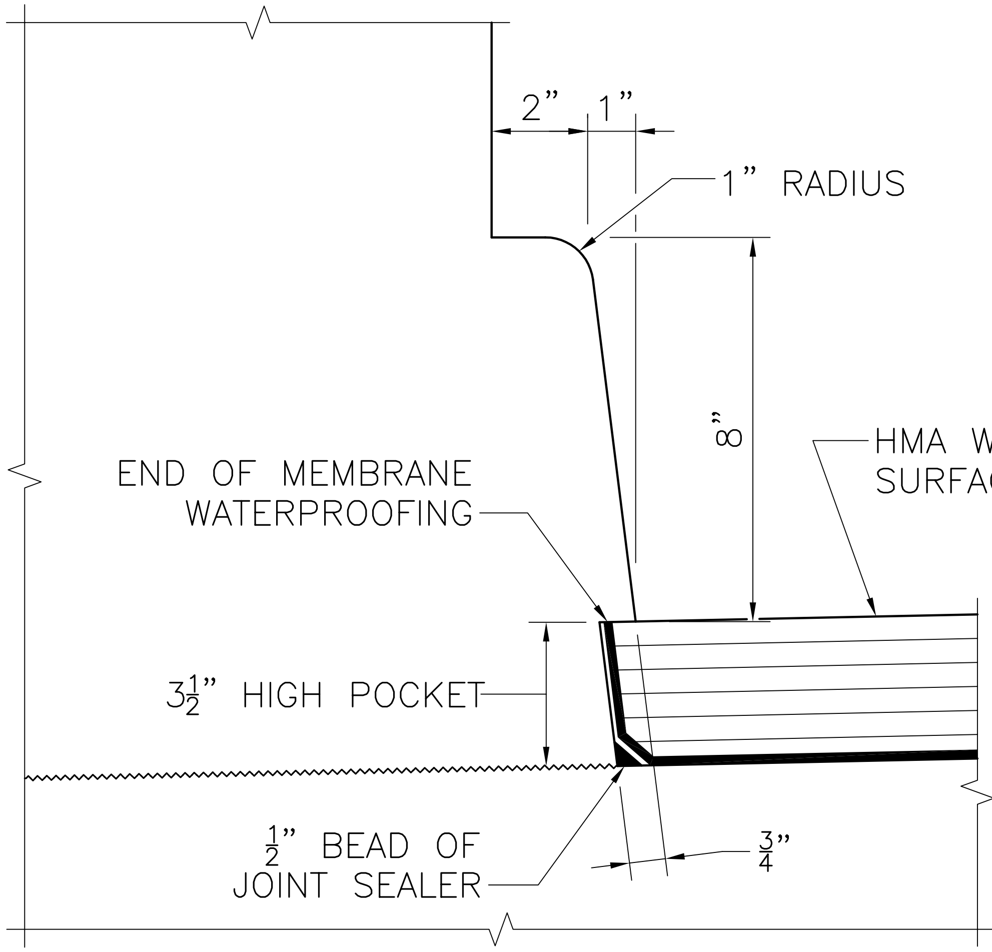
FACE OF SAFETY CURB DETAILS

SCALE: 3" = 1'-0"

NOTE:

For bridges with a variable depth HMA wearing surface, eliminate Note and omit the height of pocket dimension on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	FACE OF SAFETY CURB FOR CT-TL2 BARRIER CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.8.3**



NOTE:

TURN MEMBRANE UP INTO $3\frac{1}{2}$" HIGH POCKET.

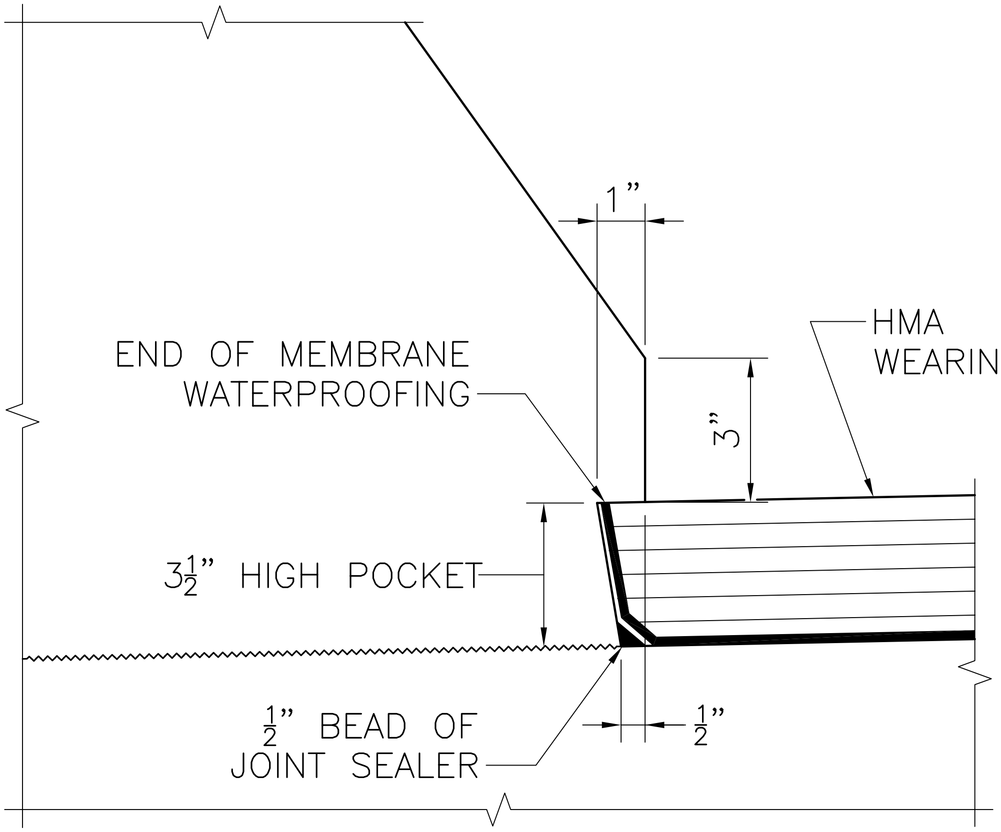
FACE OF SAFETY CURB DETAILS

SCALE: 3" = 1'–0"

NOTE:

For bridges with a variable depth HMA wearing surface, eliminate Note and omit the height of pocket dimension on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	FACE OF SAFETY CURB FOR CP–PL2 BARRIER CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.8.4**



NOTE:

TURN MEMBRANE UP INTO 3½" HIGH POCKET.

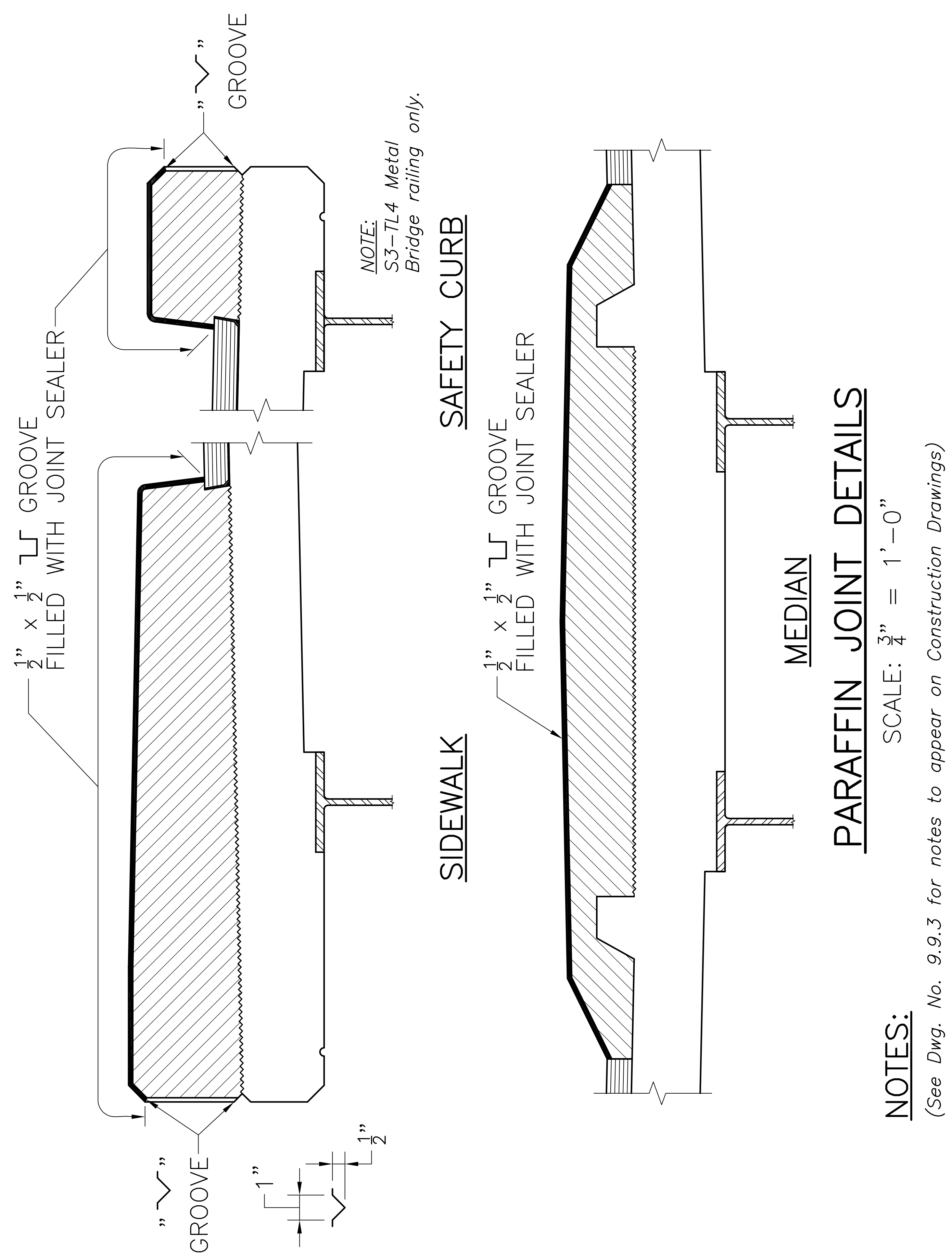
FACE OF SAFETY CURB DETAILS

SCALE: 3" = 1'-0"

NOTE:

For bridges with a variable depth HMA wearing surface, eliminate Note and omit the height of pocket dimension on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	FACE OF SAFETY CURB FOR CF BARRIERS CURB DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.8.5**



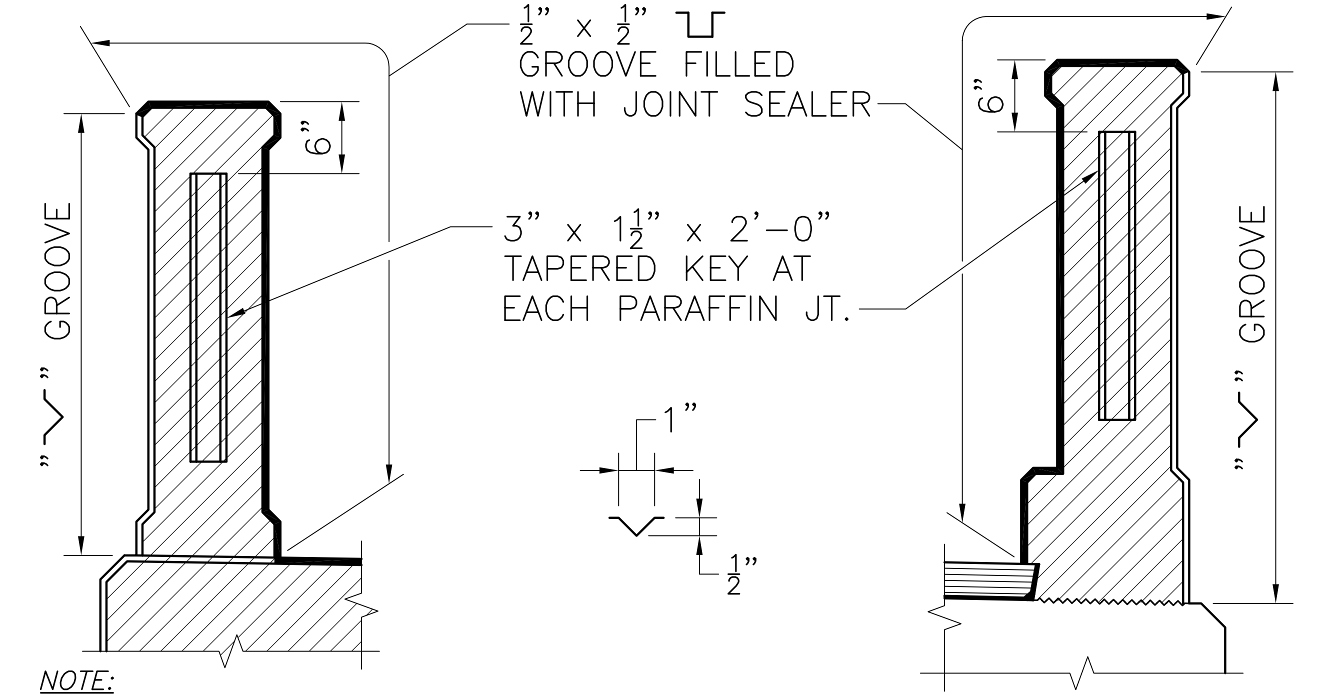
PARAFFIN JOINT DETAILS

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

(See Dwg. No. 9.9.3 for notes to appear on Construction Drawings)

MASS HIGHWAY BRIDGE MANUAL	SIDEWALK, SAFETY CURB AND MEDIAN SLABS PARAFFIN JOINT DETAILS	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **9.9.1**

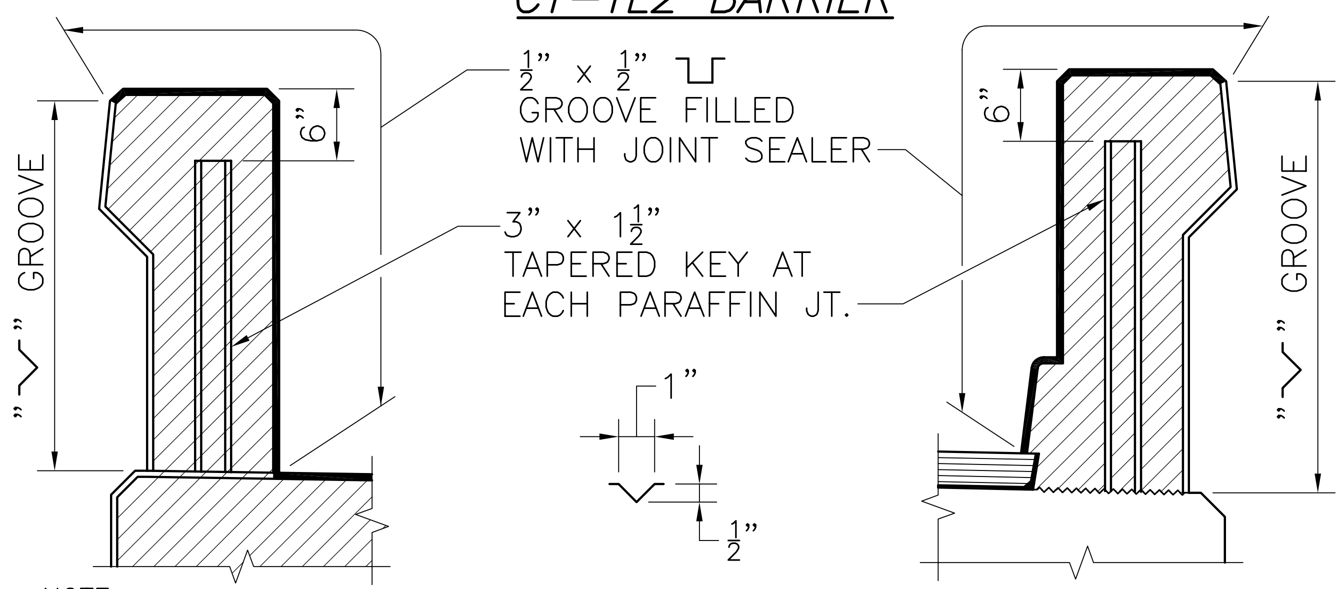


NOTE:
See Dwg. No. 9.9.1 for sidewalk details.

SIDEWALK SIDE

SAFETY CURB SIDE

CT-TL2 BARRIER



NOTE:
See Dwg. No. 9.9.1 for sidewalk details.

SIDEWALK SIDE

SAFETY CURB SIDE

CP-PL2 BARRIER

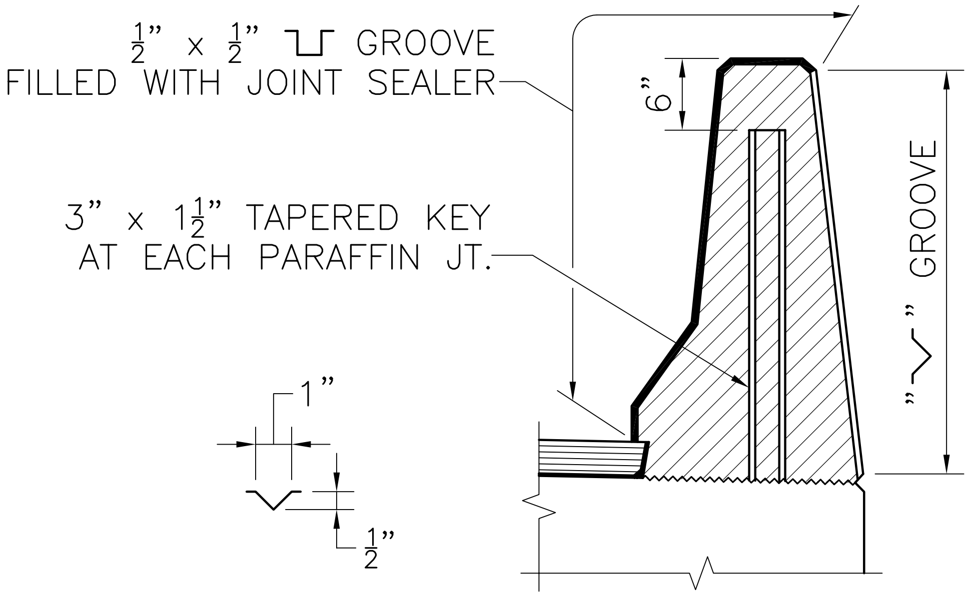
PARAFFIN JOINT DETAILS

SCALE: $\frac{3}{4}$" = 1'-0"

NOTES:

(See Dwg. No. 9.9.3 for notes to appear on Construction Drawings)

MASS HIGHWAY BRIDGE MANUAL	CT-TL2 AND CP-PL2 BARRIERS PARAFFIN JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.9.2**



CF BARRIERS

NOTES:

1. ALL CONCRETE ABOVE SLAB SHALL BE POURED IN ALTERNATING SECTIONS WITH NOT LESS THAN 3 DAYS BETWEEN POURS.

2. DO NOT CARRY LONGITUDINAL BARS THROUGH THE PARAFFIN JOINTS. END THE REINFORCEMENT 2" CLEAR OF JOINT.

3. JOINT SHALL BE SQUARE TO FACE OF CURB *(or coping).*

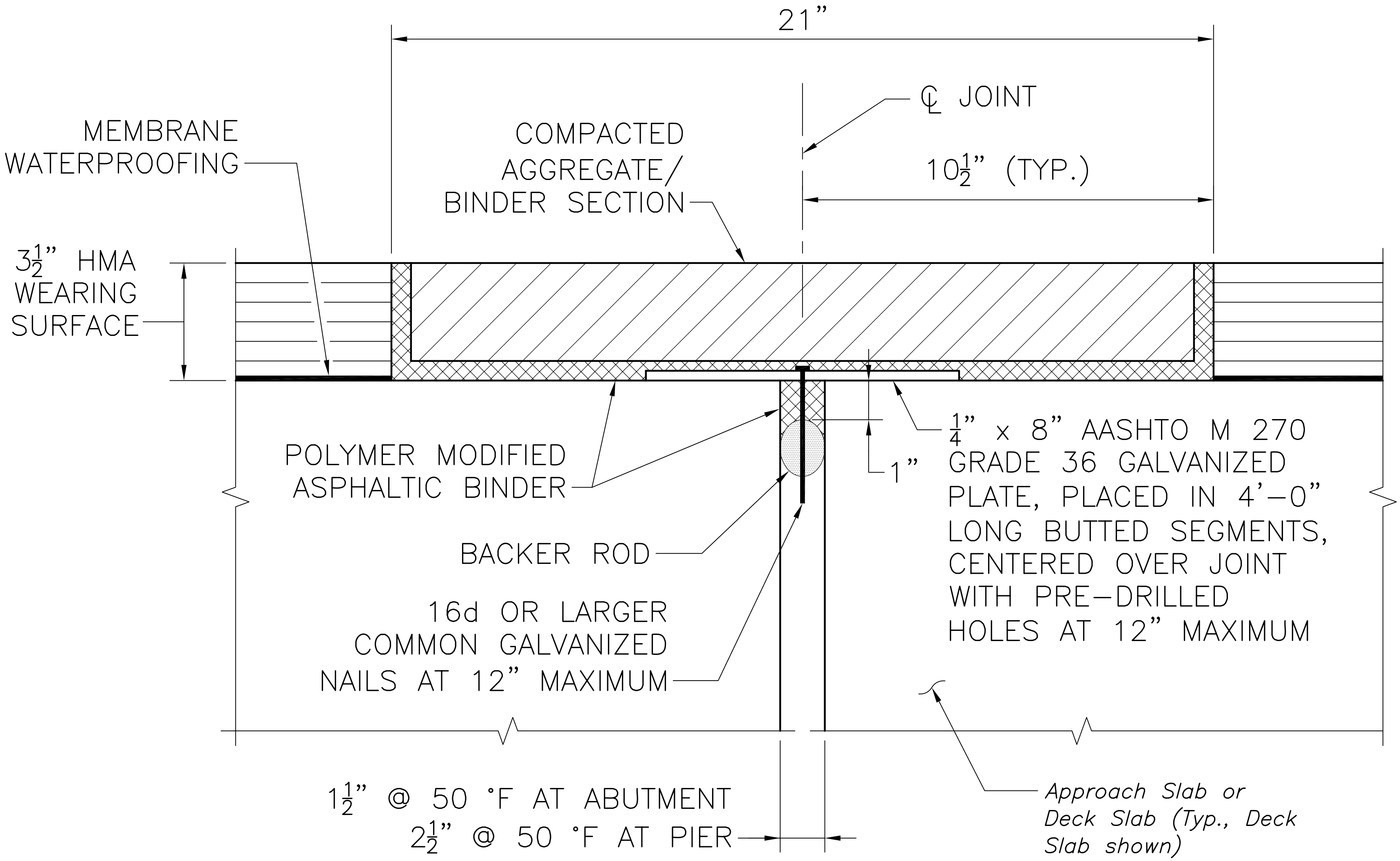
PARAFFIN JOINT DETAILS

SCALE: ¾" = 1'-0"

NOTES:

1. *Modify the details shown in this section as required to show the correct shape, wearing surface and support beams.*
2. *Paraffin joints for sidewalk and safety curb slabs for S3-TL4 Bridge metal railing shall be located at the approximate center of every third railing panel. Paraffin joints for concrete railing or barriers shall be spaced preferably between 20' and 25'. A minimum of 15' may be used, if necessary. The location of the joints shall be dimensioned on the Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	CF BARRIERS AND NOTES PARAFFIN JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **9.9.3**



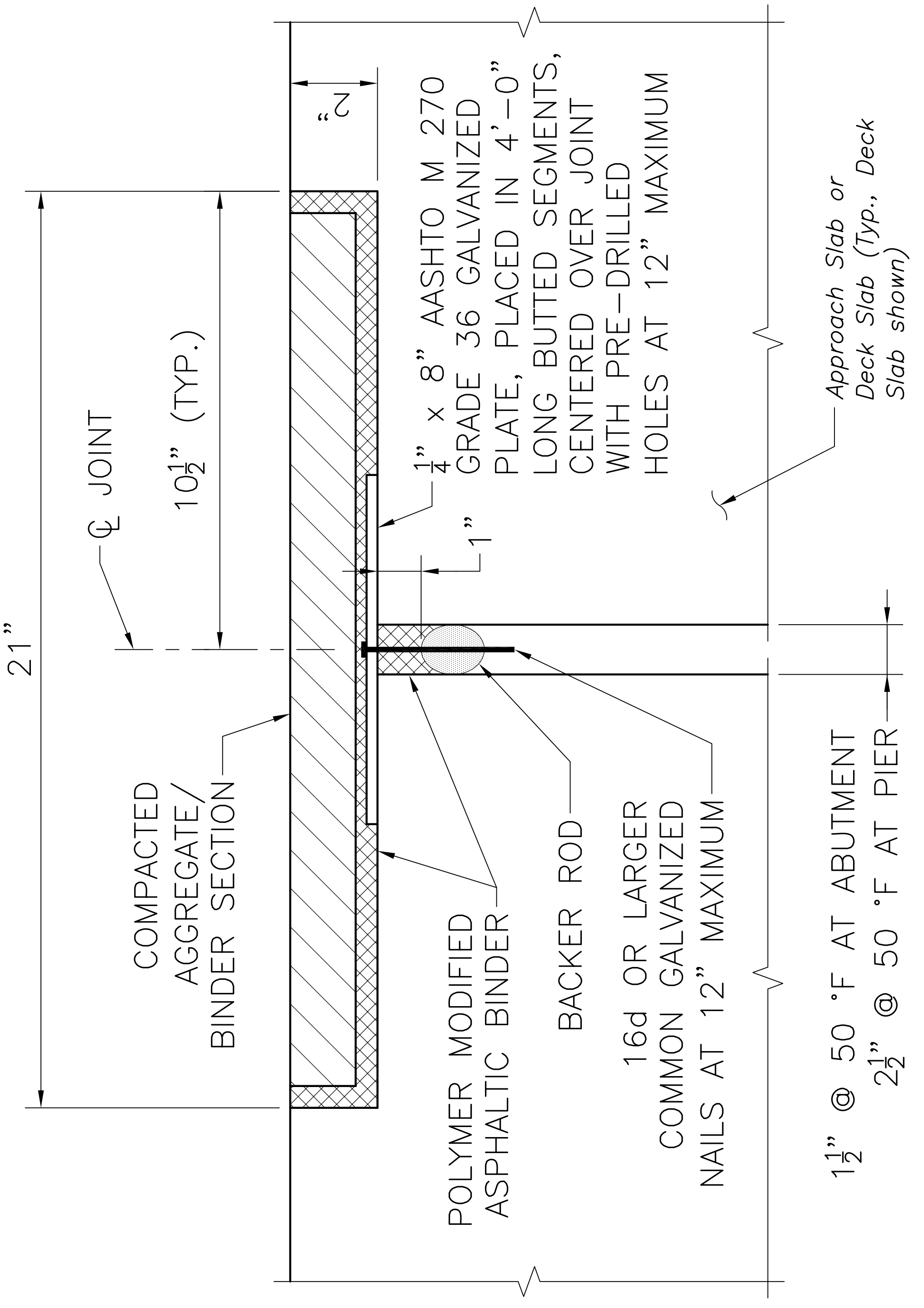
ASPHALTIC BRIDGE JOINT DETAIL

SCALE: 3" = 1'–0"

NOTES:

1. *Use of this joint is limited to a maximum of 1" of one way thermal movement or 30° maximum skew.*
2. *See Dwg. No. 10.1.3 for Construction Sequence Notes.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL JOINT DETAIL HMA WEARING SURFACE ASPHALTIC BRIDGE JOINT	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **10.1.1**



ASPHALTIC BRIDGE JOINT DETAIL

SCALE: 3" = 1'–0"

NOTES:

1. *Use of this joint is limited to a maximum of 1" of one way thermal movement or 30° maximum skew.*
2. *See Dwg. No. 10.1.3 for Construction Sequence Notes.*

MASS HIGHWAY BRIDGE MANUAL	TYPICAL JOINT DETAIL EXPOSED CONCRETE DECKS	DATE OF ISSUE FEBRUARY 2007
	ASPHALTIC BRIDGE JOINT	DRAWING NUMBER **10.1.2**

CONSTRUCTION SEQUENCE NOTES:

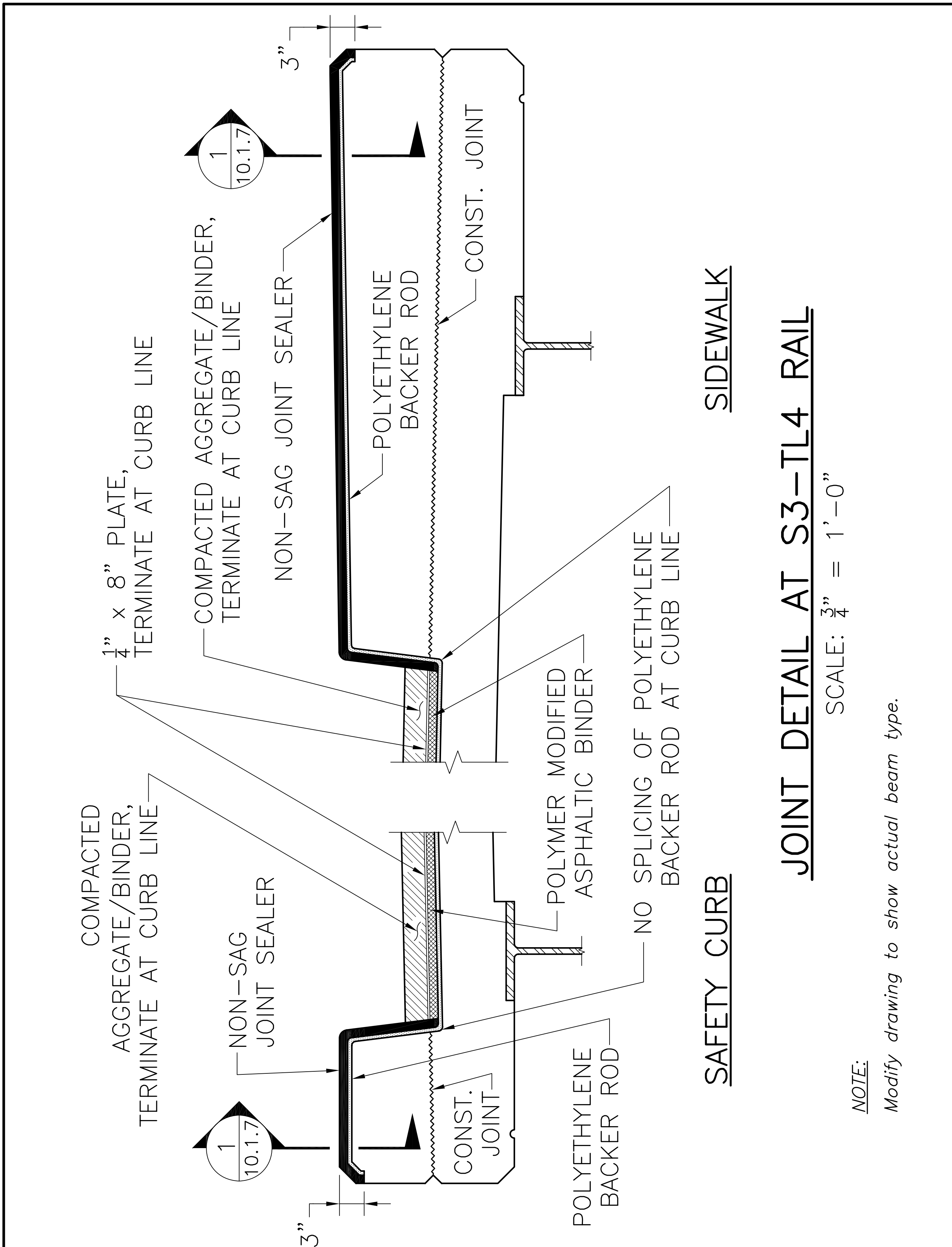
(Use for Bridges with HMA Wearing Surface)

1. CENTER 19" WIDE STRIP OF ROOFING FELT OVER THE JOINT LOCATION.
2. PLACE WATERPROOFING MEMBRANE AND HMA WEARING SURFACE UNIFORMLY ACROSS THE DECK AND JOINT LOCATIONS.
3. SAW CUT AND REMOVE THE HMA WEARING SURFACE AND MEMBRANE WATERPROOFING TO THE LIMITS REQUIRED.
4. PLACE BACKER ROD, POLYMER MODIFIED BINDER AND STEEL PLATE SECURED IN PLACE WITH GALVANIZED NAILS.
5. COAT THE SURFACES OF THE BLOCK-OUT WITH THE POLYMER MODIFIED ASPHALTIC BINDER.
6. PLACE COMPACTED AGGREGATE/BINDER TO FILL ALL VOIDS AND OBTAIN A FINAL AND EVEN SURFACE WITH THE ADJACENT WEARING SURFACE.
7. IT IS NOT NECESSARY TO CONSTRUCT THE JOINT AT MEAN TEMPERATURE, HOWEVER, THE MANUFACTURER SHOULD BE CONSULTED FOR INSTALLATION GUIDELINES FOR EXTREME CLIMATE CONDITIONS.

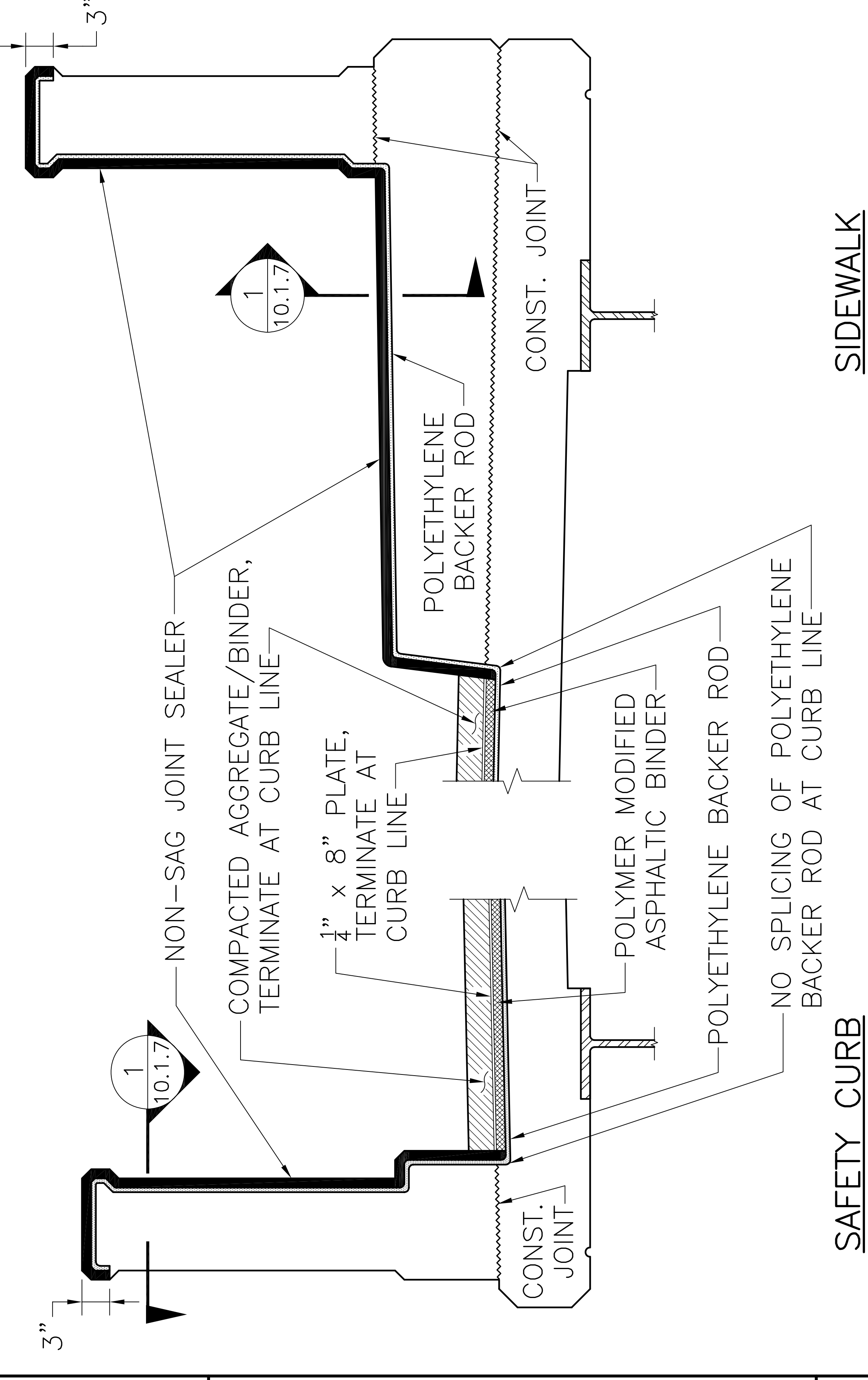
CONSTRUCTION SEQUENCE NOTES:

(Use for Bridges with Exposed Concrete Deck)

1. MAINTAIN THE REQUIRED BLOCK-OUT WHILE PLACING CONCRETE.
2. CLEAN THE BLOCK OUT TO REMOVE DELETERIOUS AND FOREIGN MATERIALS.
3. PLACE BACKER ROD, POLYMER MODIFIED BINDER AND STEEL PLATE SECURED IN PLACE WITH GALVANIZED NAILS.
4. COAT THE SURFACES OF THE BLOCK-OUT WITH THE POLYMER MODIFIED ASPHALTIC BINDER.
5. PLACE COMPACTED AGGREGATE/BINDER TO FILL ALL VOIDS AND OBTAIN A FINAL AND EVEN SURFACE WITH THE ADJACENT WEARING SURFACE.
6. IT IS NOT NECESSARY TO CONSTRUCT THE JOINT AT MEAN TEMPERATURE, HOWEVER, THE MANUFACTURER SHOULD BE CONSULTED FOR INSTALLATION GUIDELINES FOR EXTREME CLIMATE CONDITIONS.



MASS HIGHWAY BRIDGE MANUAL	JOINT DETAILS S3-TL4 RAIL ASPHALTIC BRIDGE JOINT	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **10.1.4**

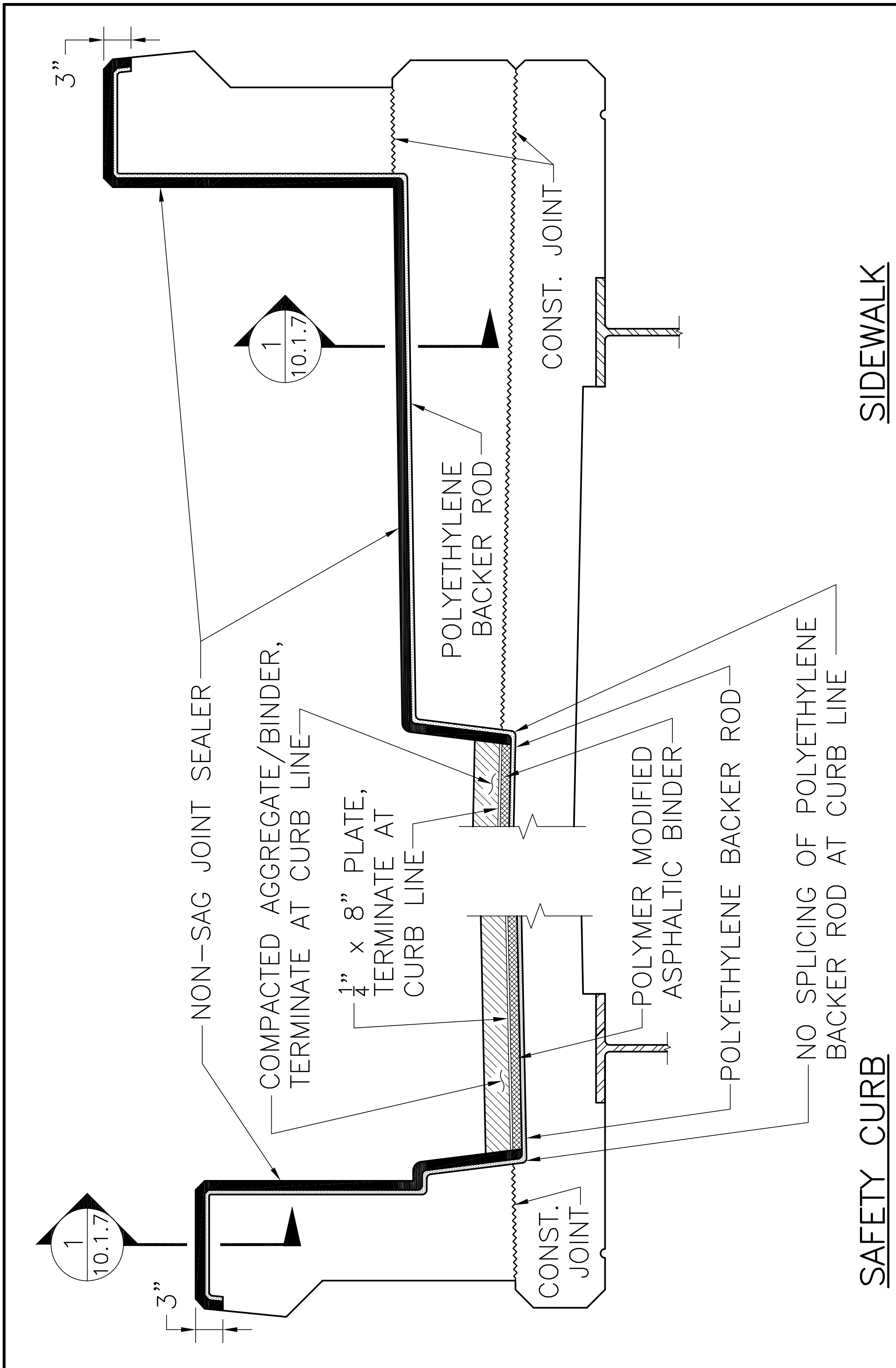


JOINT DETAIL AT CT–TL2 BARRIER

SCALE: $\frac{3}{4}$” = 1’–0”

<u>NOTE:</u>
Modify drawing to show actual beam type.

MASS HIGHWAY BRIDGE MANUAL	JOINT DETAILS CT–TL2 BARRIER ASPHALTIC BRIDGE JOINT	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **10.1.5**

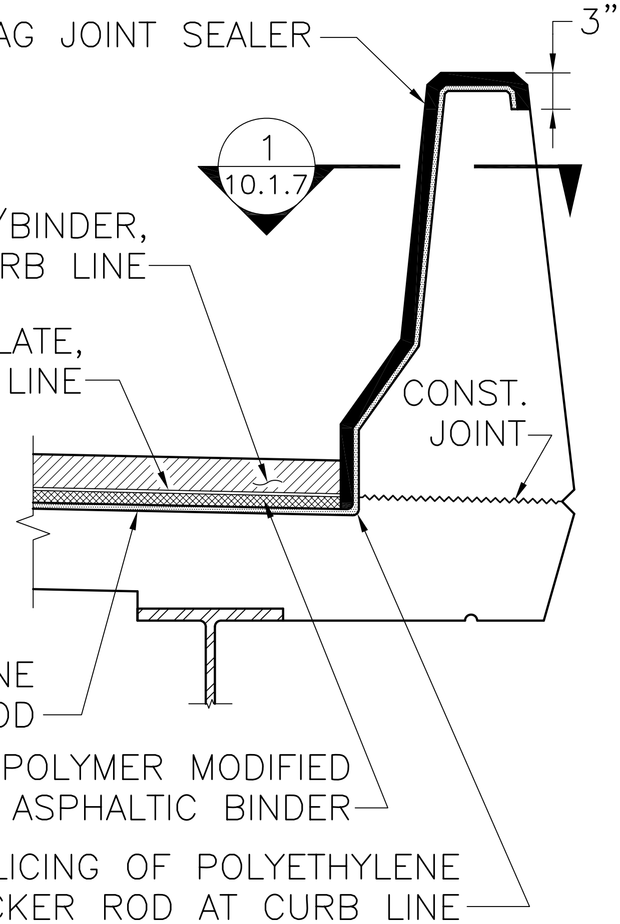


JOINT DETAIL AT CP-PL2 BARRIER

SCALE: $\frac{3}{4}$” = 1'-0”

NOTE: *Modify drawing to show actual beam type.*

MASS HIGHWAY BRIDGE MANUAL	JOINT DETAILS CP-PL2 BARRIER ASPHALTIC BRIDGE JOINT	DATE OF ISSUE: NOVEMBER 2010 / DRAWING NUMBER: **10.1.6**

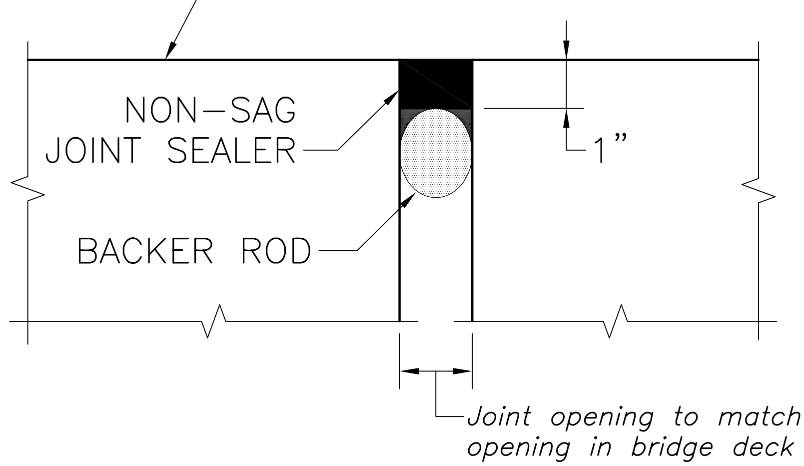


JOINT DETAIL AT CF BARRIERS

SCALE: $\frac{3}{4}$" = 1'-0"

NOTE:

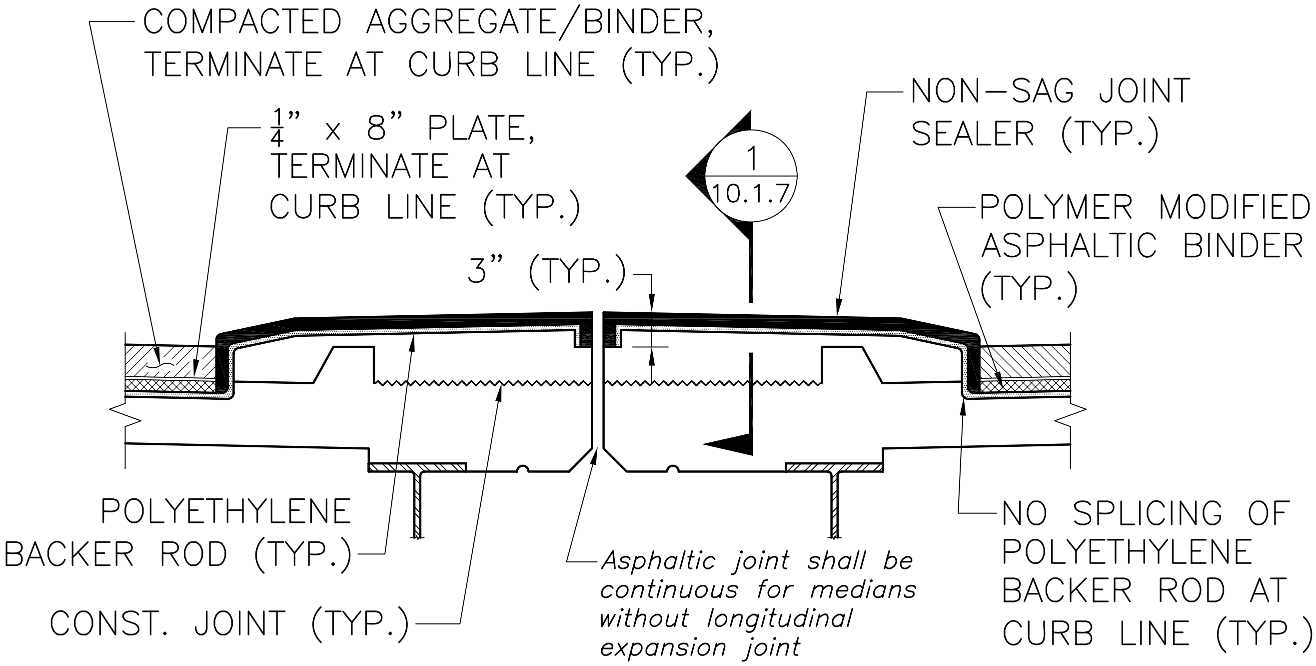
Modify drawing to show actual beam type.



SECTION 1

SCALE: 3" = 1'-0"

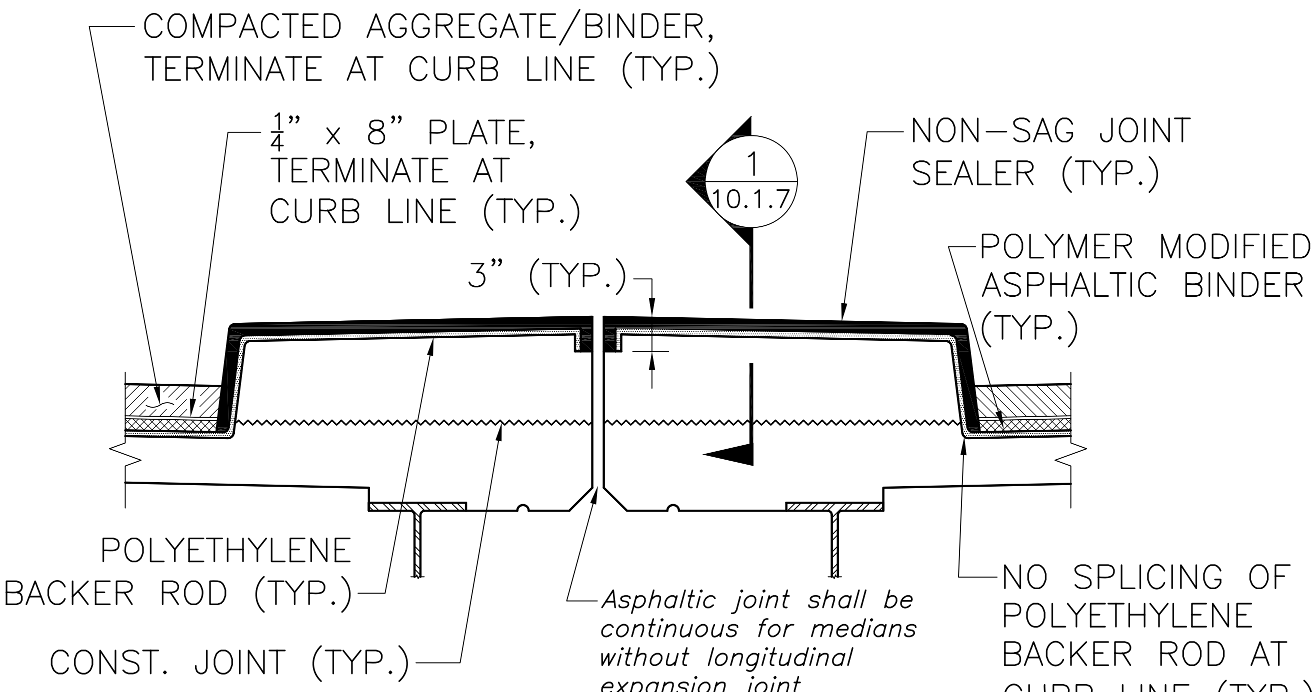
MASS HIGHWAY BRIDGE MANUAL	JOINT DETAILS CF BARRIERS ASPHALTIC BRIDGE JOINT	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **10.1.7**



(MEDIANS WITHOUT APPROACH CURB)

DETAIL AT MEDIAN

SCALE: 3/4" = 1'–0"



(MEDIANS WITH APPROACH CURB)

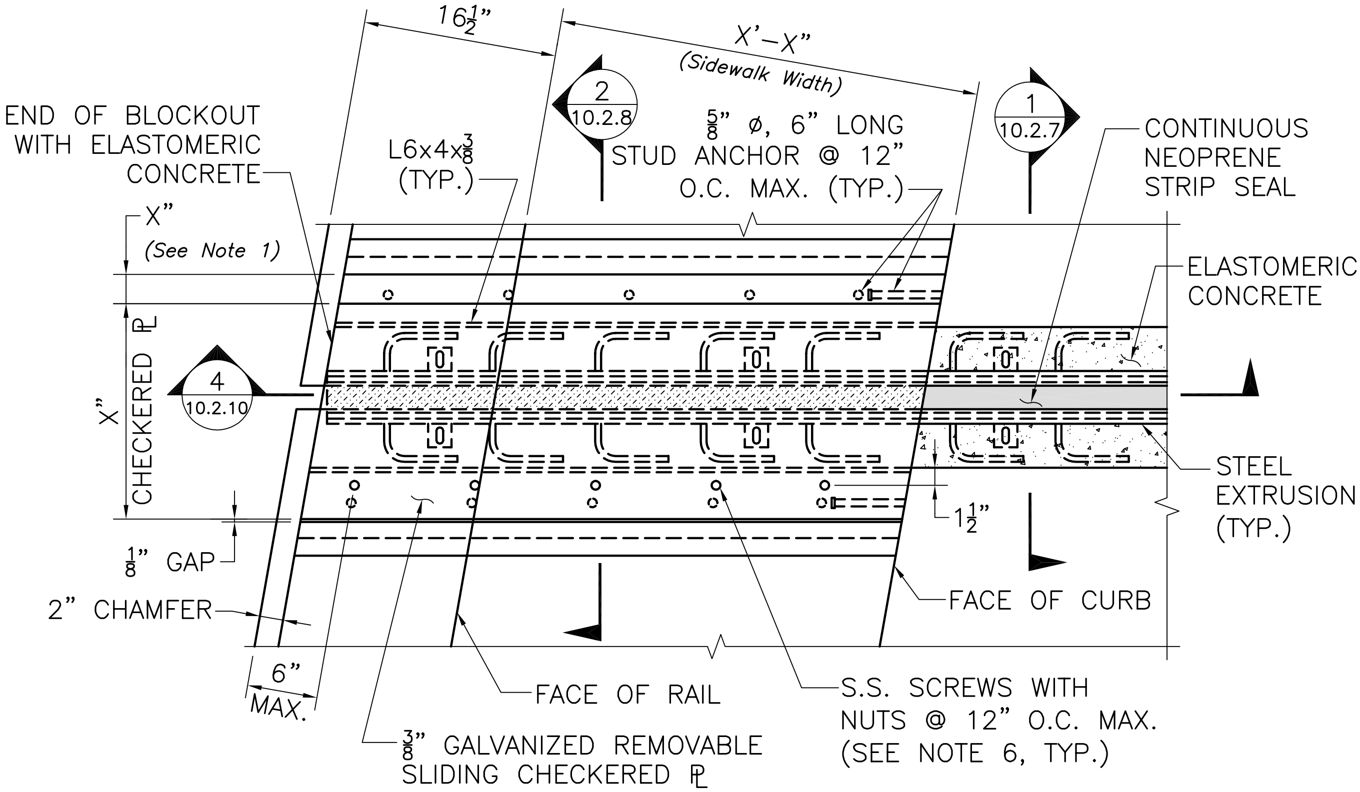
DETAIL AT MEDIAN

SCALE: 3/4" = 1'–0"

NOTE:

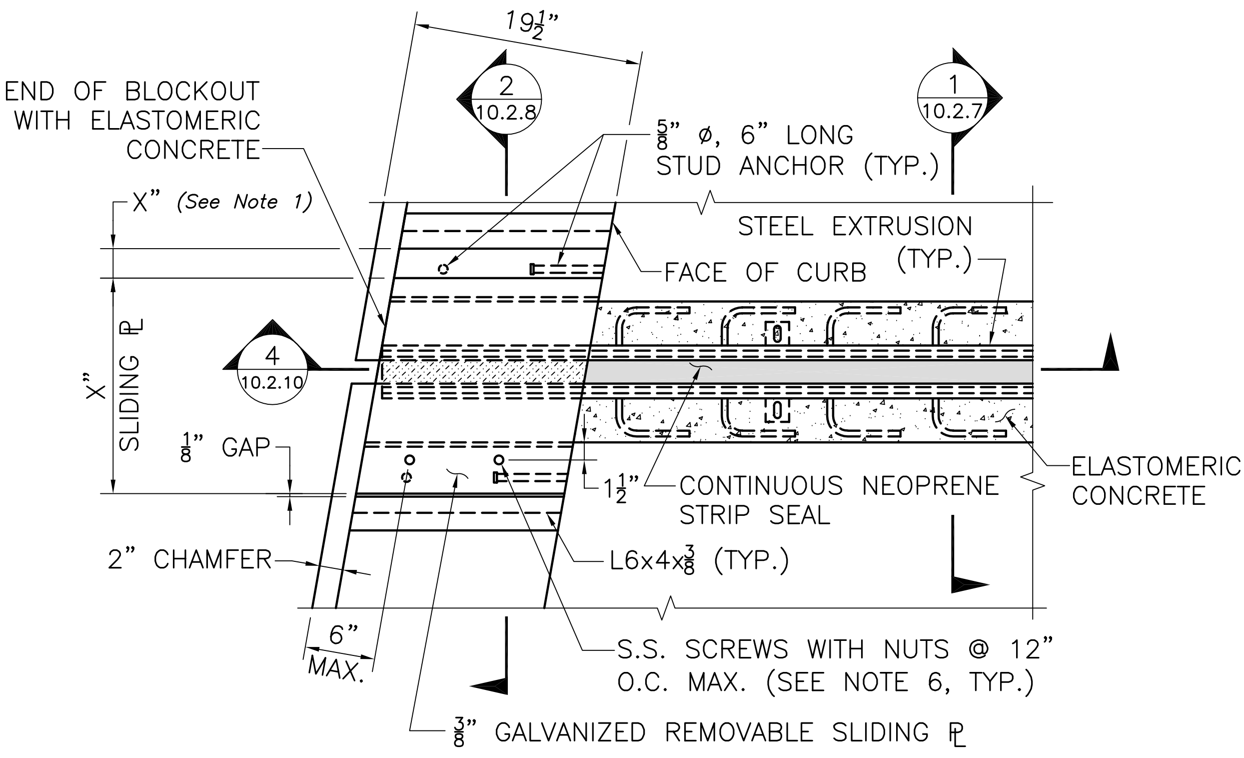
Modify drawing to show actual beam type.

MASS HIGHWAY BRIDGE MANUAL	JOINT DETAIL AT MEDIAN ASPHALTIC BRIDGE JOINT	DATE OF ISSUE NOVEMBER 2010 DRAWING NUMBER **10.1.8**



PLAN – STRIP SEAL JOINT AT SIDEWALK

SCALE: 1" = 1'–0"



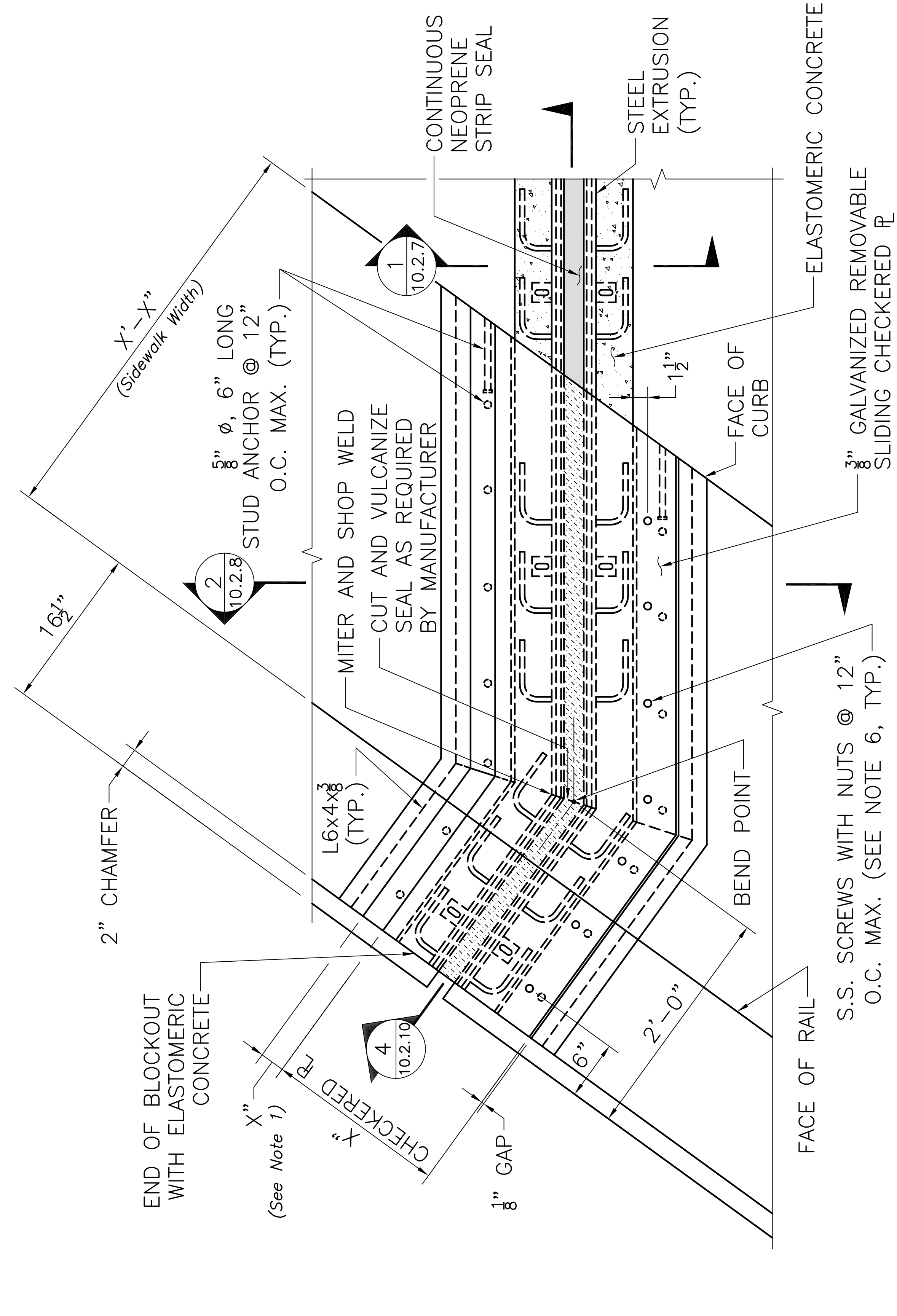
PLAN – STRIP SEAL JOINT AT SAFETY CURB

SCALE: 1" = 1'–0"

NOTES:

1. *X" = (Joint Width + ½")*
2. *See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.*

MASS HIGHWAY BRIDGE MANUAL	S3–TL4 RAIL PLAN, SKEW ≤ 35° STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.1**



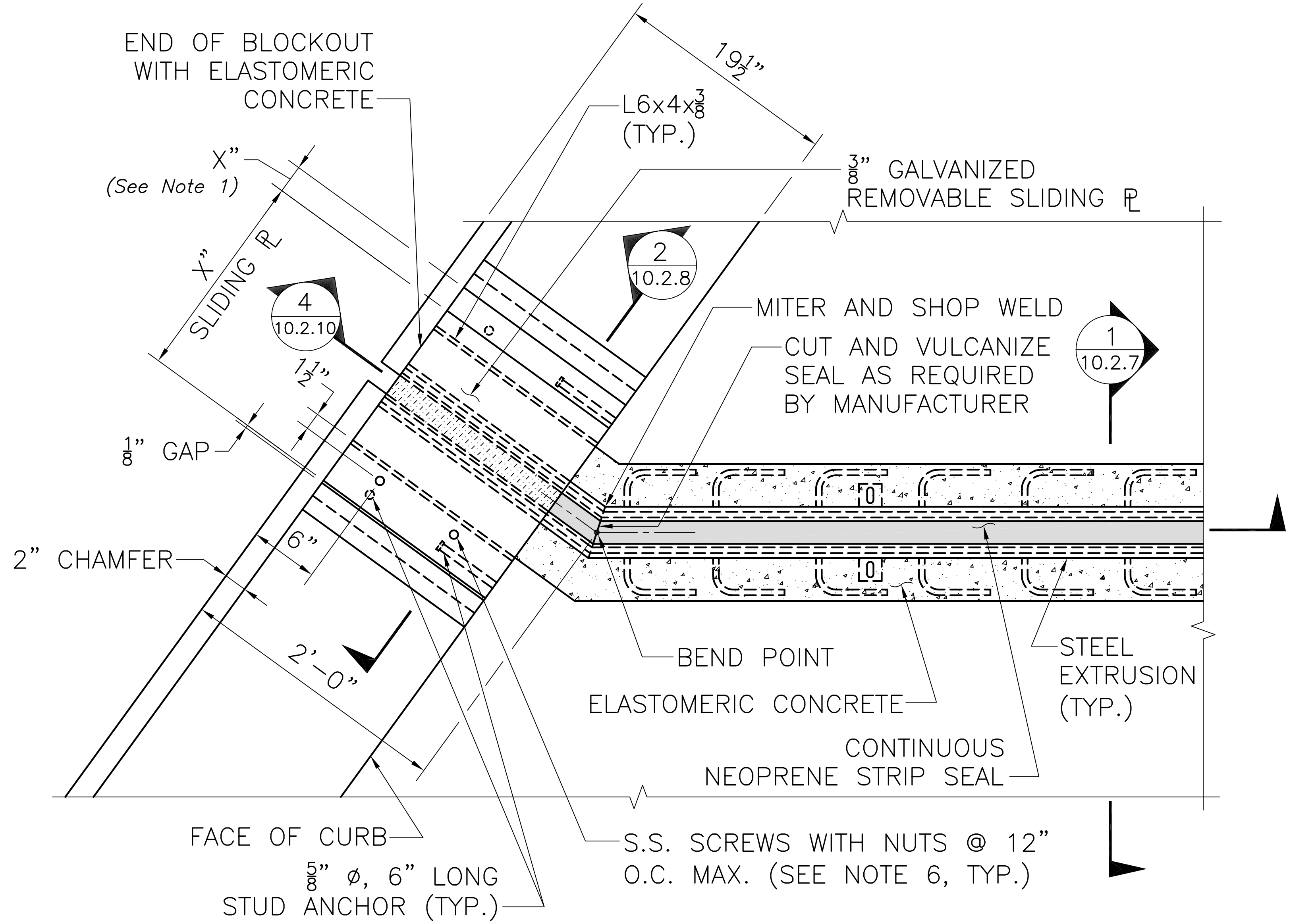
PLAN – STRIP SEAL JOINT AT SIDEWALK

SCALE: 1" = 1'–0"

NOTES:

1. X" = (Joint Width + ½")
2. See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	S3–TL4 RAIL AT SIDEWALK PLAN, SKEW > 35° STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.2**



PLAN – STRIP SEAL JOINT AT SAFETY CURB

SCALE: 1" = 1'–0"

NOTES:

1. *X" = (Joint Width + ½")*
2. *See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.*

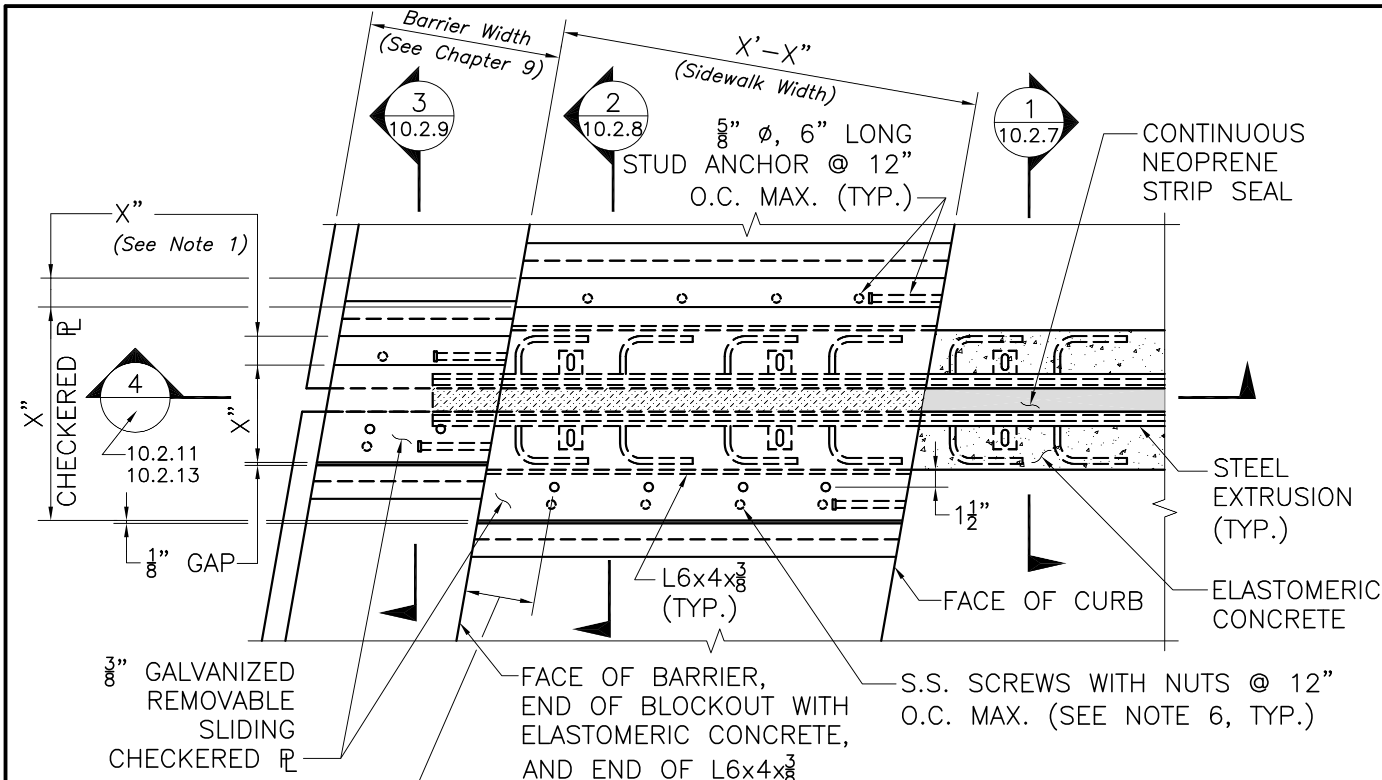
MASS HIGHWAY BRIDGE MANUAL

S3–TL4 RAIL AT SAFETY CURB PLAN, SKEW > 35°

STRIP SEAL JOINT DETAILS

DATE OF ISSUE: MAY 2005

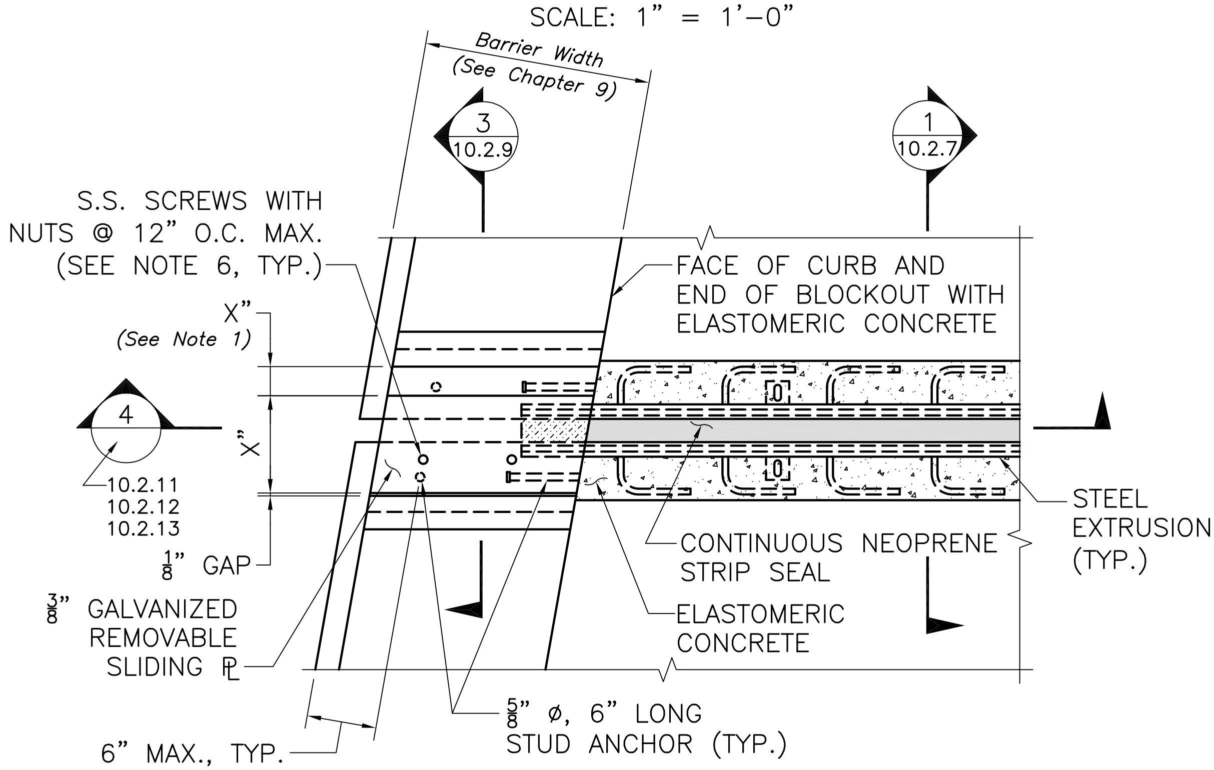
DRAWING NUMBER: **10.2.3**



(CP–PL2 AND CT–TL2, BARRIERS)

PLAN – STRIP SEAL JOINT AT SIDEWALK

SCALE: 1" = 1'–0"



(CP–PL2, CT–TL2, CF–PL2 AND CF–PL3 BARRIERS)

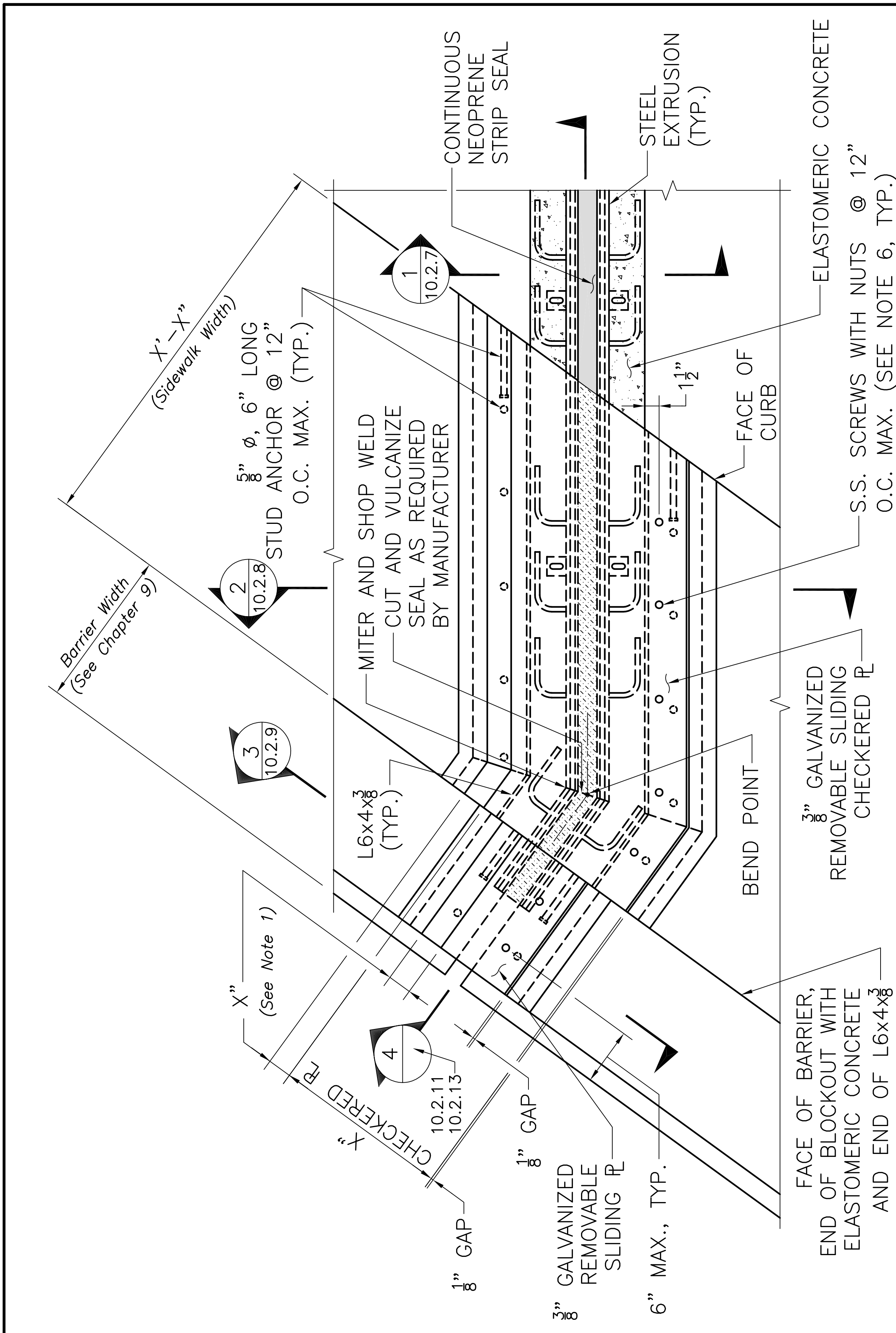
PLAN – STRIP SEAL JOINT AT SAFETY CURB

SCALE: 1" = 1'–0"

NOTES:

1. X" = (Joint Width + 1/2")
2. See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	BARRIERS PLAN, SKEW ≤ 35° STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.4**



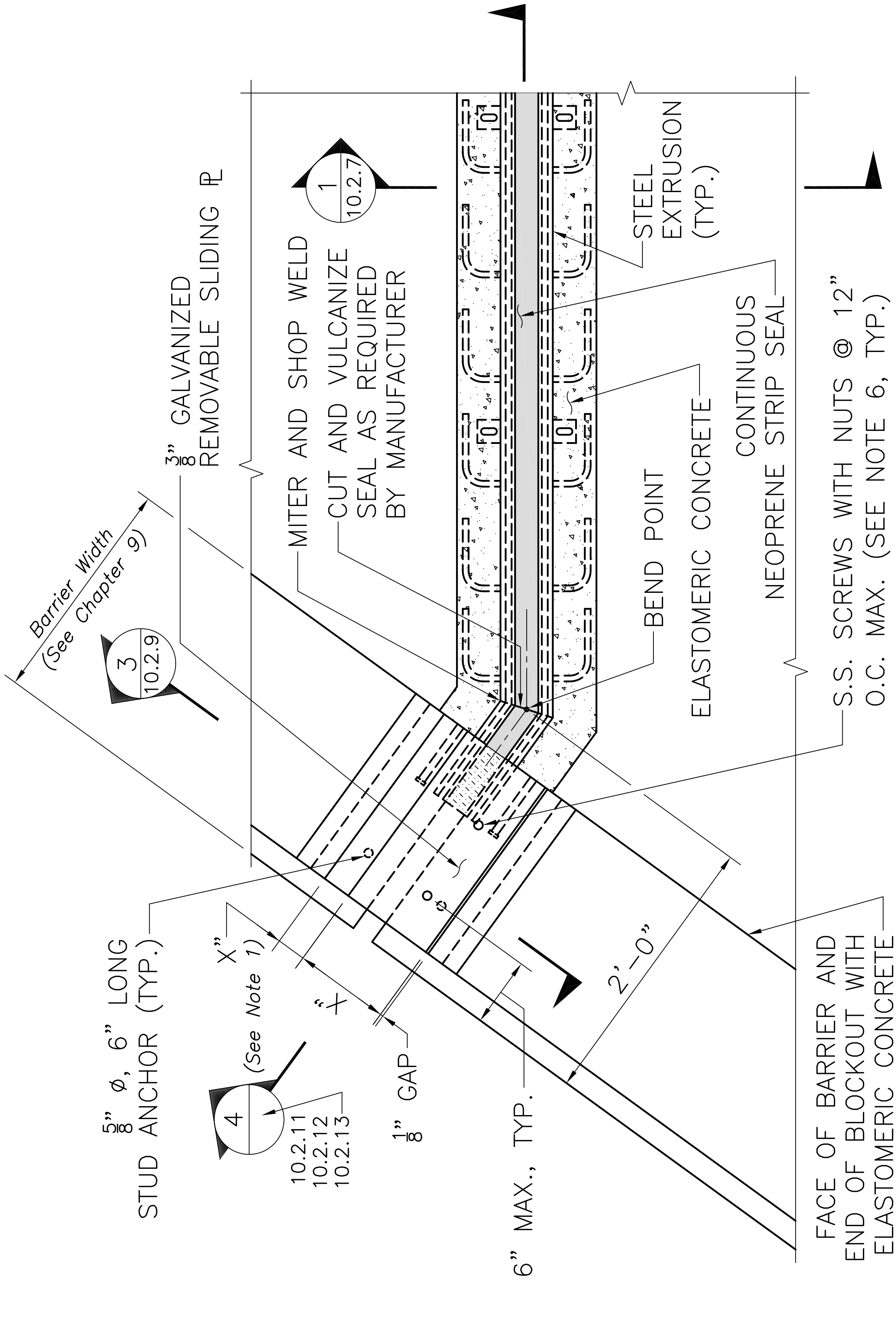
PLAN – STRIP SEAL JOINT AT SIDEWALK

SCALE: 1" = 1'–0"

NOTES:

1. X" = (Joint Width + 1/2")
2. See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	CP AND CT BARRIERS AT SDWK. PLAN, SKEW > 35° STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005	DRAWING NUMBER 10.2.5



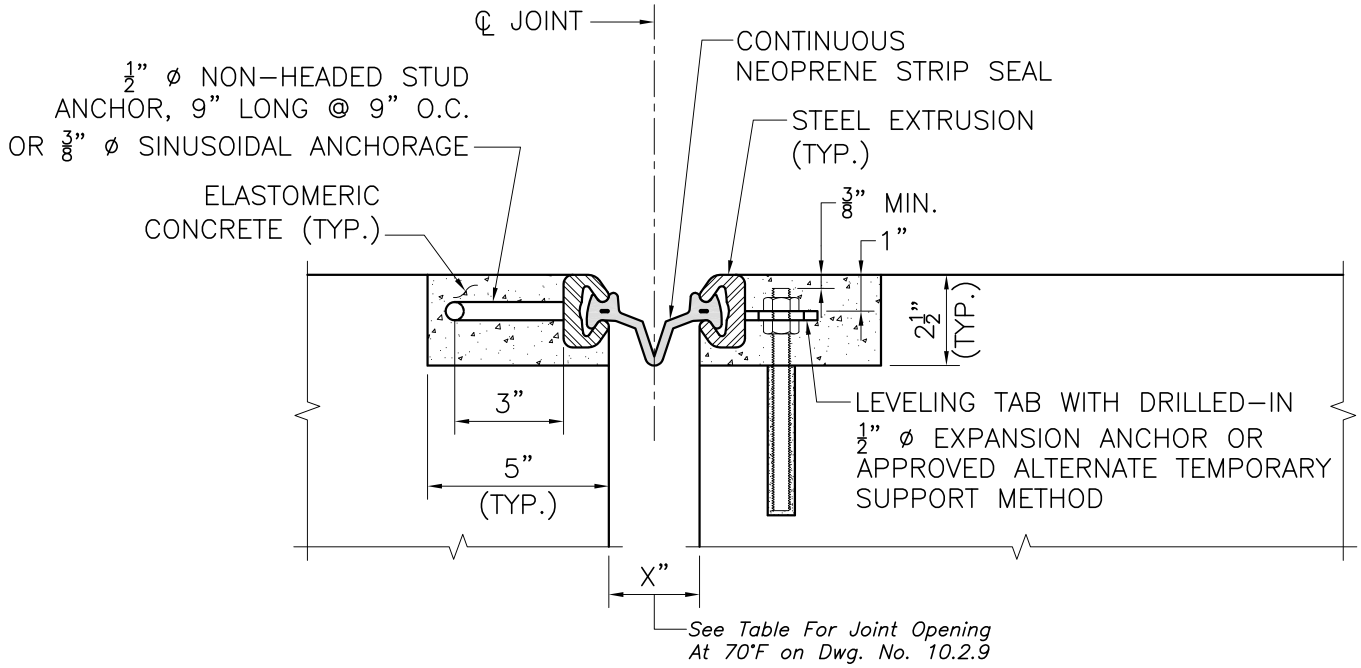
PLAN – STRIP SEAL JOINT AT SAFETY CURB

SCALE: 1" = 1'–0"

NOTES:

1. X" = (Joint Width + 1/2")
2. See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	BARRIERS AT SAFETY CURB PLAN, SKEW > 35° STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.6**

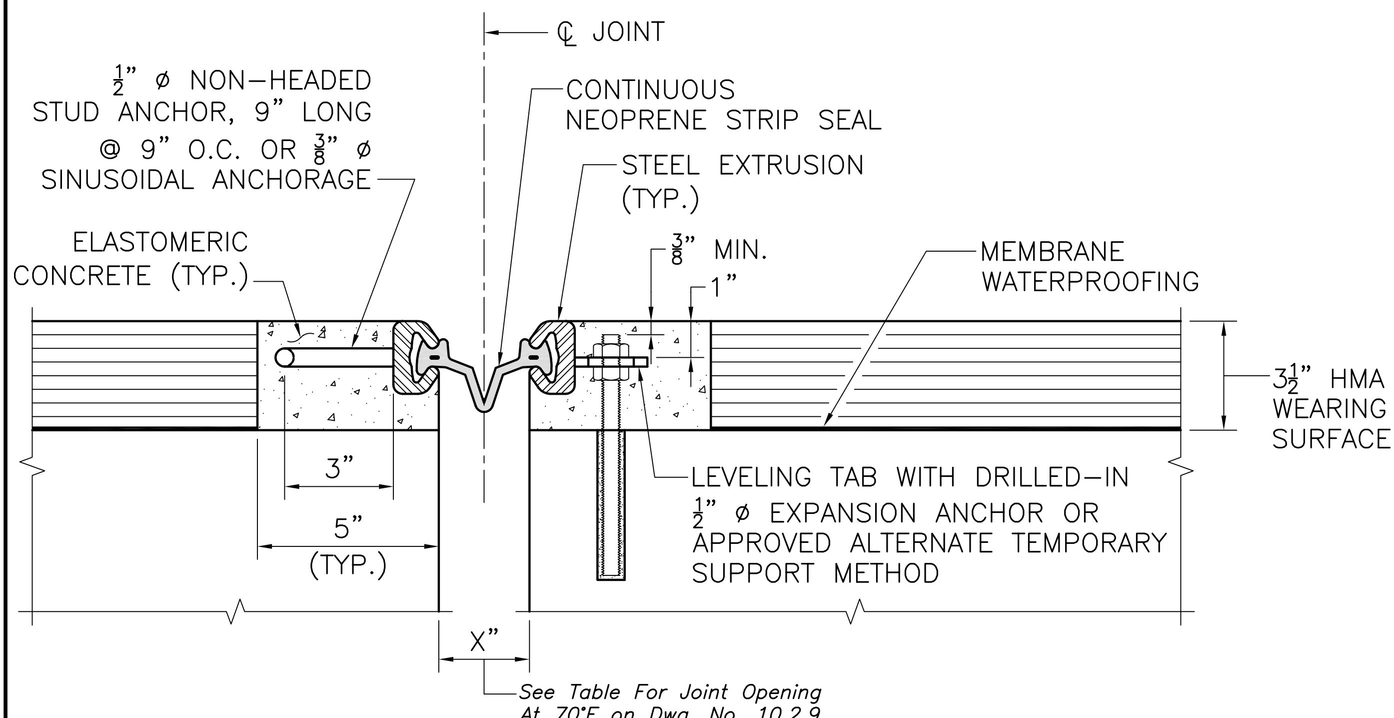


AT ANCHOR LOCATION — AT TEMPORARY SUPPORT LOCATION

SECTION 1

SCALE: 3" = 1'–0"

(EXPOSED CONCRETE DECKS)



AT ANCHOR LOCATION — AT TEMPORARY SUPPORT LOCATION

SECTION 1

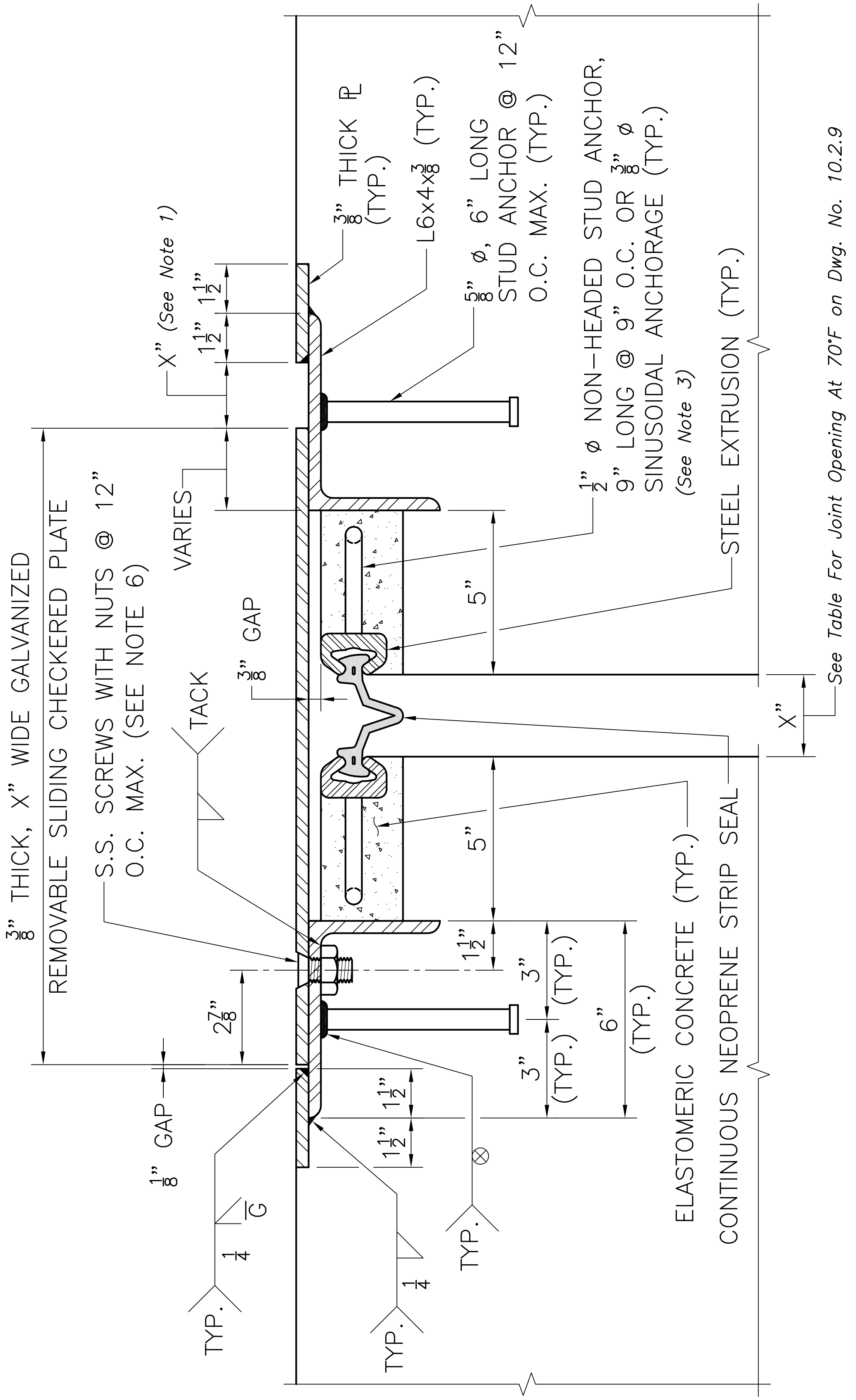
SCALE: 3" = 1'–0"

(DECKS WITH HMA WEARING SURFACE)

NOTE:

See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	TRANSVERSE SECTION THRU ROADWAY	DATE OF ISSUE: MAY 2005
	STRIP SEAL JOINT DETAILS	DRAWING NUMBER: 10.2.7



SECTION 2

SCALE: 3" = 1'-0"

NOTES:

1. X" = (Joint Width + 1/2")
2. The stud anchor or sinusoidal anchorage shall be omitted at Safety Curb.
3. See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

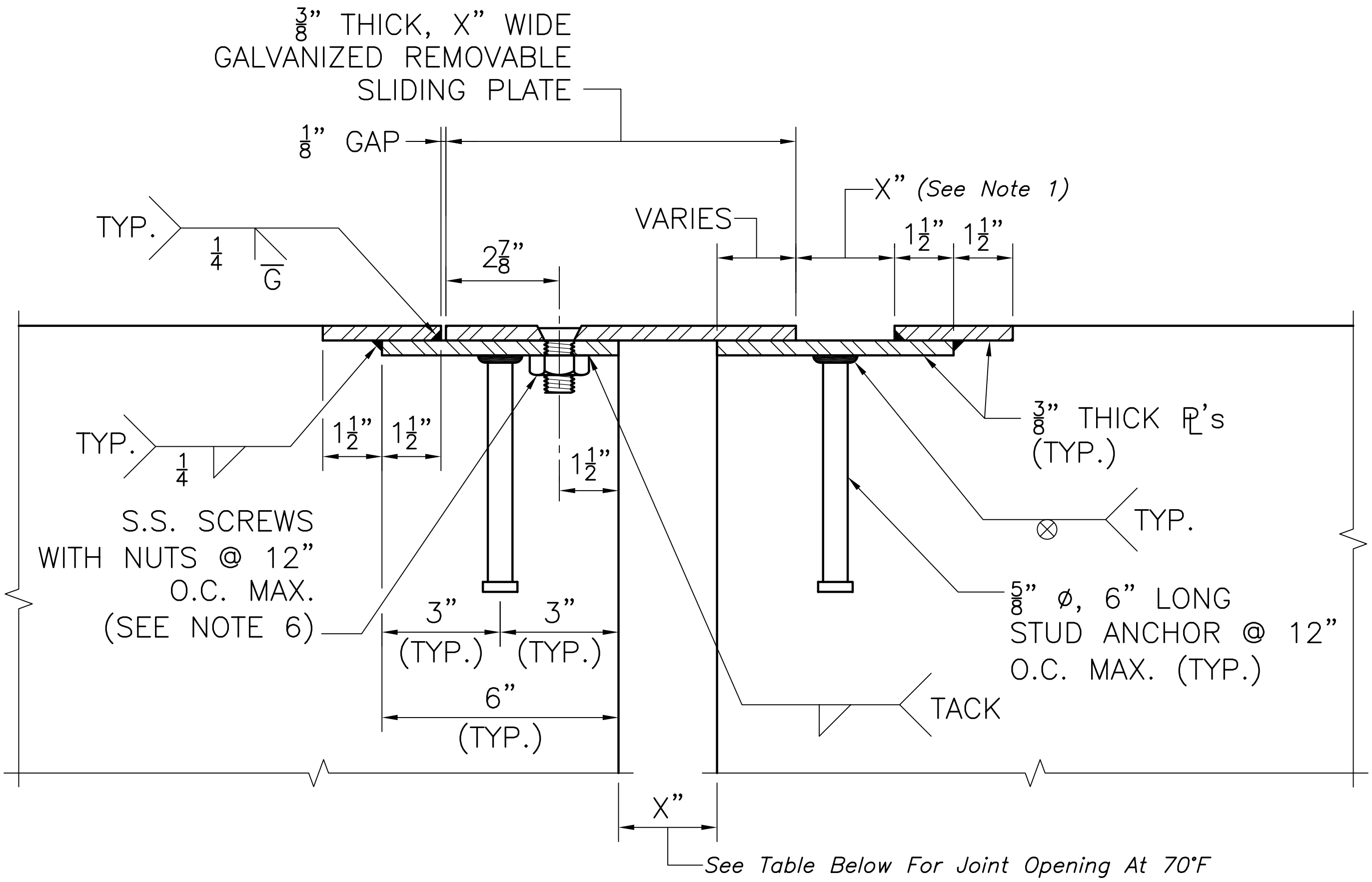
MASS HIGHWAY
BRIDGE MANUAL

TRANSVERSE SECTION THRU SIDEWALK

STRIP SEAL JOINT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
10.2.8



SECTION 3
SCALE: 3" = 1'-0"

NOTES:
1. *X" = (Joint Width + 1/2")*
2. *See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.*
3. *This joint system is acceptable for use on bridges where the total movement range is 4" or less.*

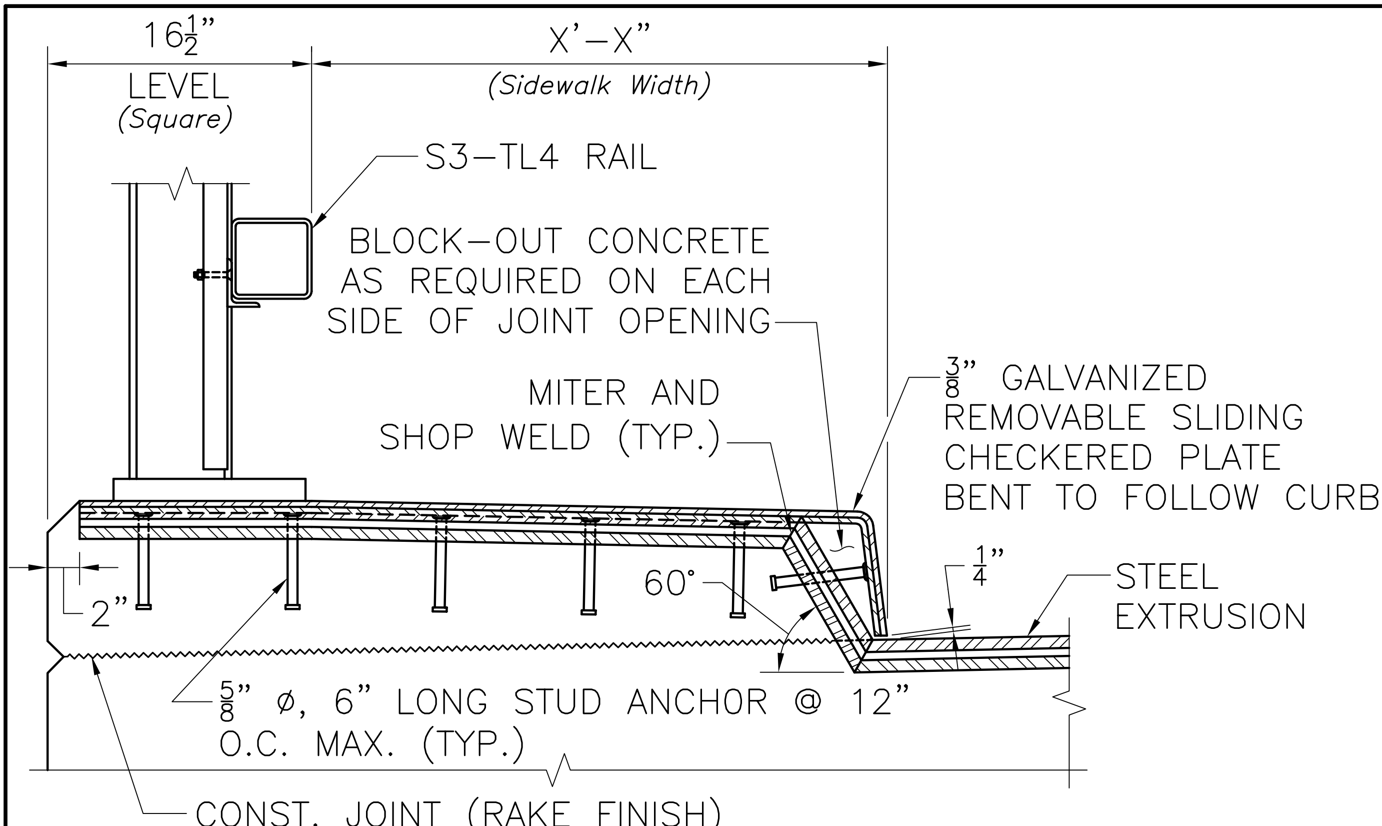
ACCEPTABLE STRIP SEAL JOINTS			
MANUFACTURER	STEEL EXTRUSION MODEL	NEOPRENE STRIP SEAL MODEL	JOINT OPENING
WATSON BOWMAN ACME	TYPE A	SE-400	1 3/4"
D.S. BROWN	TYPE SSA2	A2R-400	1 3/4"

MASS HIGHWAY BRIDGE MANUAL

TRANSVERSE SECTION THRU SIDEWALK AND TABLE
STRIP SEAL JOINT DETAILS

DATE OF ISSUE
MAY 2005

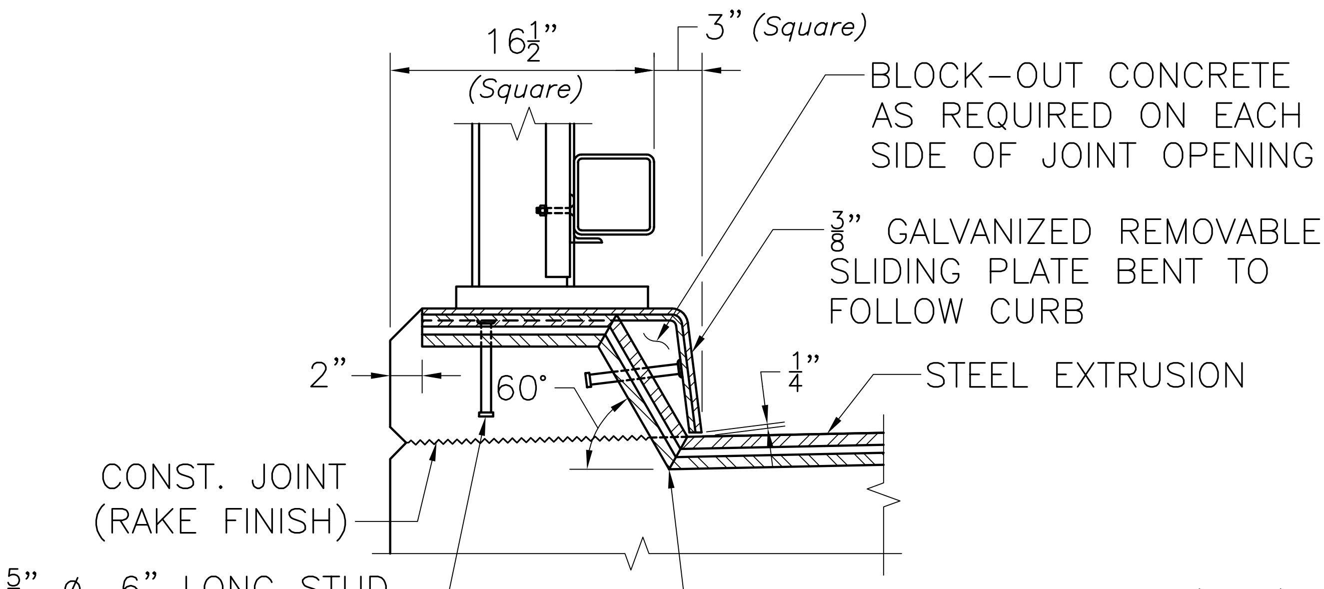
DRAWING NUMBER
10.2.9



(THRU SIDEWALK)

SECTION 4

SCALE: 1" = 1'–0"



(THRU SAFETY CURB)

SECTION 4

SCALE: 1" = 1'–0"

NOTE:

See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

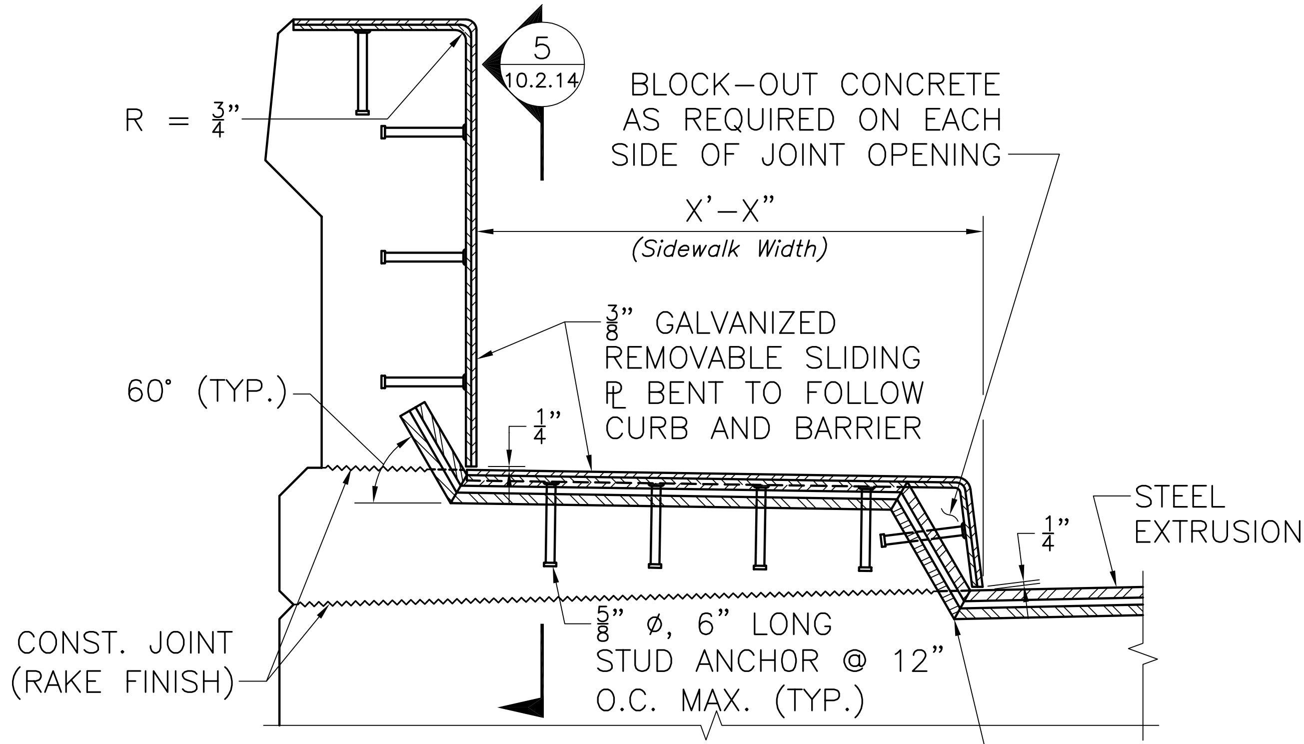
MASS HIGHWAY
BRIDGE MANUAL

LONGITUDINAL SECTIONS S3–TL4 RAIL

STRIP SEAL JOINT DETAILS

DATE OF ISSUE
MAY 2005

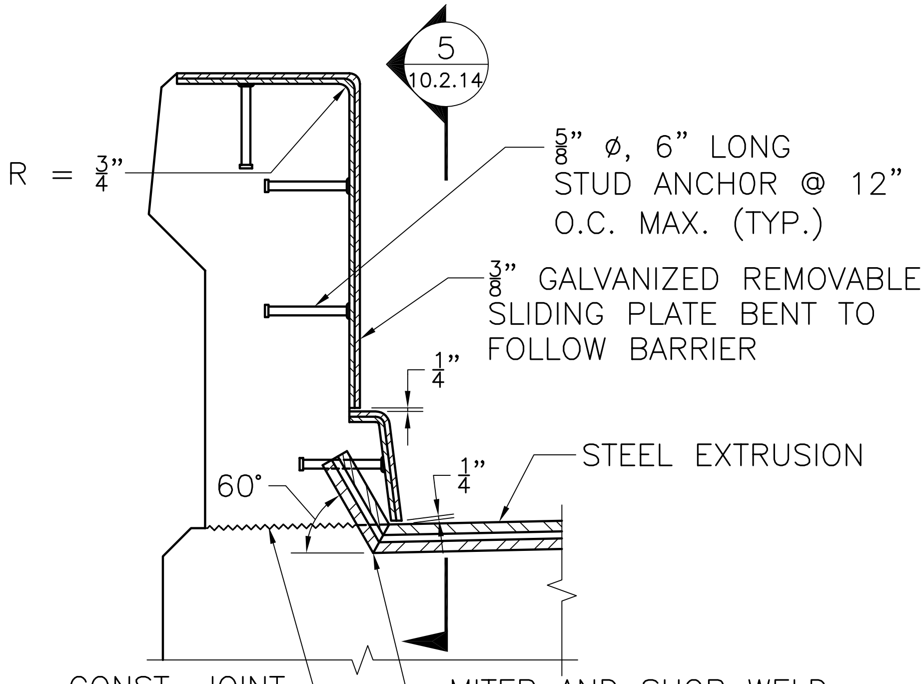
DRAWING NUMBER
10.2.10



(THRU SIDEWALK)

SECTION 4

SCALE: 1" = 1'-0"



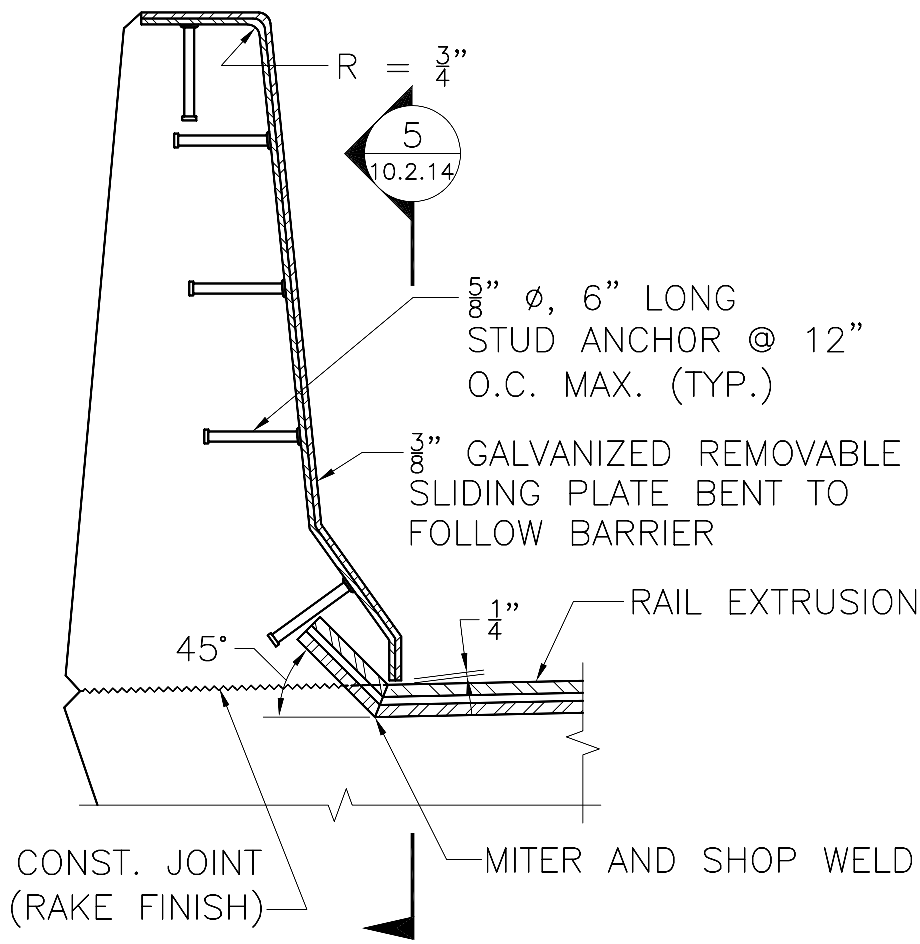
(THRU SAFETY CURB)

SECTION 4

SCALE: 1" = 1'-0"

NOTE:
See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

MASS HIGHWAY BRIDGE MANUAL	LONGITUDINAL SECTIONS CP-PL2 BARRIER STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 / DRAWING NUMBER **10.2.11**



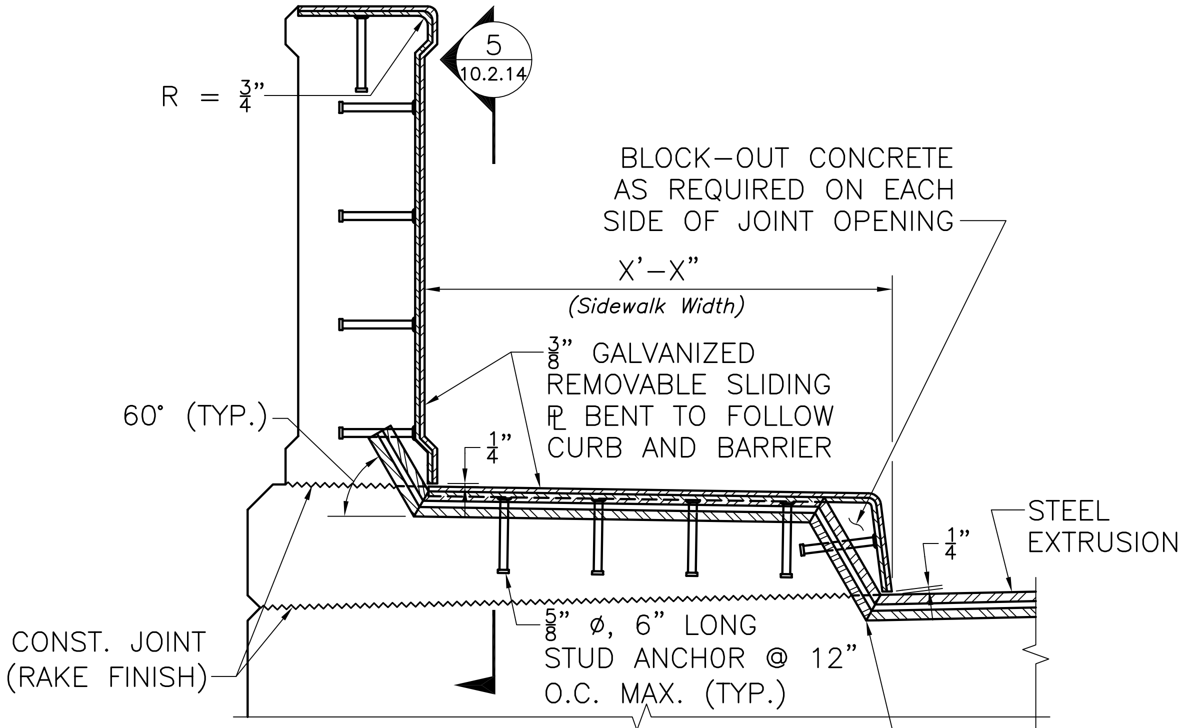
SECTION 4

SCALE: 1" = 1'–0"

NOTE:

See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

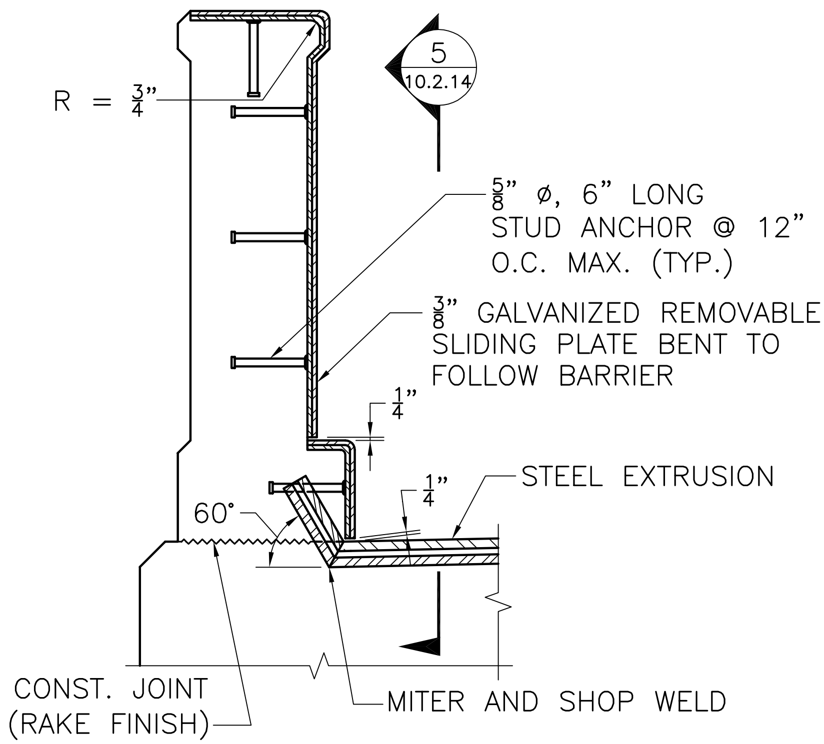
MASS HIGHWAY BRIDGE MANUAL	LONGITUDINAL SECTION CF BARRIERS STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.12**



(THRU SIDEWALK)

SECTION 4

SCALE: 1" = 1'-0"



NOTE:
See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.

(THRU SAFETY CURB)

SECTION 4

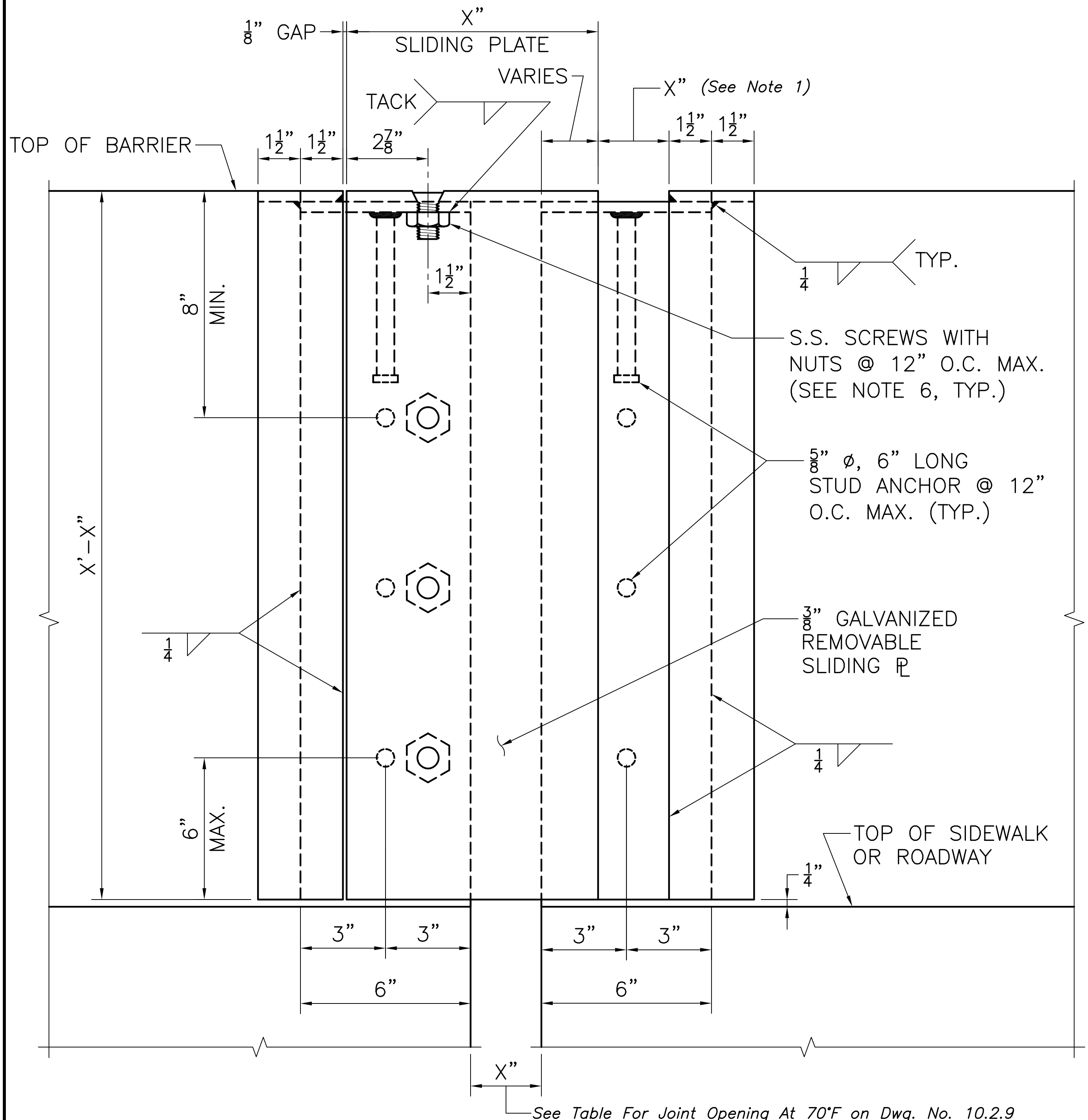
SCALE: 1" = 1'-0"

MASS HIGHWAY
BRIDGE MANUAL

LONGITUDINAL SECTIONS
CT-TL2 BARRIER
STRIP SEAL JOINT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
10.2.13



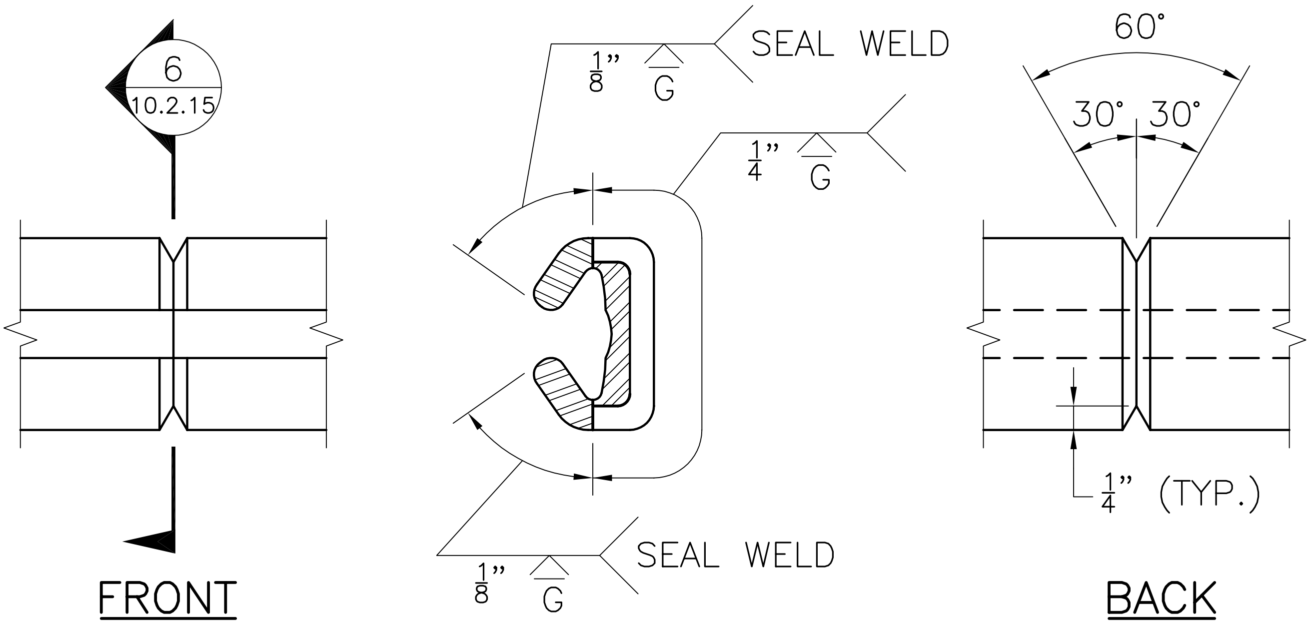
SECTION 5

SCALE: 3" = 1'–0"

NOTES:

1. *X" = (Joint Width + 1/2")*
2. *See Dwg. No. 10.2.16 for Construction Notes to be placed on Construction Drawings.*
3. *This joint system is acceptable for use on bridges where the total movement range is 4" or less.*

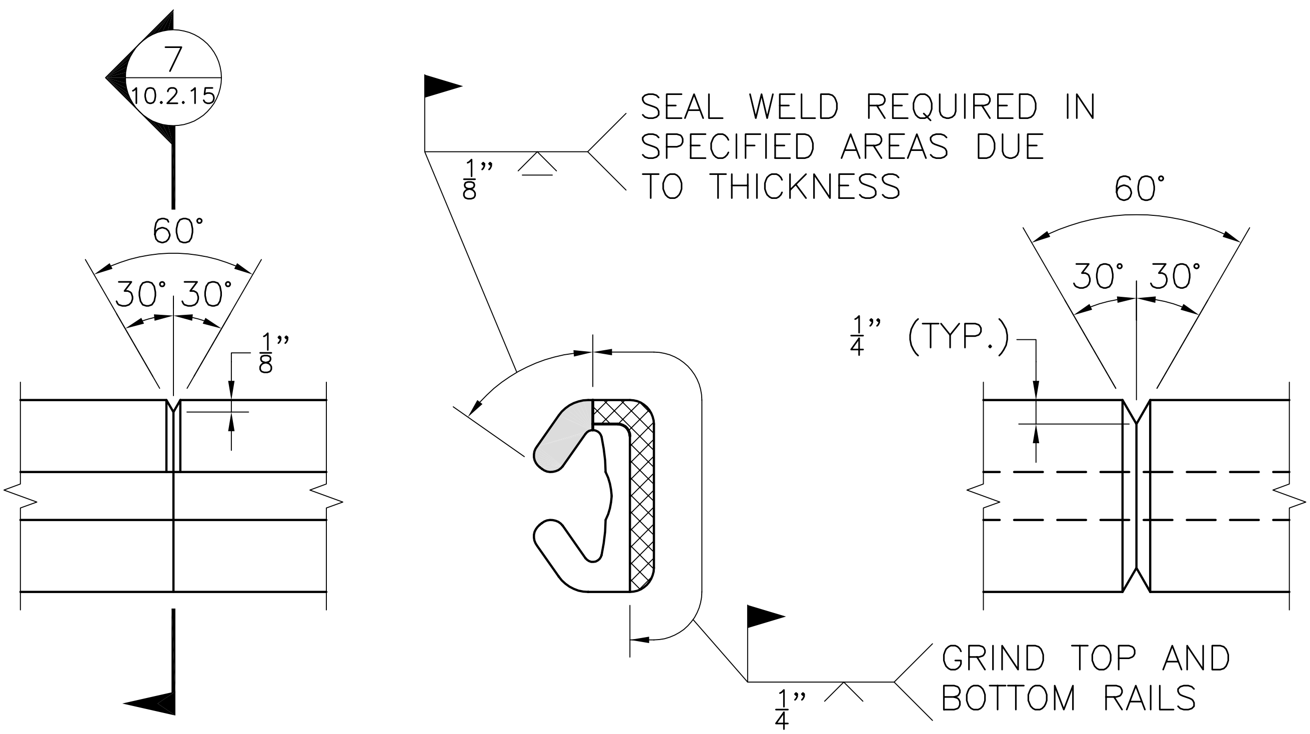
MASS HIGHWAY BRIDGE MANUAL	TYPICAL VERTICAL SECTION THRU BARRIERS STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **10.2.14**



FRONT SECTION 6 BACK

STEEL EXTRUSION SHOP SPLICE DETAIL

SCALE: 6" = 1'–0"



FRONT SECTION 7 BACK

STEEL EXTRUSION FIELD SPLICE DETAIL

SCALE: 6" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	SPLICE DETAILS STRIP SEAL JOINT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER 10.2.15

STRIP SEAL JOINT NOTES:

1. THE DETAILS SHOWN HERE ARE INTENDED AS A GENERAL GUIDE FOR A TYPICAL GLANDULAR TYPE STRIP SEAL JOINT SYSTEM. SHOP DRAWINGS WHICH INCLUDE DETAILS OF THE GLAND SHAPE, STEEL EXTRUSION SHAPE, WELDING PROCEDURE SPECIFICATIONS, ANCHOR ARRANGEMENT, TEMPERATURE CORRECTION REQUIREMENTS, AND TEMPORARY SUPPORT DETAILS SHALL BE SUBMITTED FOR APPROVAL OF THE ENGINEER ACCORDING TO THE STANDARD SPECIFICATIONS.

2. ALL STRUCTURAL STEEL COMPONENTS SHALL CONFORM TO AASHTO M270 GRADE 36. AFTER THE COMPLETION OF ALL WELDING OPERATIONS STEEL PLATE ASSEMBLIES SHALL BE HOT-DIP GALVANIZED.

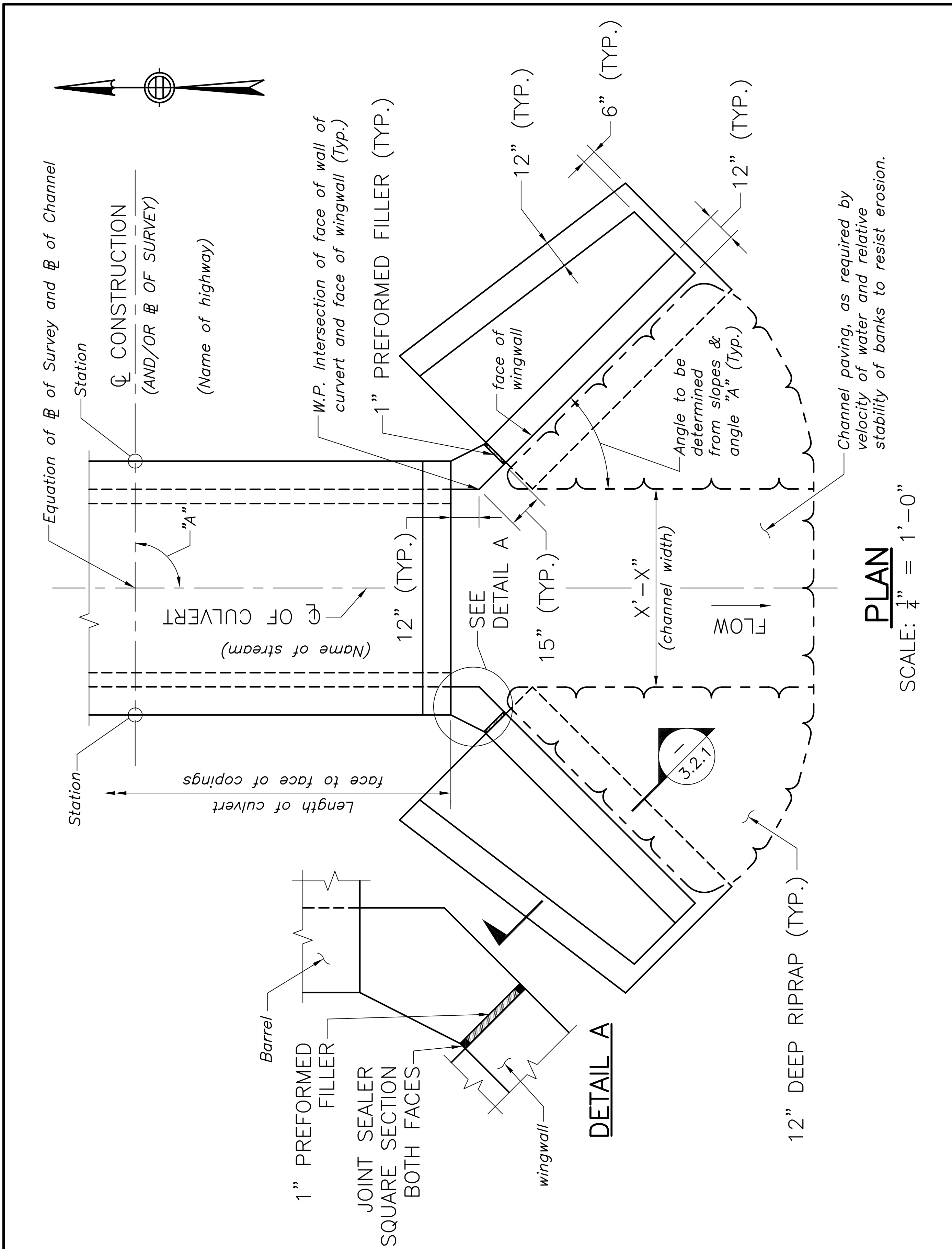
3. ELASTOMERIC CONCRETE BLOCKOUT SHALL BE SANDBLASTED, CLEANED WITH COMPRESSED OIL LESS AIR, AND PRIMED WITH BONDING COMPOUND PRIOR TO CASTING ELASTOMERIC CONCRETE.

4. NEOPRENE STRIP SEAL SHALL BE BONDED TO STEEL EXTRUSION WITH APPROVED ADHESIVE.

5. INSTALL CONTINUOUS NEOPRENE STRIP SEAL IN THE FIELD. SPLICING OF SEAL IS NOT PERMITTED. TEMPORARY SEAL SHALL BE REQUIRED ON STAGE CONSTRUCTION PROJECTS.

6. $\frac{3}{4}$" Ø STAINLESS STEEL FLAT HEAD MACHINE SCREWS STAINLESS STEEL NUTS. RECESS $\frac{1}{16}$" BELOW PLATE SURFACE. PRIOR TO PLACEMENT OF SIDEWALK/SAFETY CURB CONCRETE, LUBRICATE STAINLESS STEEL SCREWS WITH GRAPHITE AND SET SECURELY IN PLACE. MACHINE SCREWS TO BE TEMPORARILY REMOVED AFTER CONCRETE HAS ATTAINED FINAL SET.

7. NO WELDING OF PORTIONS OF STEEL EXTRUSIONS IN DIRECT CONTACT WITH NEOPRENE SEAL SHALL BE PERMITTED.



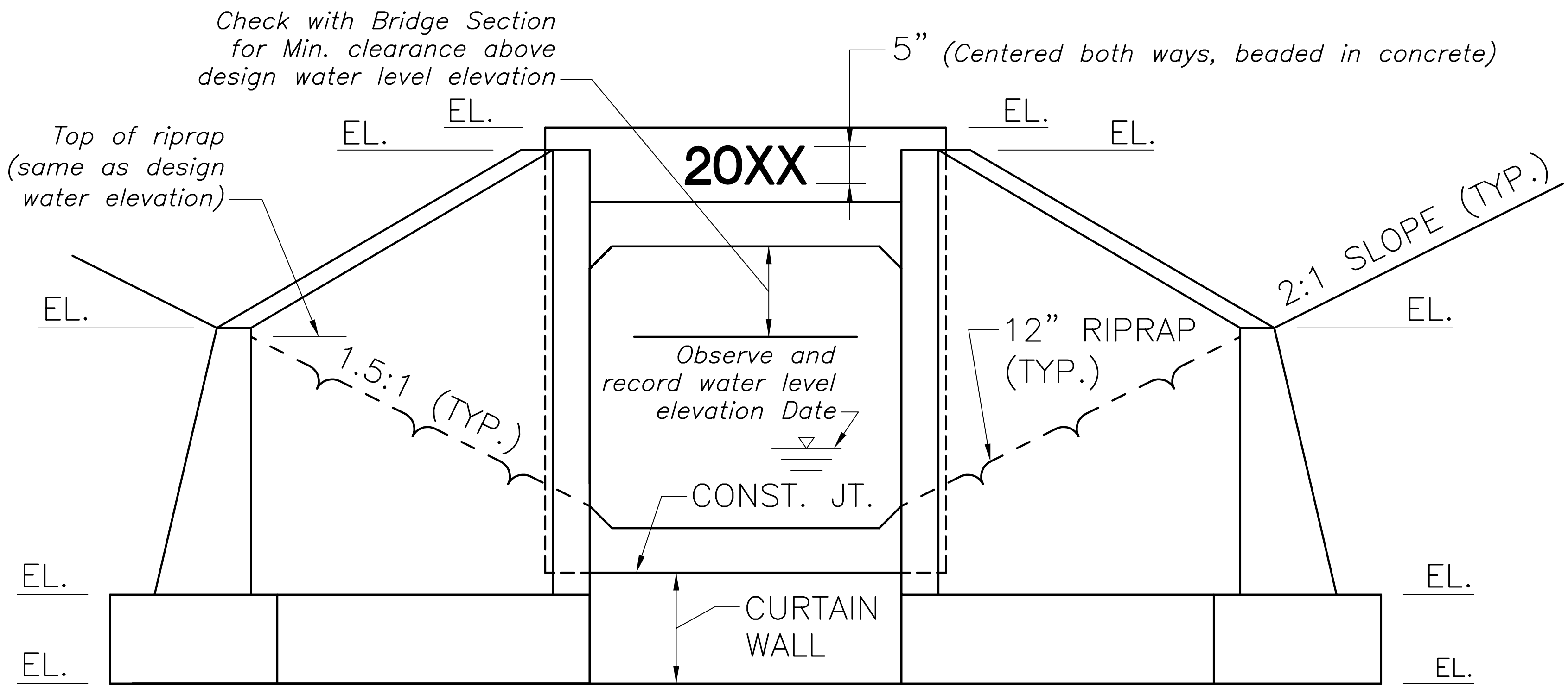
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL PLAN VIEW

ROADWAY OVER FILL

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
11.1.1



ELEVATION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Construction Drawings will be prepared incorporating the design features shown in these standards.*
2. *Borings: At least two borings will be taken for each culvert.*
   A boring plan will be prepared in accordance with Bridge Manual standards.
3. *Show typical channel cross section.*
4. *Note on Sketch Plans and Construction Drawings design loading used.*
5. *Ends of culverts to be parallel to ℄ of construction up to 10'–0" of cover. Where height of cover is 10'–0" or more, ends of culverts are to be square regardless of skew of culvert.*
6. *Bottom of footing should not be less than 4'–0" below bed of stream.*
7. *Show approximate existing ground.*

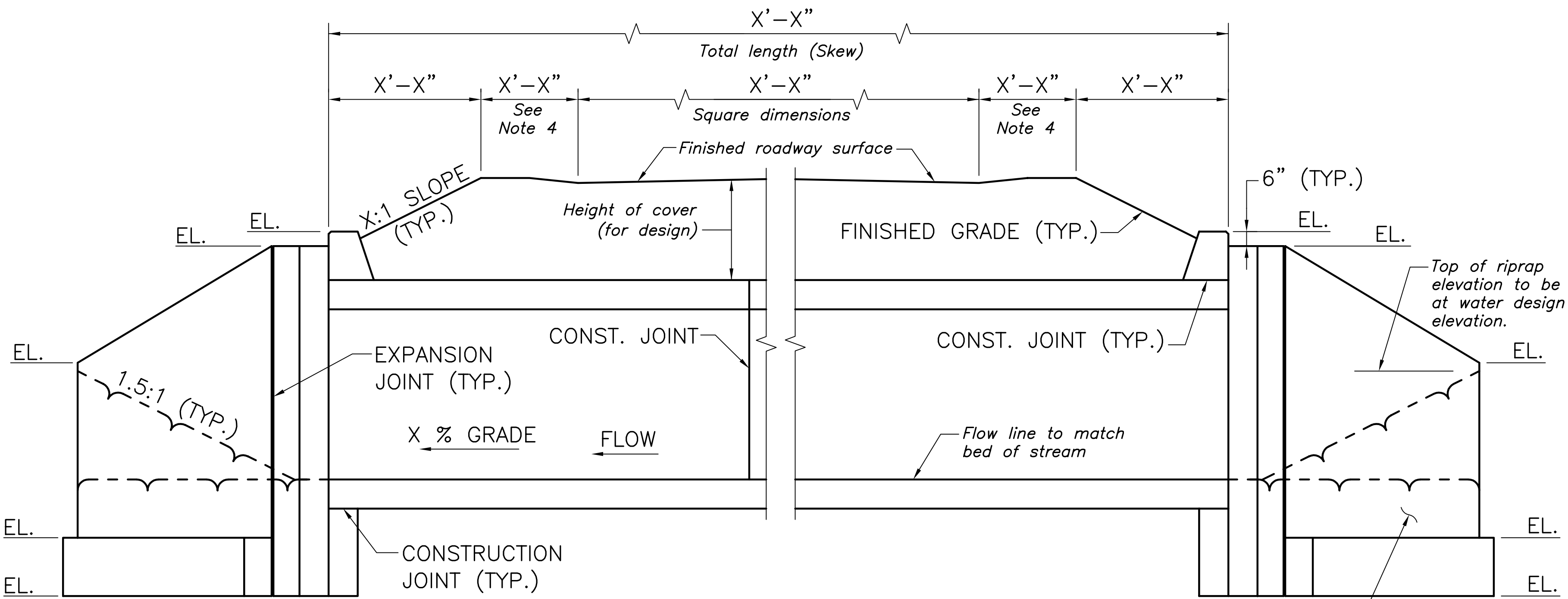
MASS HIGHWAY BRIDGE MANUAL

TYPICAL ELEVATION VIEW

ROADWAY OVER FILL

DATE OF ISSUE: MAY 2005

DRAWING NUMBER: **11.1.2**

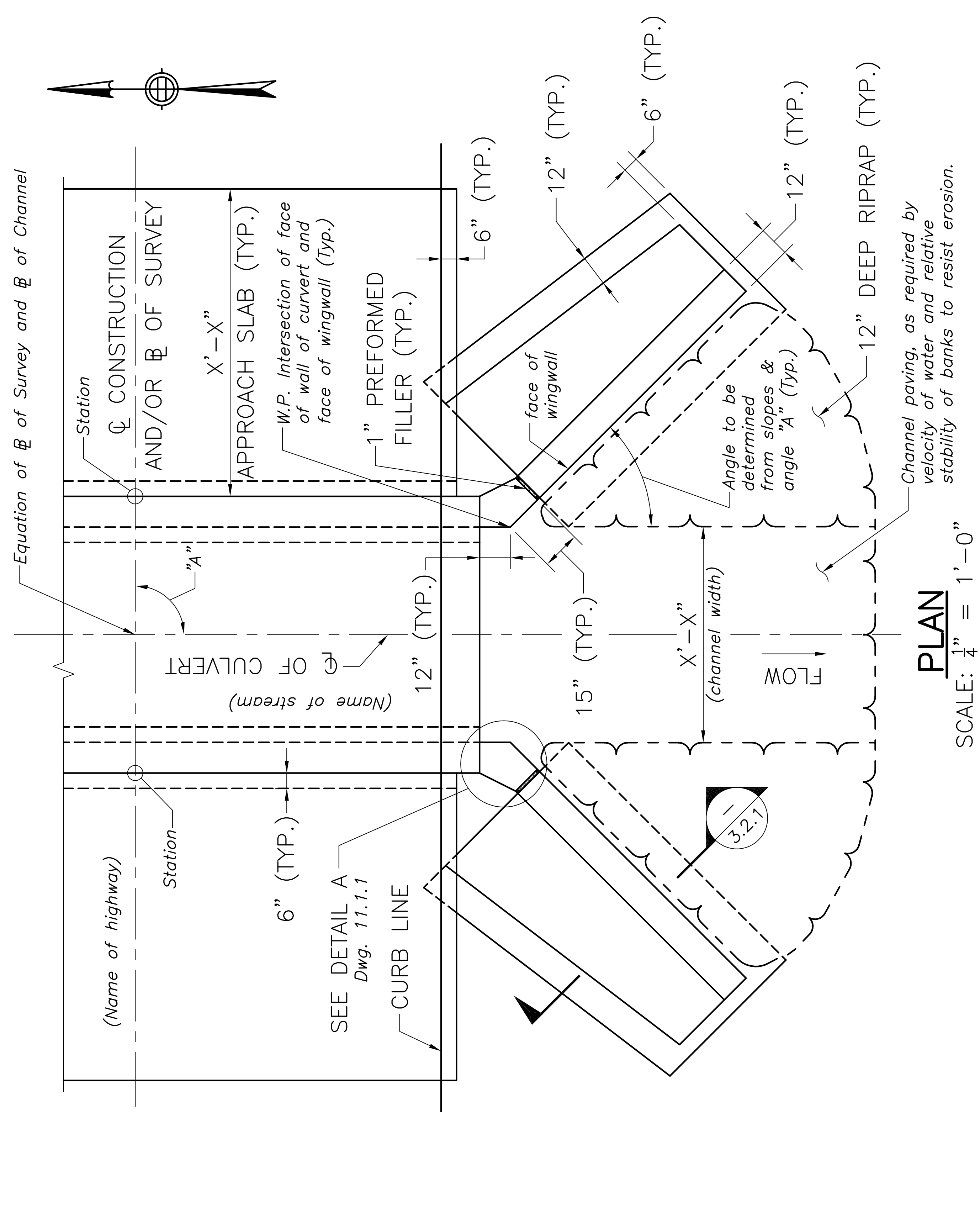


LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. *Expansion joints 70'–0" O.C., Max.*
2. *Construction joints 25'–0" O.C., Max.*
3. *Show approximate existing ground.*
4. *Show approximate guardrail system with sufficient height of cover for post embeddment. Otherwise, consider culvert with roadway on barrel roof.*



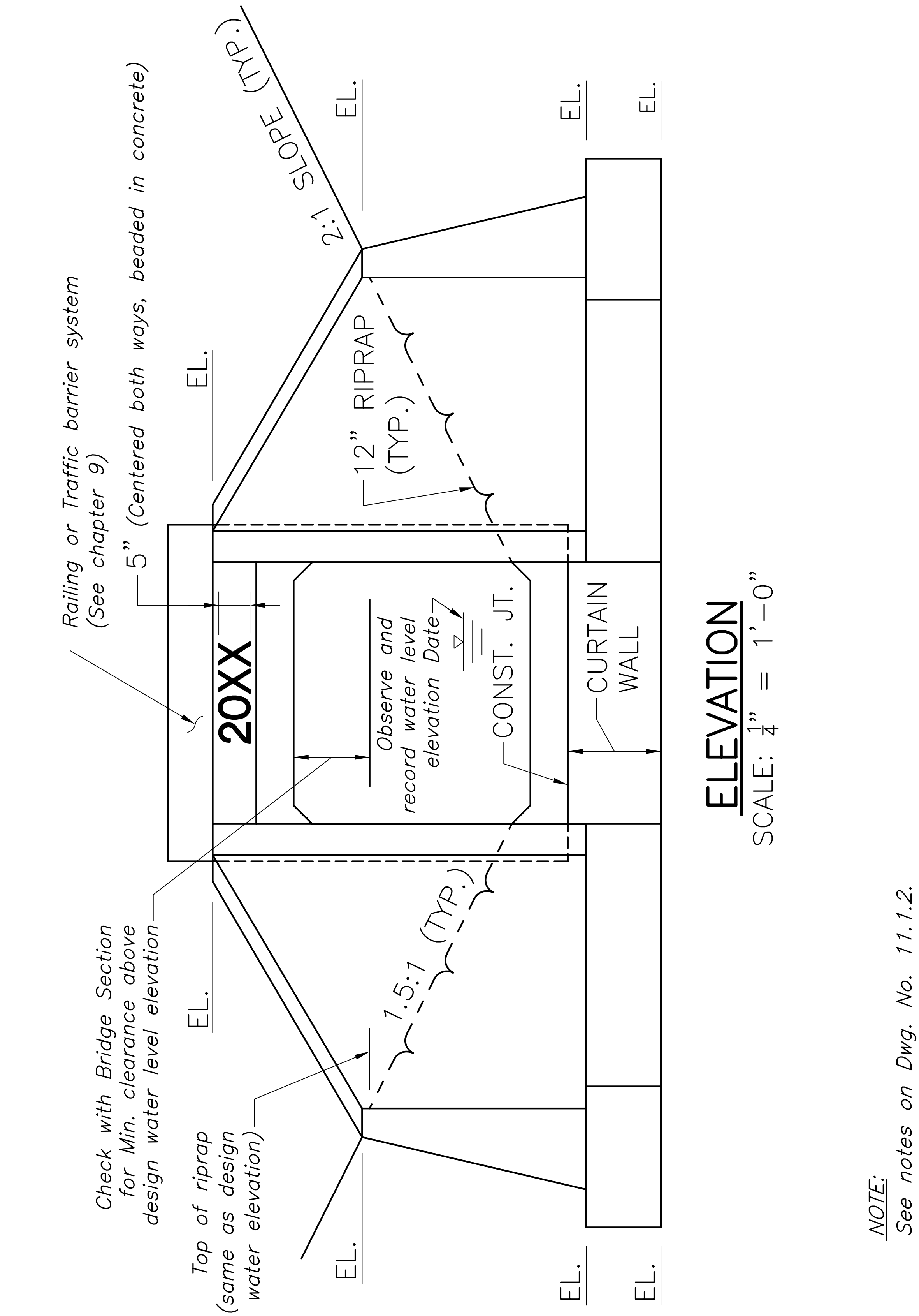
MASS HIGHWAY
BRIDGE MANUAL

TYPICAL PLAN VIEW

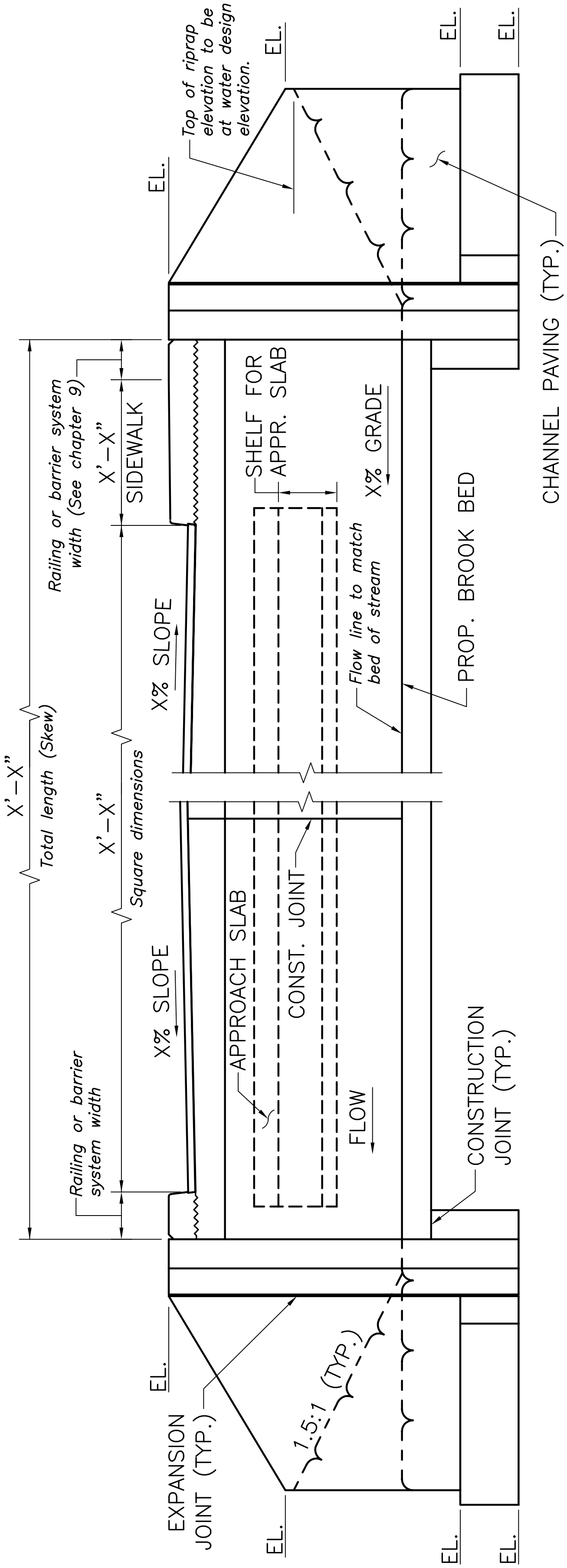
ROADWAY ON BARREL ROOF

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
11.2.1



MASS HIGHWAY BRIDGE MANUAL	TYPICAL ELEVATION VIEW	DATE OF ISSUE MAY 2005
	ROADWAY ON BARREL ROOF	DRAWING NUMBER **11.2.2**



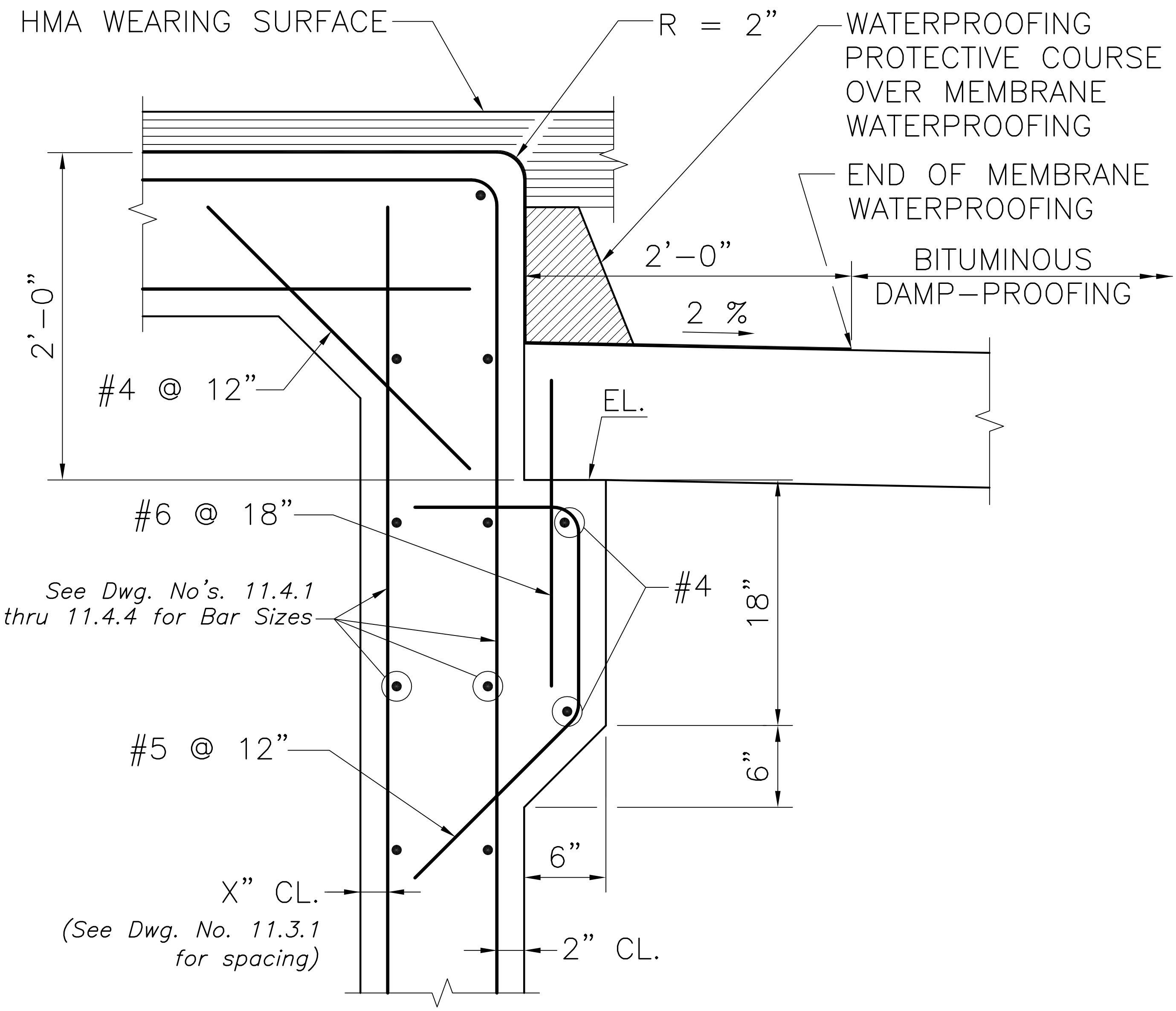
LONGITUDINAL SECTION

SCALE: $\frac{1}{4}$" = 1'–0"

NOTES:

1. Expansion joints 70'–0" O.C., Max.
2. Construction joints 25'–0" O.C., Max.
3. Show approximate existing ground.

MASS HIGHWAY BRIDGE MANUAL	TYPICAL LONGITUDINAL SECTION ROADWAY ON BARREL ROOF	DATE OF ISSUE MAY 2005 DRAWING NUMBER **11.2.3**



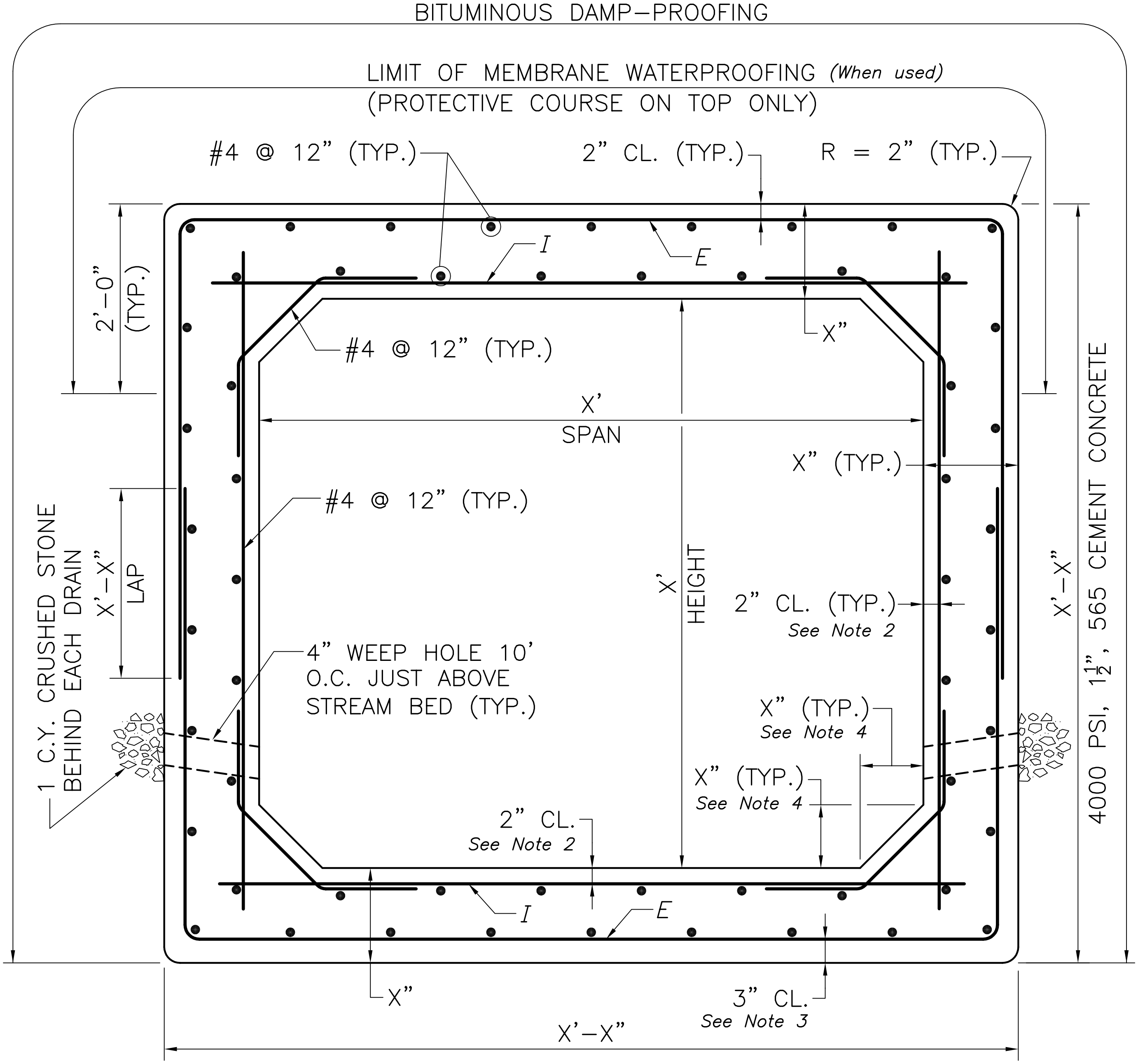
SHELF FOR APPROACH SLAB

SCALE: 1" = 1'-0"

NOTE:

This detail is to be used with Approach Slab Type I.

MASS HIGHWAY BRIDGE MANUAL	APPROACH SLAB SHELF DETAILS ROADWAY ON BARREL ROOF	DATE OF ISSUE MAY 2005 DRAWING NUMBER **11.2.4**



NOTES:

1. MAXIMUM BEARING PRESSURE = XXX KSF.
2. TRANSVERSE REINFORCING SHALL BE PLACED NORMAL TO THE ℄ OF THE CULVERT.

SECTION THRU BARREL

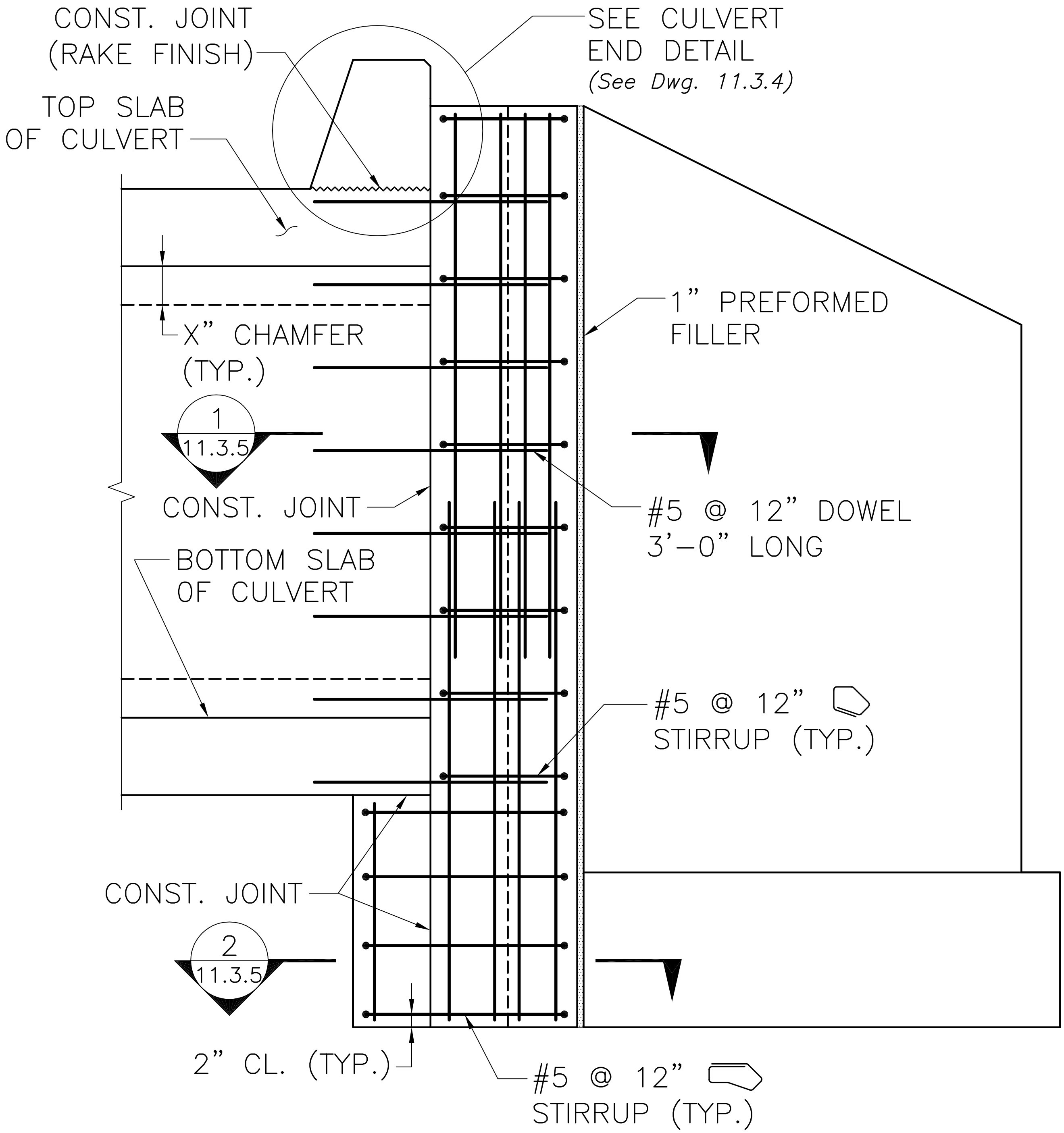
SCALE: $\frac{3}{4}$" = 1'–0"

For Designer Notes see Dwg. No. 11.3.2

MASS HIGHWAY BRIDGE MANUAL	TYPICAL SECTION BOX CULVERT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **11.3.1**

NOTES: *(for use with details on Dwg. No. 11.3.1)*

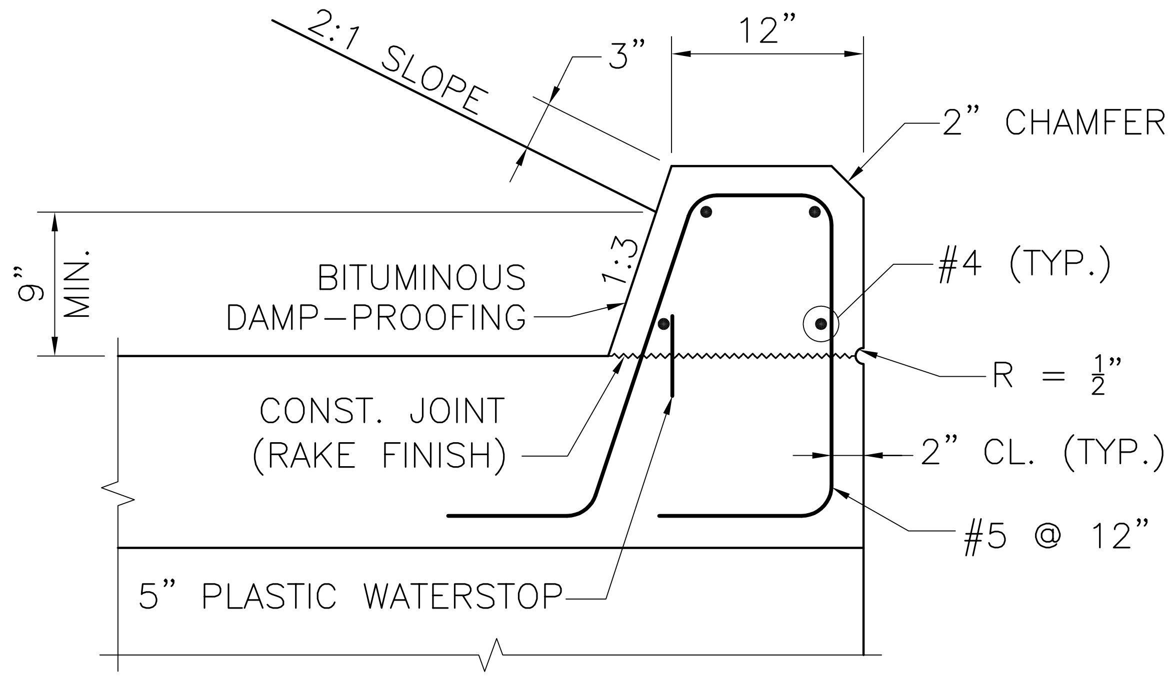
1. Use membrane waterproofing with a waterproofing protective course where roadway pavement is directly on the structure and on all structures where the clear span is over 20'–0". Use bituminous damp–proofing where roadway is not directly on the structure and the clear span is less than 20'–0".
2. 3" if exposed to salt water thus increasing sidewalls 1".
3. 4" if exposed to salt water thus increasing bottom slab 2".
4. X" shall equal the span width in inches.
5. All culverts shall be:
   - Assigned a Bridge Number (BDEPT#) when the square span is 4'–0" or greater.
   - Submitted for approval in accordance with Sketch Plan requirements of Part I of the Bridge Manual.
   - Designed in accordance with the provisions noted in Part I of the Bridge Manual.
6. Where culverts are under high fills the Special Provisions should be explicit in the placement of backfill.
7. Culverts shown in these standards are not designed to provide for unbalanced horizontal forces. These forces shall be considered in the design of all culverts where conditions require.
8. For cases involving a cover in excess of 40' an alternate design such as a reinforced concrete arch should be considered. Dimensions for culverts are for clear inside opening, horizontal dimensions given first. The volume of steel is not to be deducted from the volume of concrete when estimating quantities. This sheet to be used in conjunction with Dwg. No.'s 11.3.6 thru 11.3.9.
9. A sufficient number of borings shall be taken for all culverts.
10. Steel reinforcement to be placed perpendicular to ℄ of construction.
11. See Dwg. No.'s 11.3.6 thru 11.3.9 for values of S, I and E.



ELEVATION

SCALE: $\frac{1}{2}$" = 1'-0"

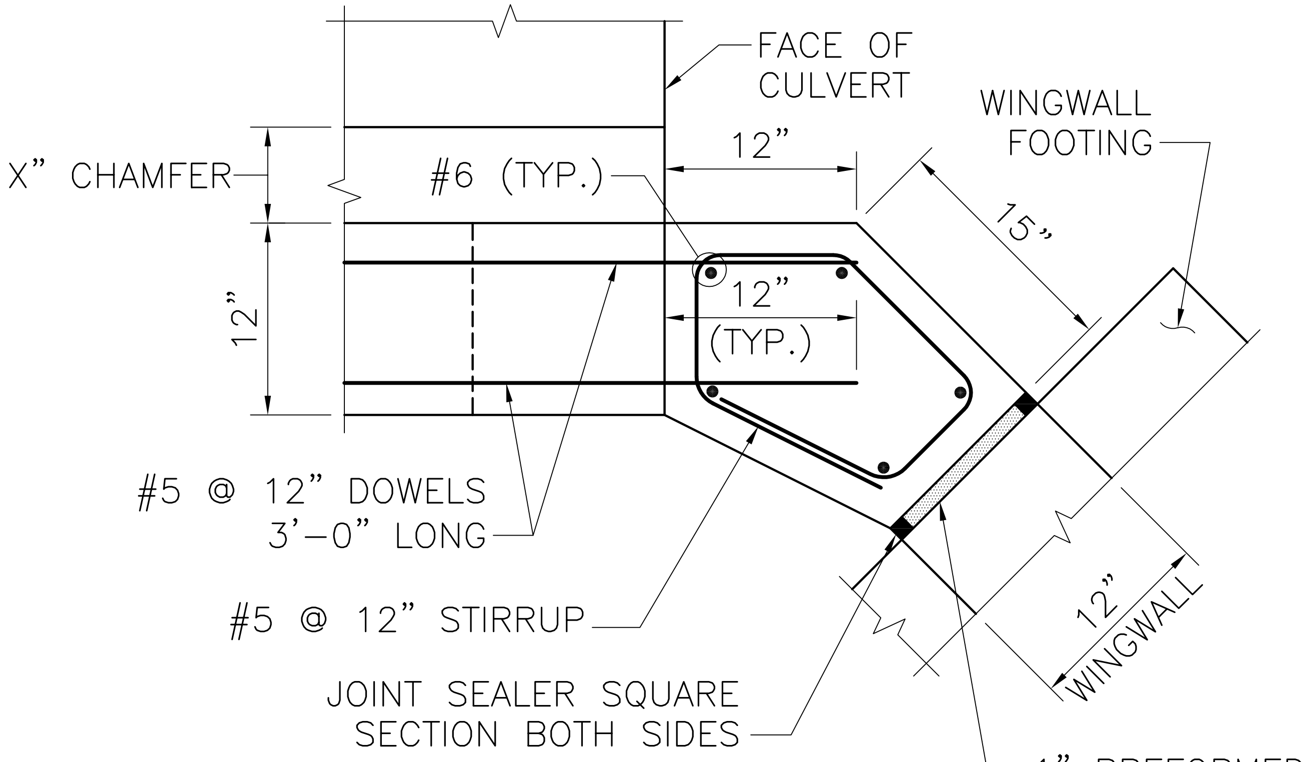
MASS HIGHWAY BRIDGE MANUAL	CULVERT JOINT DETAIL AT WINGWALL ELEVATION BOX CULVERT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **11.3.3**



CULVERT END DETAIL

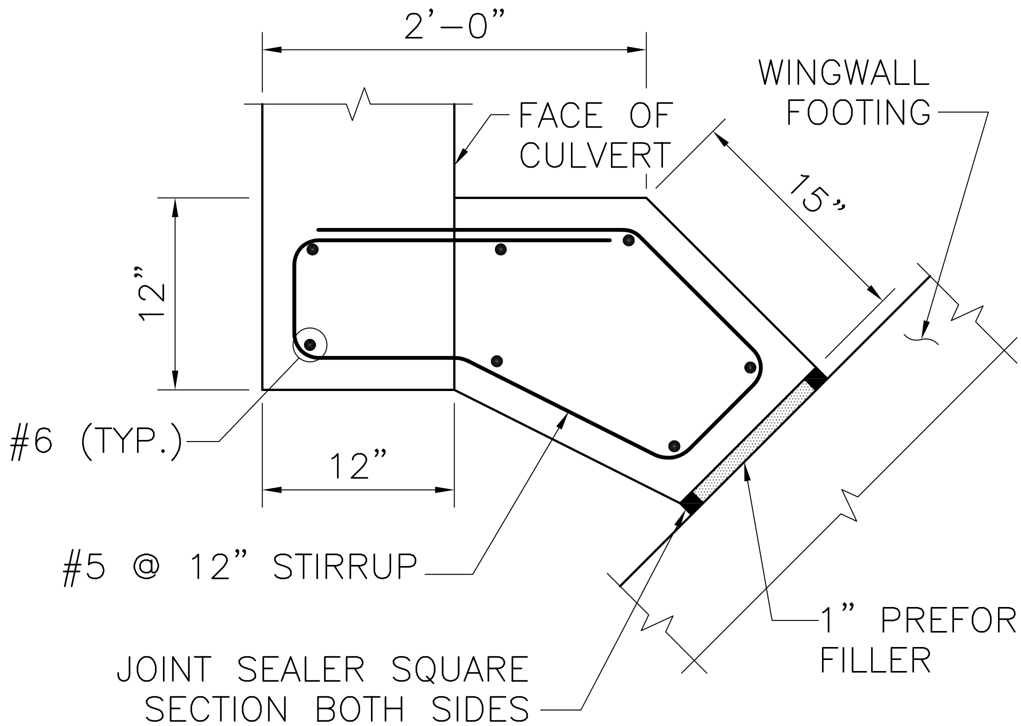
SCALE: 1" = 1'–0"

NOTE:
Coping for roadway over fill shown. For roadway on barrel roof, use appropriate sidewalk and safety curb detail from Chapter 9.



SECTION 1

SCALE: 1" = 1'-0"



SECTION 2

SCALE: 1" = 1'-0"

MASS HIGHWAY BRIDGE MANUAL	FACE OF CULVERT DETAILS BOX CULVERT DETAILS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **11.3.5**

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 3' X HEIGHT = 2' & 3'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 12"
2	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 12"
3–20	7	7	8	#4 @ 12"	#4 @ 12"	#4 @ 12"	#4 @ 12"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 4' X HEIGHT = 2'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#4 @ 12"
2	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 9"
3–12	7	7	8	#4 @ 12"	#4 @ 12"	#4 @ 12"	#4 @ 12"
13–14	7	7	8	#5 @ 12"	#4 @ 12"	#4 @ 9"	#4 @ 9"
15–19	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
20	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 4' X HEIGHT = 3'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#4 @ 8"	#4 @ 8"	#5 @ 8"	#4 @ 12"
2	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 9"
3–11	7	7	8	#4 @ 12"	#4 @ 12"	#4 @ 12"	#4 @ 12"
12	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 12"	#4 @ 12"
13–18	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
19–20	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 4' X HEIGHT = 4'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0	7	7	8	#4 @ 5"	#4 @ 5"	#4 @ 5"	#4 @ 12"
1	7	7	8	#4 @ 7"	#4 @ 7"	#5 @ 7"	#4 @ 12"
2	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 9"
3–12	7	7	8	#4 @ 12"	#4 @ 12"	#4 @ 12"	#4 @ 12"
13	7	7	8	#4 @ 12"	#4 @ 12"	#4 @ 9"	#4 @ 9"
14	7	7	8	#5 @ 12"	#4 @ 12"	#4 @ 9"	#4 @ 9"
15–18	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
19	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 8"
20	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"

This sheet is to be used in conjunction with Dwg. No. 11.3.1

PRE–ENGINEERED REINFORCEMENT

BOX CULVERT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
11.3.6

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 5' X HEIGHT = 3'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#5 @ 9"	#5 @ 9"	#6 @ 9"	#4 @ 9"
2	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 8"
3–7	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
8–11	7	7	8	#5 @ 12"	#4 @ 12"	#4 @ 12"	#4 @ 9"
12	7	7	8	#5 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
13	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"
14–15	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
16–18	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
19	7	7	8	#6 @ 9"	#6 @ 9"	#5 @ 9"	#5 @ 9"
20	7	7	8	#4 @ 8"	#4 @ 8"	#5 @ 8"	#5 @ 8"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 5' X HEIGHT = 4'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#5 @ 9"	#5 @ 9"	#6 @ 9"	#4 @ 9"
2	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#4 @ 7"
3	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 9"
4–7	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
8–15	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
16–18	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
19	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#4 @ 6"
20	7	7	8	#4 @ 8"	#4 @ 8"	#5 @ 8"	#5 @ 8"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 5' X HEIGHT = 5'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0	7	7	8	#5 @ 9"	#5 @ 9"	#6 @ 9"	#4 @ 9"
1	7	7	8	#4 @ 6"	#4 @ 6"	#5 @ 6"	#4 @ 9"
2	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#4 @ 7"
3	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 9"
4–7	7	7	8	#4 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
8–13	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"
14	7	7	8	#5 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"
15	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
16–20	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"

This sheet is to be used in conjunction with Dwg. No. 11.3.1

MASS HIGHWAY
BRIDGE MANUAL

PRE–ENGINEERED REINFORCEMENT

BOX CULVERT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
11.3.7

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 6' X HEIGHT = 4'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0	7	7	8	#5 @ 8"	#5 @ 8"	#6 @ 8"	#4 @ 9"
1	7	7	8	#5 @ 7"	#5 @ 7"	#6 @ 7"	#4 @ 8"
2	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#4 @ 6"
3	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
4–7	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
8	7	7	8	#5 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
9	7	7	8	#4 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"
10	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
11–12	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
13–14	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#5 @ 8"
15	7	7	8	#6 @ 8"	#6 @ 8"	#5 @ 8"	#5 @ 8"
16–18	7	7	8	#5 @ 7"	#5 @ 7"	#5 @ 7"	#5 @ 7"
19–20	7	7	8	#6 @ 9"	#6 @ 9"	#6 @ 9"	#6 @ 9"

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 6' X HEIGHT = 5'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#5 @ 7"	#5 @ 7"	#6 @ 7"	#4 @ 8"
2	7	7	8	#6 @ 9"	#6 @ 9"	#6 @ 9"	#4 @ 6"
3	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
4–10	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
11–12	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
13–14	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#5 @ 8"
16–20	7	7	8	#5 @ 7"	#5 @ 7"	#5 @ 7"	#5 @ 7"

This sheet is to be used in conjunction with Dwg. No. 11.3.1

HEIGHT OF FILL IN FEET	CONCRETE THICKNESS IN INCHES			SPAN = 6' X HEIGHT = 6'			
				E		I	
	TOP	SIDE	BOT	TOP	BOT	TOP	BOT
0–1	7	7	8	#5 @ 7"	#5 @ 7"	#6 @ 7"	#4 @ 7"
2	7	7	8	#5 @ 9"	#5 @ 9"	#6 @ 9"	#4 @ 6"
3	7	7	8	#4 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
4–7	7	7	8	#4 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
8	7	7	8	#5 @ 9"	#4 @ 9"	#4 @ 9"	#4 @ 9"
9	7	7	8	#5 @ 8"	#4 @ 8"	#4 @ 8"	#4 @ 8"
10–11	7	7	8	#5 @ 7"	#4 @ 7"	#4 @ 7"	#4 @ 7"
12–13	7	7	8	#5 @ 6"	#4 @ 6"	#4 @ 6"	#4 @ 6"
14–15	7	7	8	#6 @ 8"	#5 @ 8"	#5 @ 8"	#5 @ 8"
16	7	7	8	#5 @ 8"	#5 @ 8"	#5 @ 8"	#5 @ 8"
17–20	7	7	8	#5 @ 7"	#5 @ 7"	#5 @ 7"	#5 @ 7"

This sheet is to be used in conjunction with Dwg. No. 11.3.1

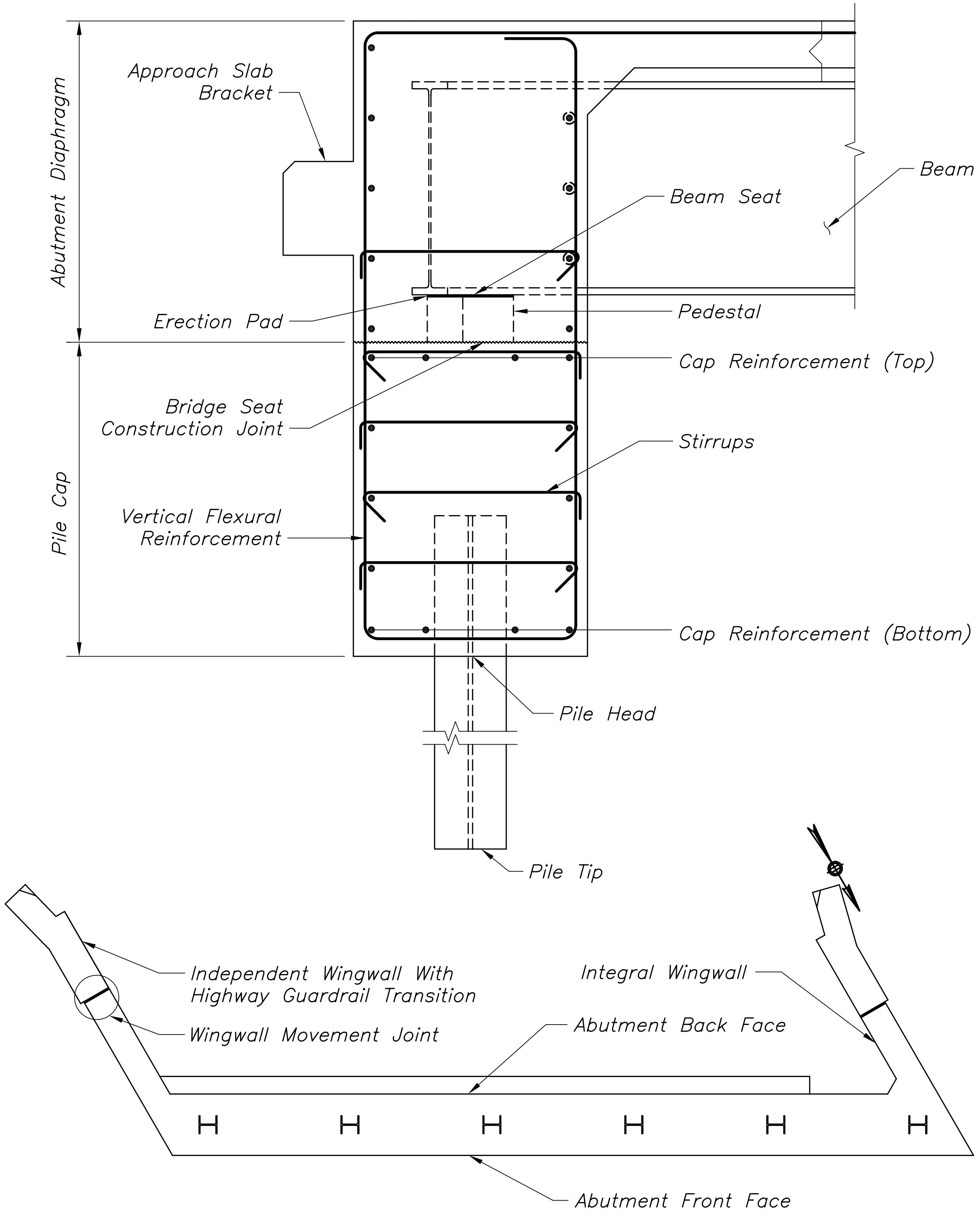
MASS HIGHWAY
BRIDGE MANUAL

PRE–ENGINEERED REINFORCEMENT

BOX CULVERT DETAILS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
11.3.9



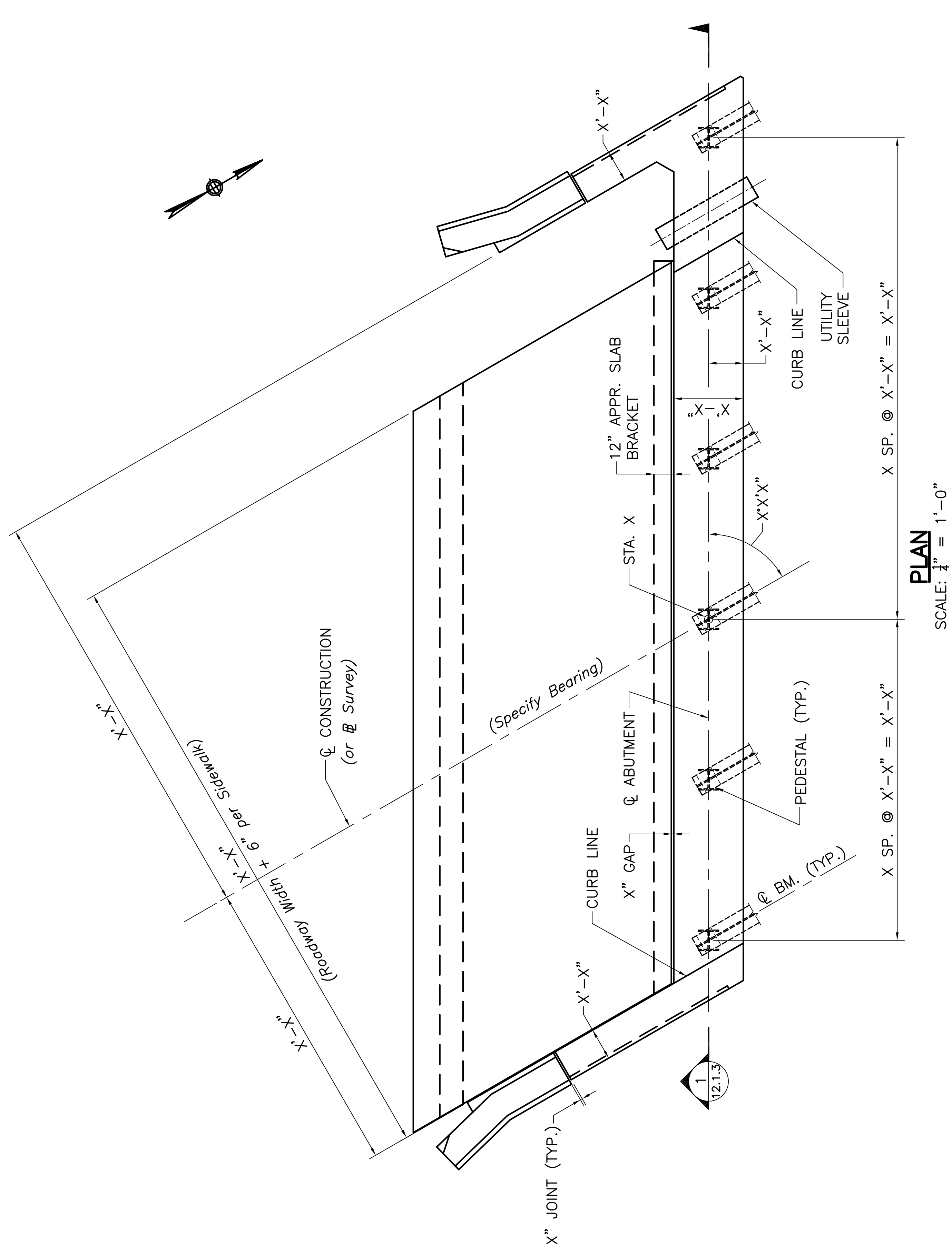
MASS HIGHWAY BRIDGE MANUAL

TERMINOLOGY

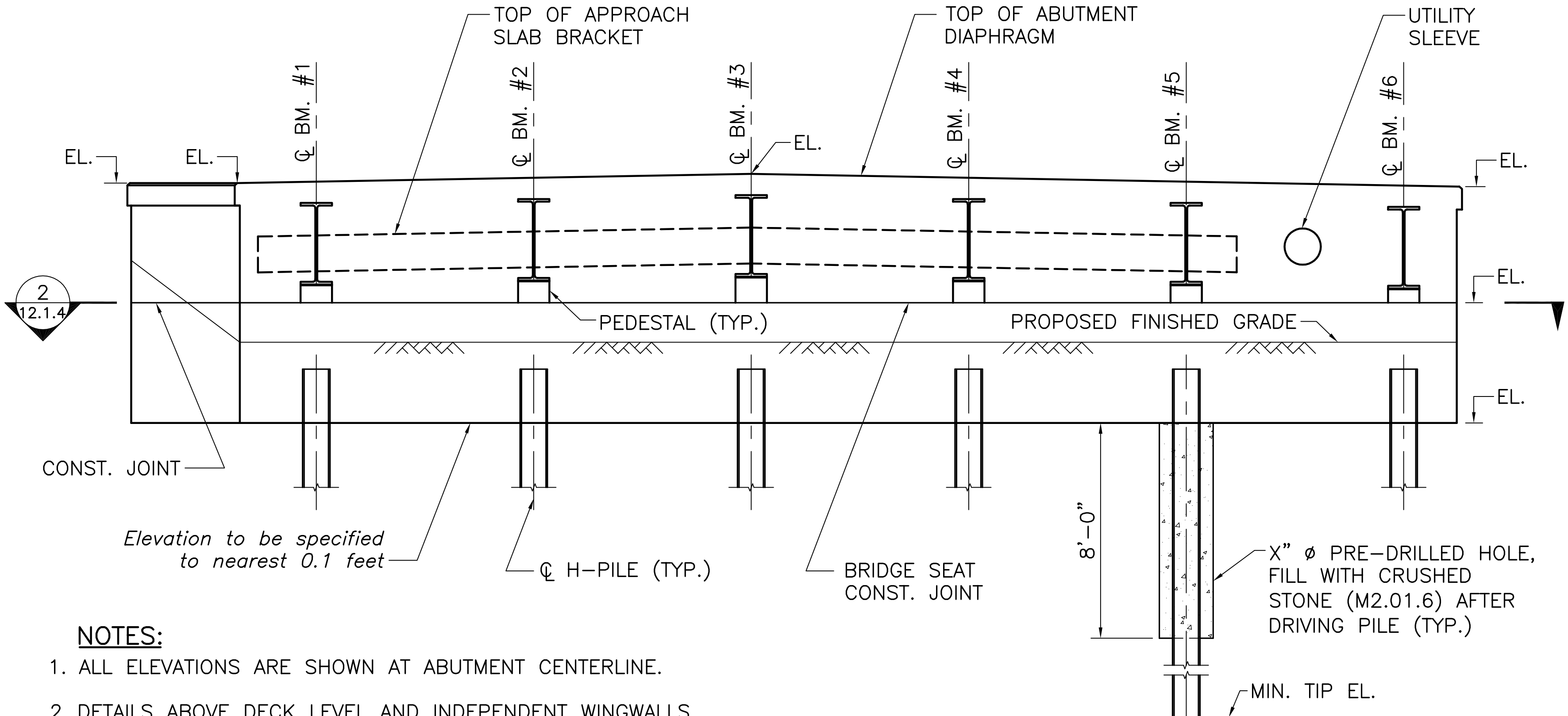
INTEGRAL ABUTMENTS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
12.1.1



MASS HIGHWAY BRIDGE MANUAL	ABUTMENT PLAN INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.1.2**



NOTES:

1. ALL ELEVATIONS ARE SHOWN AT ABUTMENT CENTERLINE.
2. DETAILS ABOVE DECK LEVEL AND INDEPENDENT WINGWALLS OMITTED FOR CLARITY.

SECTION 1

SCALE: $\frac{1}{4}$" = 1'–0"

TOP OF PEDESTAL ELEVATIONS			
BM. #1	##.##	BM. #4	##.##
BM. #2	##.##	BM. #5	##.##
BM. #3	##.##	BM. #6	##.##

NOTE:

ELEVATIONS DO NOT INCLUDE ERECTION PAD THICKNESS.

NOTES:

1. *Show and label stage construction joint(s).*
2. *Provide top of pedestal elevations to nearest 0.01 ft.*
3. *Rolled beams are shown. Show actual beam type and position of the beams relative to the piles at the centerline of the abutment.*
4. *Show steps in the bridge seat, if any, centered between stringers.*

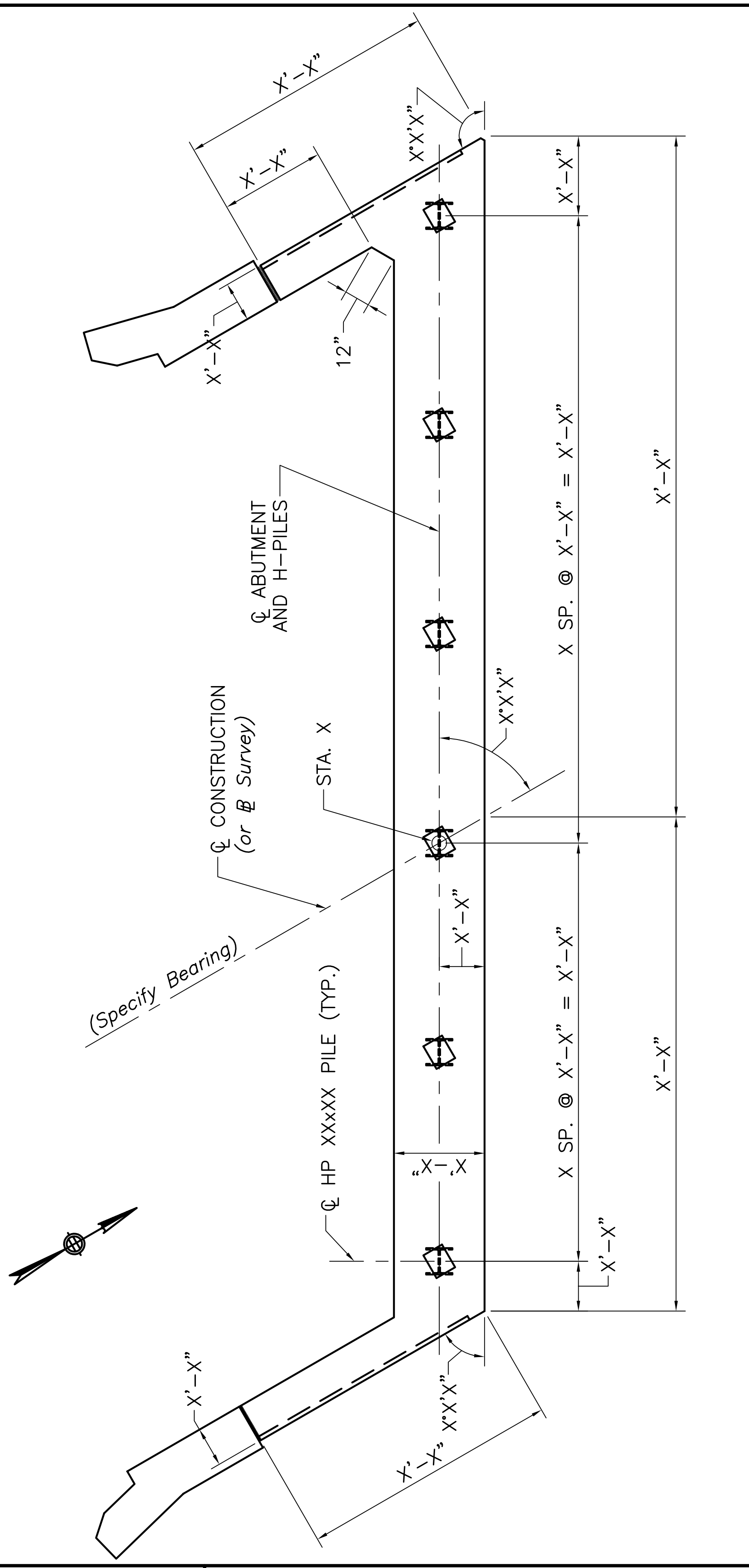
MASS HIGHWAY BRIDGE MANUAL

SECTION AT CENTERLINE OF ABUTMENT

INTEGRAL ABUTMENTS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
12.1.3

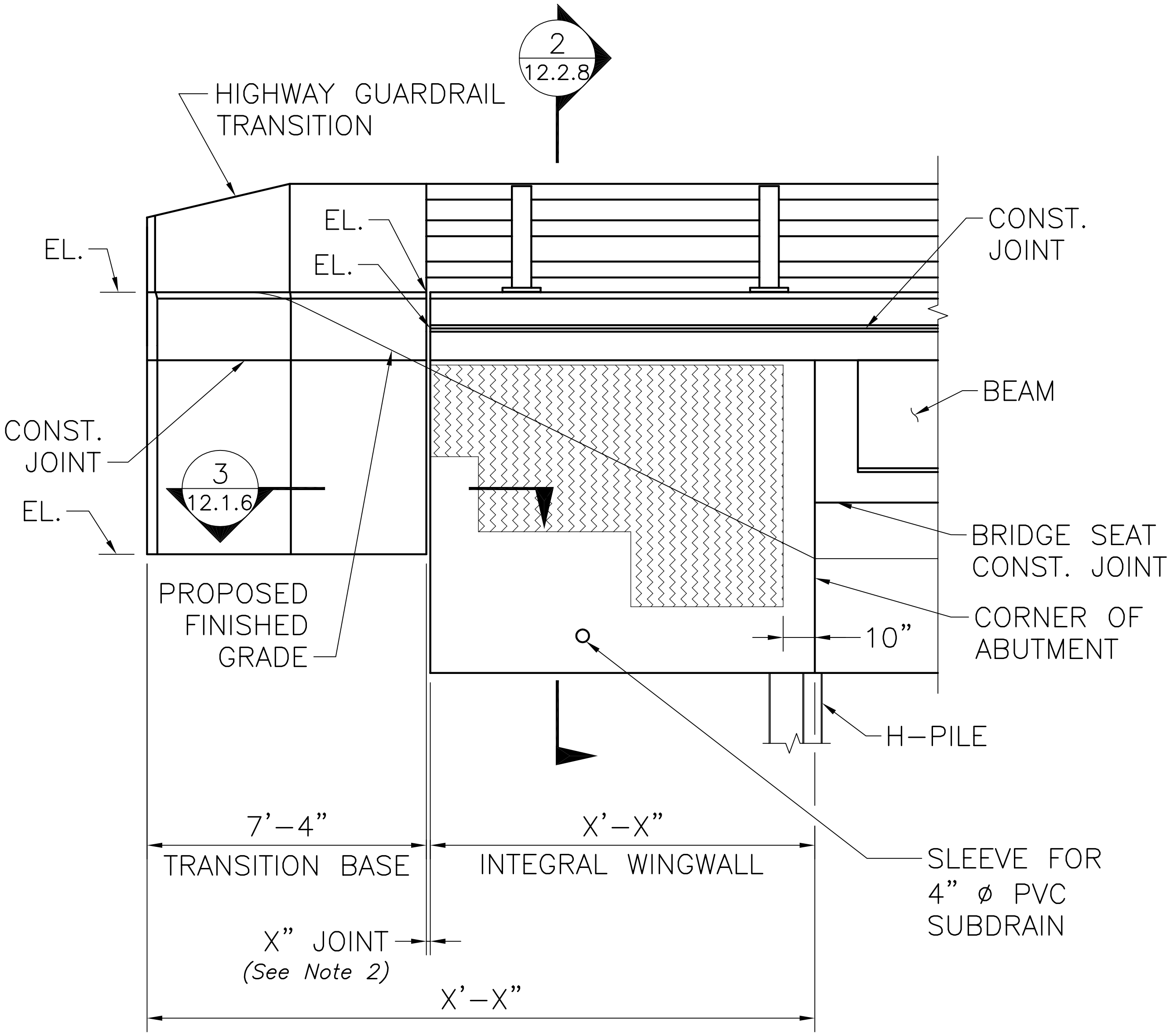


SECTION 2
SCALE: $\frac{1}{4}$" = 1'-0"

NOTES:

1. Stage construction joint(s), if any, shall be shown on the plan view on Construction Drawings.
2. On the Construction Drawings, the plan view of each abutment shall be as shown above and aligned with elevation view.
3. Show steps in the bridge seat, if any, centered between stringers and square to the abutment centerline. Minimize the number of required steps (refer to Dwg. No. 12.3.1 thru 12.3.4).
4. Movement joint between Integral and Independent Wingwalls shall be dimensioned as specified on Dwg. No. 12.1.6.

MASS HIGHWAY BRIDGE MANUAL	HORIZONTAL SECTION AT BRIDGE SEAT INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.1.4**



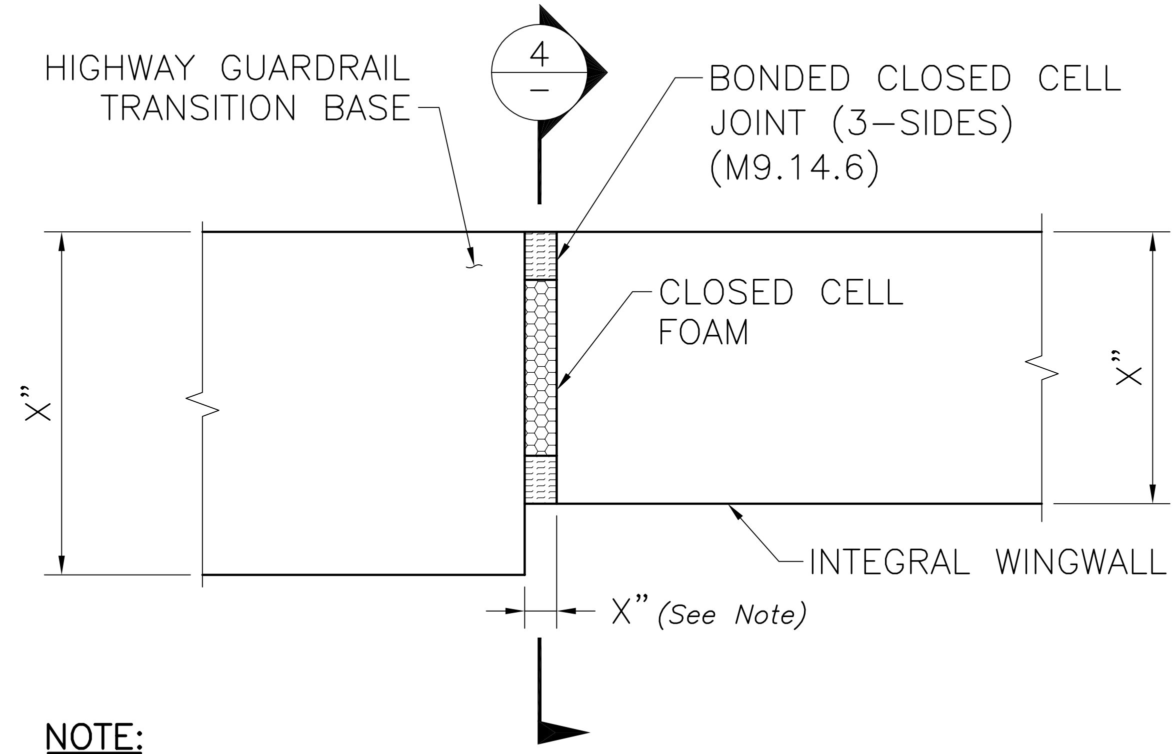
NOTE:
RAILING PICKETS NOT SHOWN FOR CLARITY.

WINGWALL ELEVATION

SCALE: $\frac{1}{4}$" = 1'-0"

NOTES:

1. *Rolled Beam with Type S3-TL4 railing shown. Modify for other beam types and railing/barriers as required.*
2. *See Dwg. No. 12.1.6 to determine movement joint width.*
3. *Show each wingwall in elevation.*
4. *Refer to Chapter 3 for wingwall geometry.*
5. *Striations shall be provided on wingwall only. They shall not be provided on front face of abutments. See Section 3.4 for general striation details.*

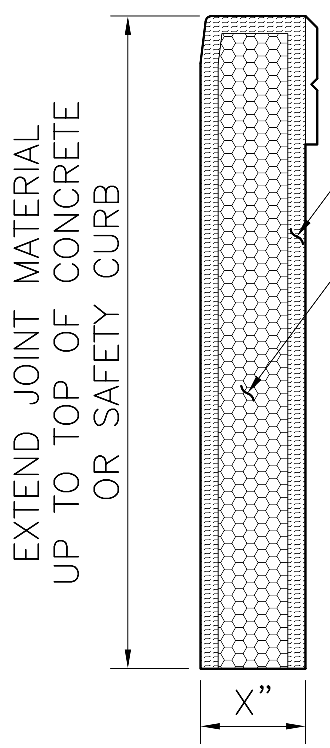


NOTE:

REINFORCEMENT NOT SHOWN FOR CLARITY.

SECTION 3

SCALE: 1" = 1'–0"



SECTION 4

SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

Movement joint width based on length of bridge and stringer material, as shown below.

JOINT WIDTH	*MAXIMUM TOTAL BRIDGE LENGTH* *STEEL*	*CONCRETE*
1"	*85'*	*200'*
$1\frac{1}{4}$"	*135'*	*300'*
$1\frac{1}{2}$"	*185'*	*450'*
2"	*215'*	*550'*
$2\frac{1}{2}$"	*265'*	*650'*
3"	*365'*	*850'*

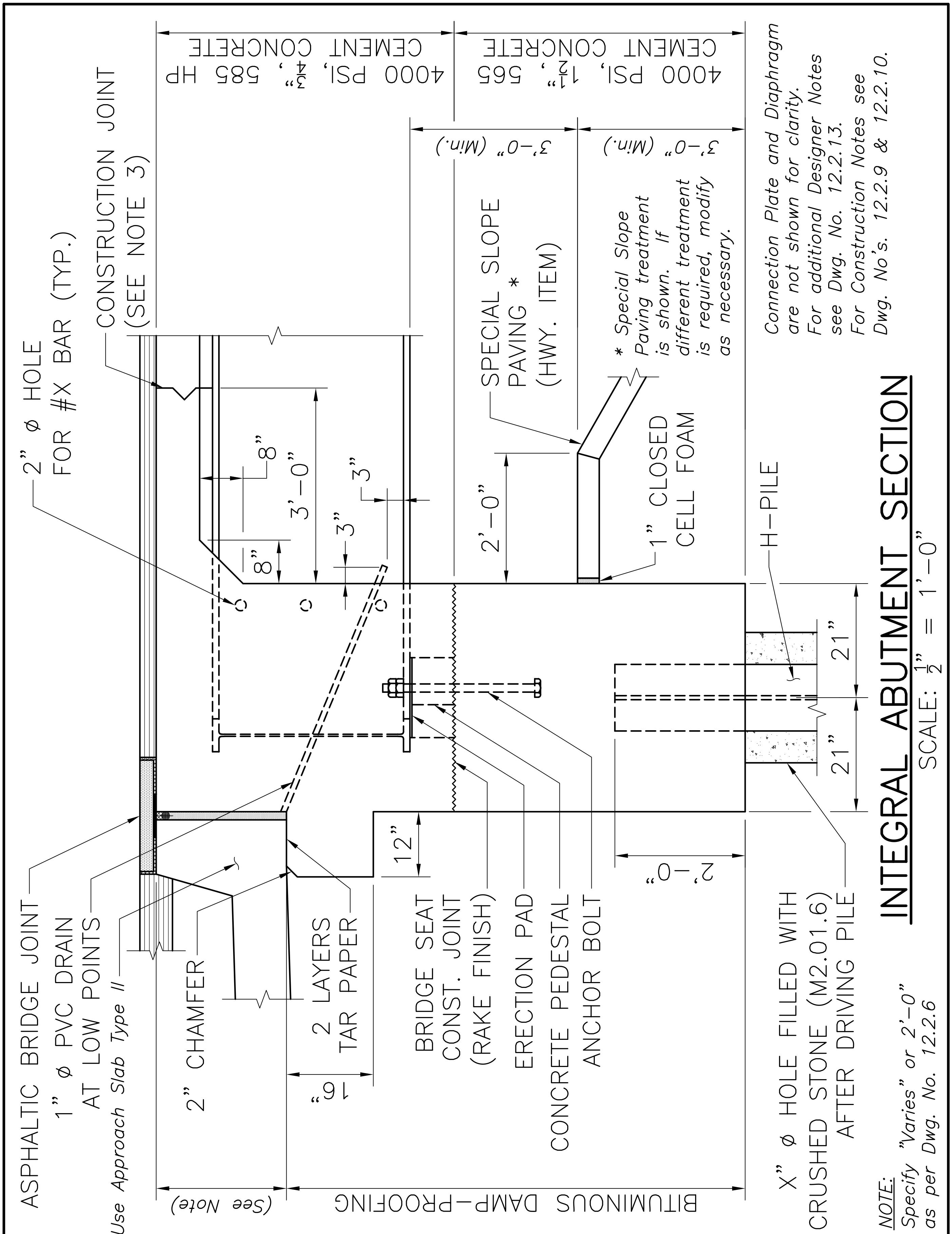
MASS HIGHWAY
BRIDGE MANUAL

WINGWALL SECTION AND MOVEMENT JOINT SECTION

INTEGRAL ABUTMENTS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
12.1.6



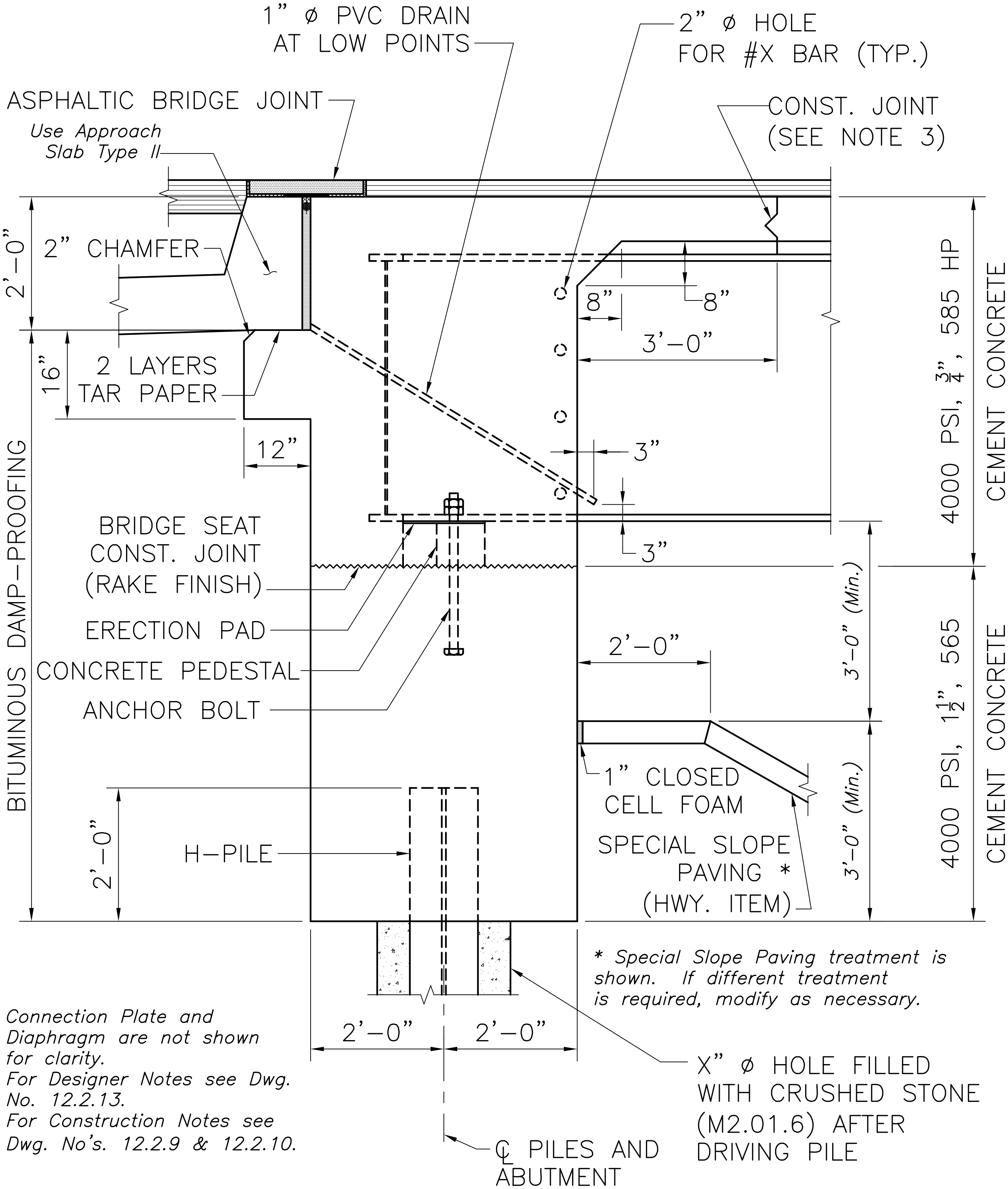
MASS HIGHWAY BRIDGE MANUAL

ABUTMENT SECTION ROLLED BEAMS

INTEGRAL ABUTMENTS

DATE OF ISSUE AUGUST 2007

DRAWING NUMBER **12.2.1**



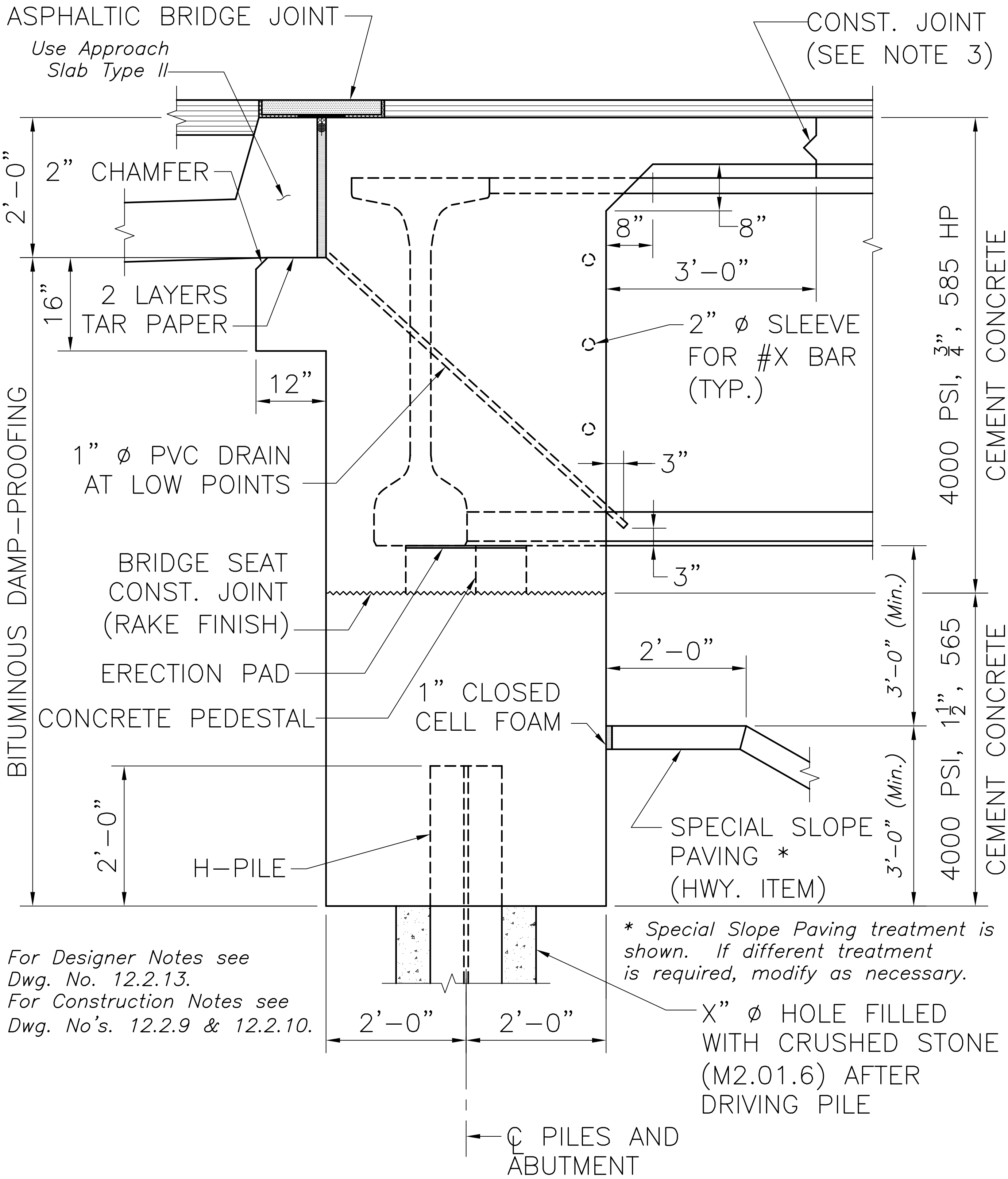
* Special Slope Paving treatment is shown. If different treatment is required, modify as necessary.

Connection Plate and Diaphragm are not shown for clarity.
For Designer Notes see Dwg. No. 12.2.13.
For Construction Notes see Dwg. No's. 12.2.9 & 12.2.10.

INTEGRAL ABUTMENT SECTION

SCALE: $\frac{1}{2}$" = 1'-0"

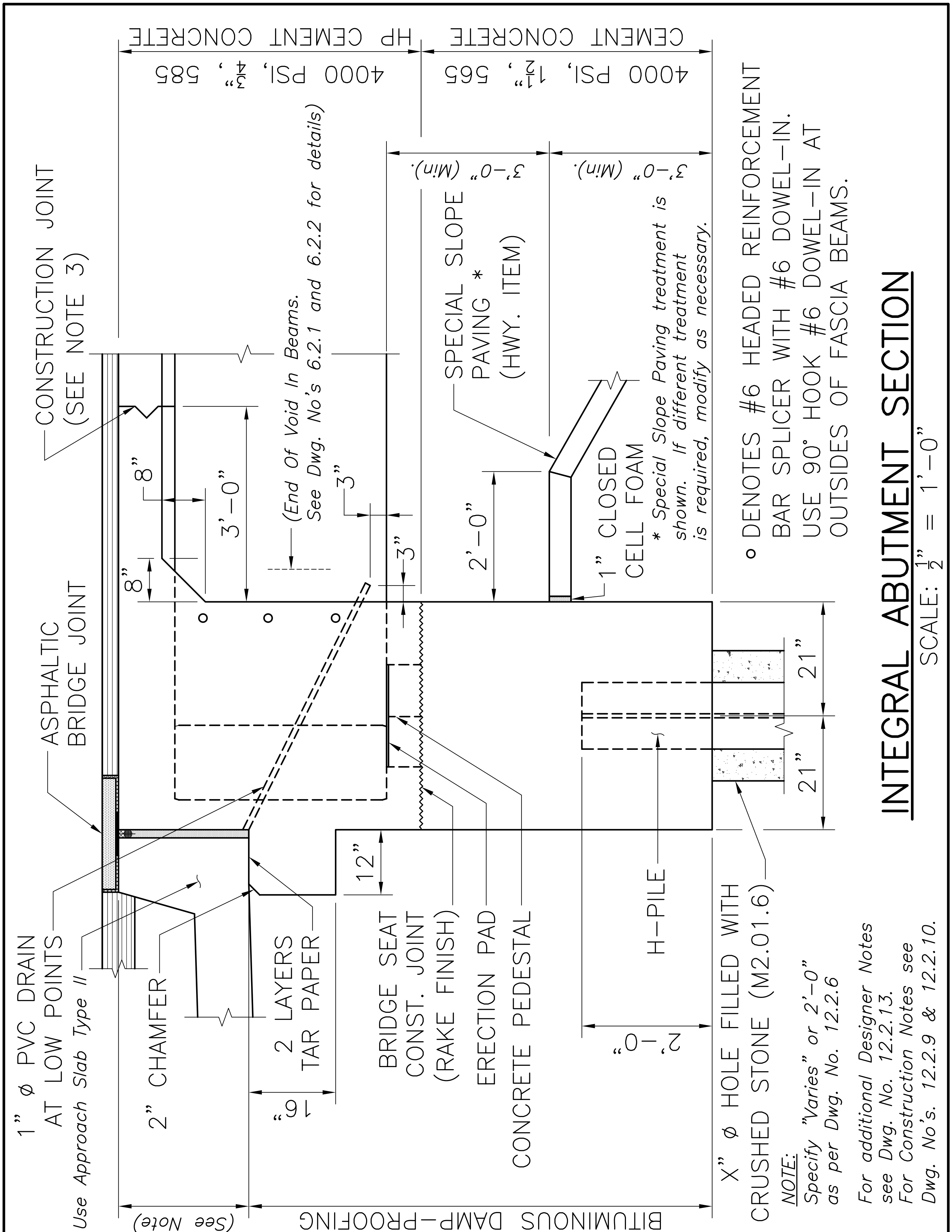
MASS HIGHWAY BRIDGE MANUAL	ABUTMENT SECTION PLATE GIRDERS INTEGRAL ABUTMENTS	DATE OF ISSUE AUGUST 2007 DRAWING NUMBER **12.2.2**



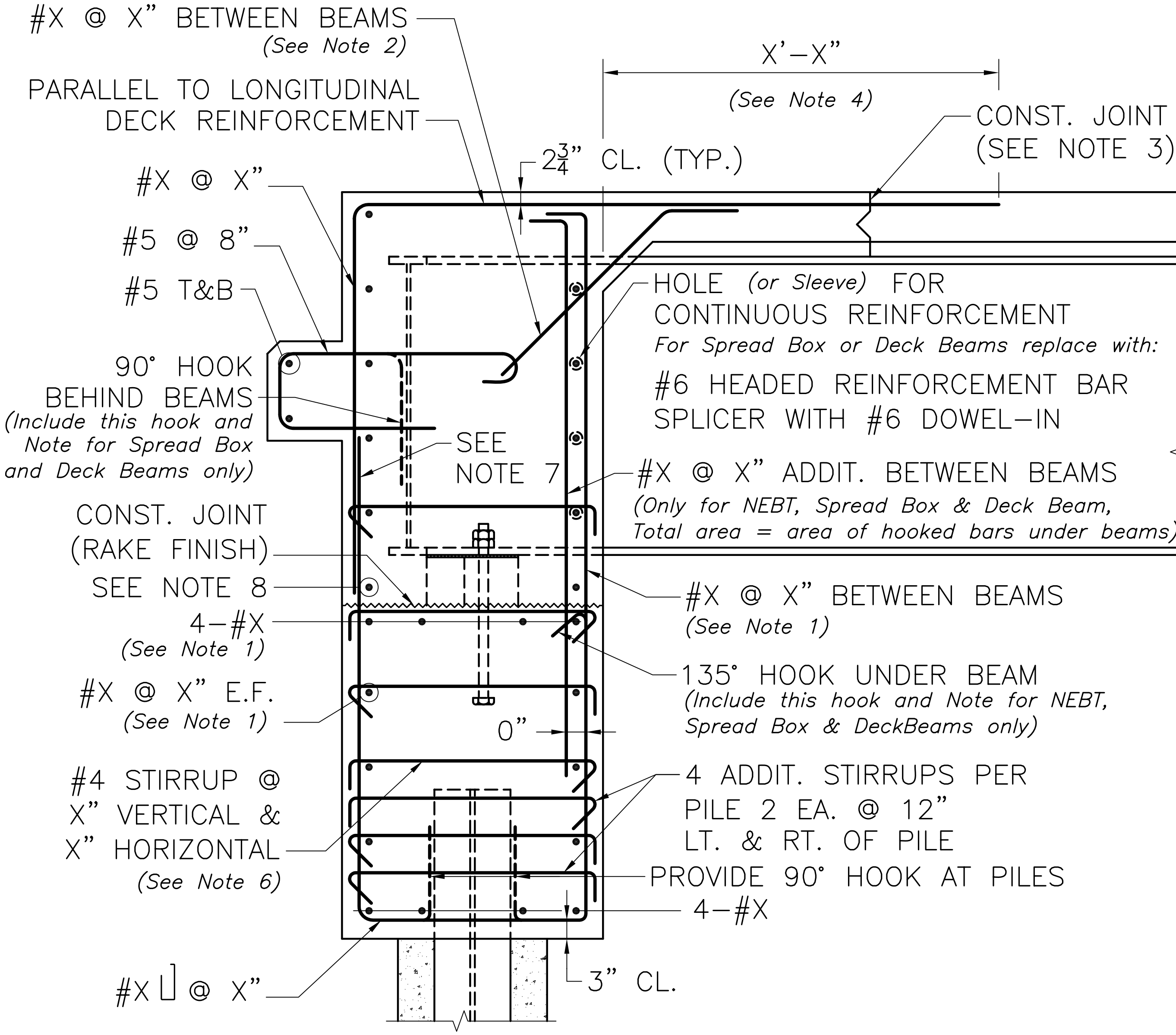
INTEGRAL ABUTMENT SECTION

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	ABUTMENT SECTION NEBT BEAMS INTEGRAL ABUTMENTS	DATE OF ISSUE AUGUST 2007
		DRAWING NUMBER **12.2.3**



MASS HIGHWAY BRIDGE MANUAL	ABUTMENT SECTION SPREAD BOX AND DECK BEAMS INTEGRAL ABUTMENTS	DATE OF ISSUE: AUGUST 2007 DRAWING NUMBER: **12.2.4**

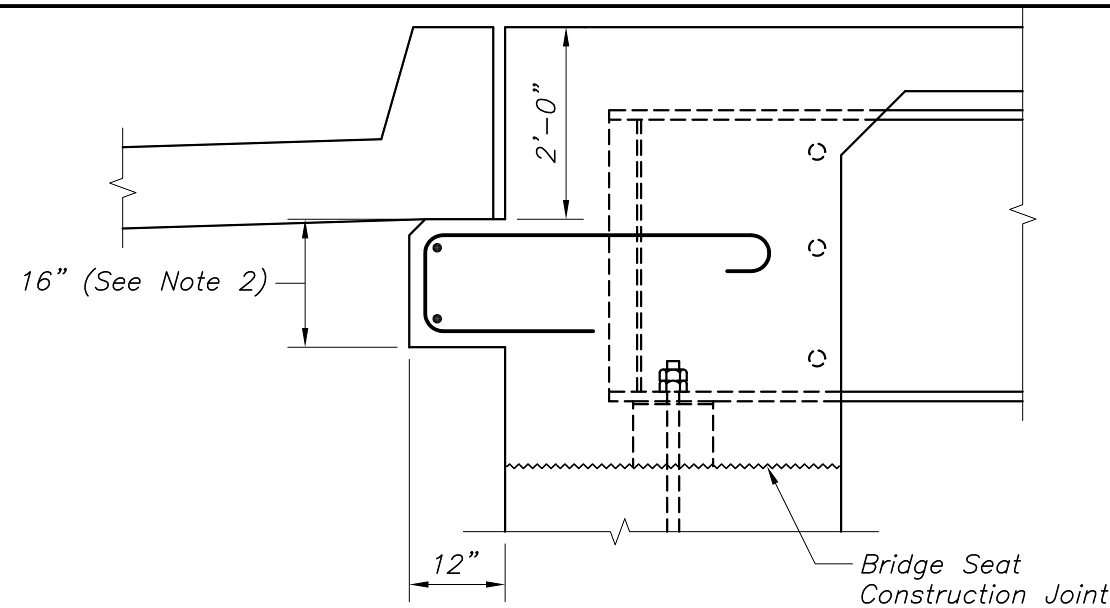


TYPICAL INTEGRAL ABUTMENT REINFORCEMENT

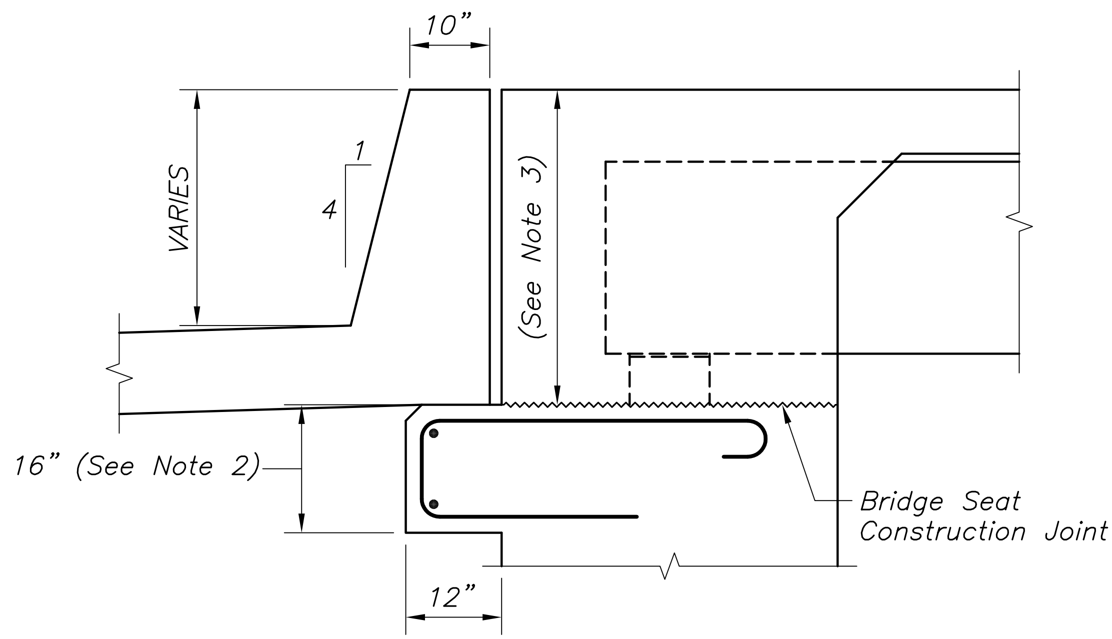
SCALE: ½" = 1'–0"

For Designer Notes see Dwg. No. 12.2.13
For Pre–engineered Abutment Reinforcement see Dwg. No. 12.2.11
For Construction Notes see Dwg. Nos. 12.2.9 and 12.2.10
Plate Girder shown. Substitute actual beam type for design under consideration.

MASS HIGHWAY BRIDGE MANUAL	ABUTMENT REINFORCEMENT INTEGRAL ABUTMENTS	DATE OF ISSUE FEBRUARY 2007 DRAWING NUMBER **12.2.5**



APPROACH SLAB BRACKET ABOVE BRIDGE SEAT CONSTRUCTION JOINT

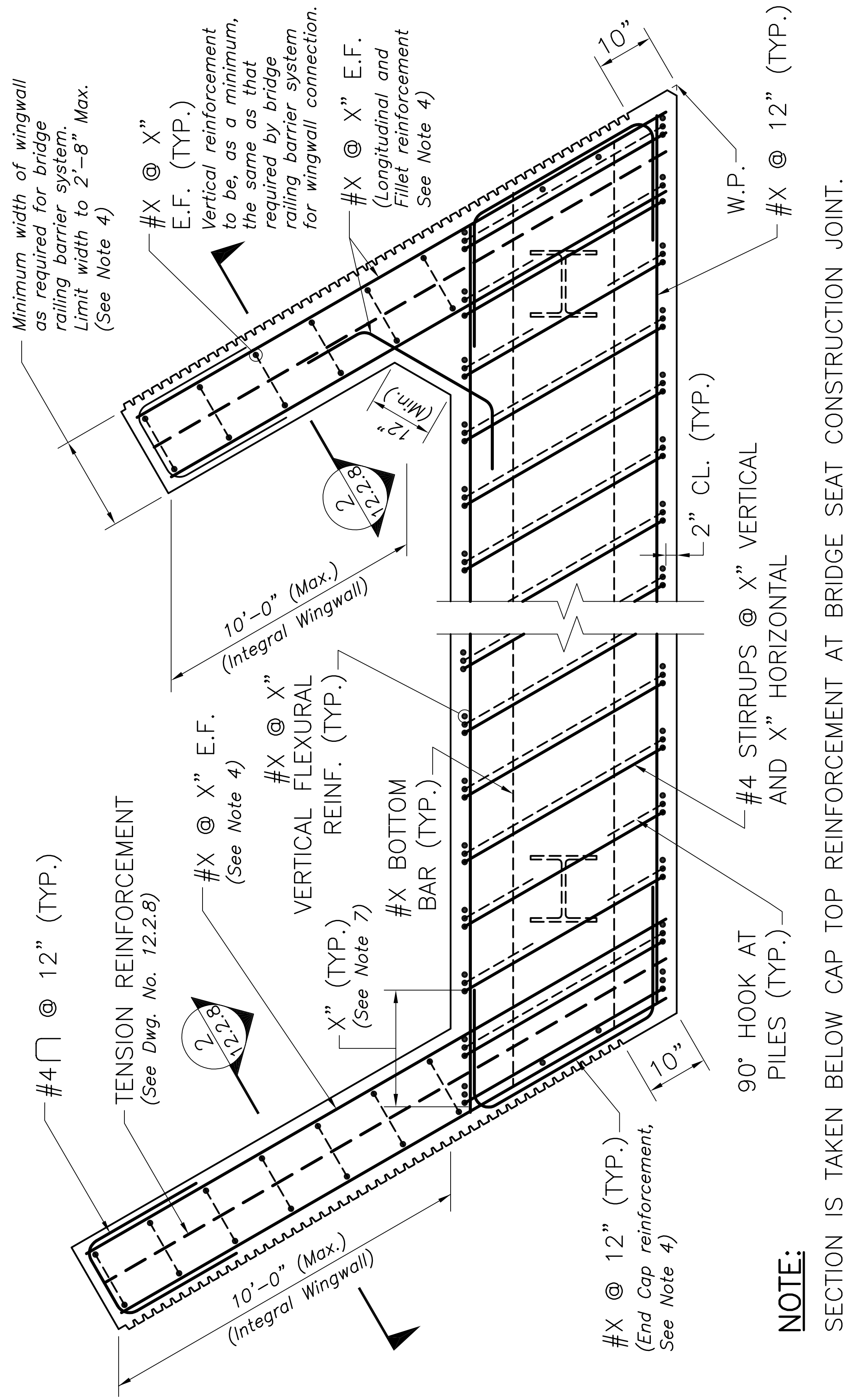


APPROACH SLAB BRACKET BELOW BRIDGE SEAT CONSTRUCTION JOINT

NOTE:

1. Modify Dwg. No's. 12.2.1 through 12.2.5 and 3.1.14 according to requirements of Dwg. No. 12.2.6.
2. Approach Slab Bracket shall be 16" deep. If bracket of this dimension will not fit above the bridge seat construction joint, relocate entire bracket below bridge seat construction joint and modify approach slab as shown.
3. Minimum depth shall be 2'–0". Top of approach slab shall match top of abutment diaphragm.

MASS HIGHWAY BRIDGE MANUAL	APPROACH SLAB BRACKET	DATE OF ISSUE MAY 2005
	INTEGRAL ABUTMENTS	DRAWING NUMBER **12.2.6**



HORIZONTAL SECTION

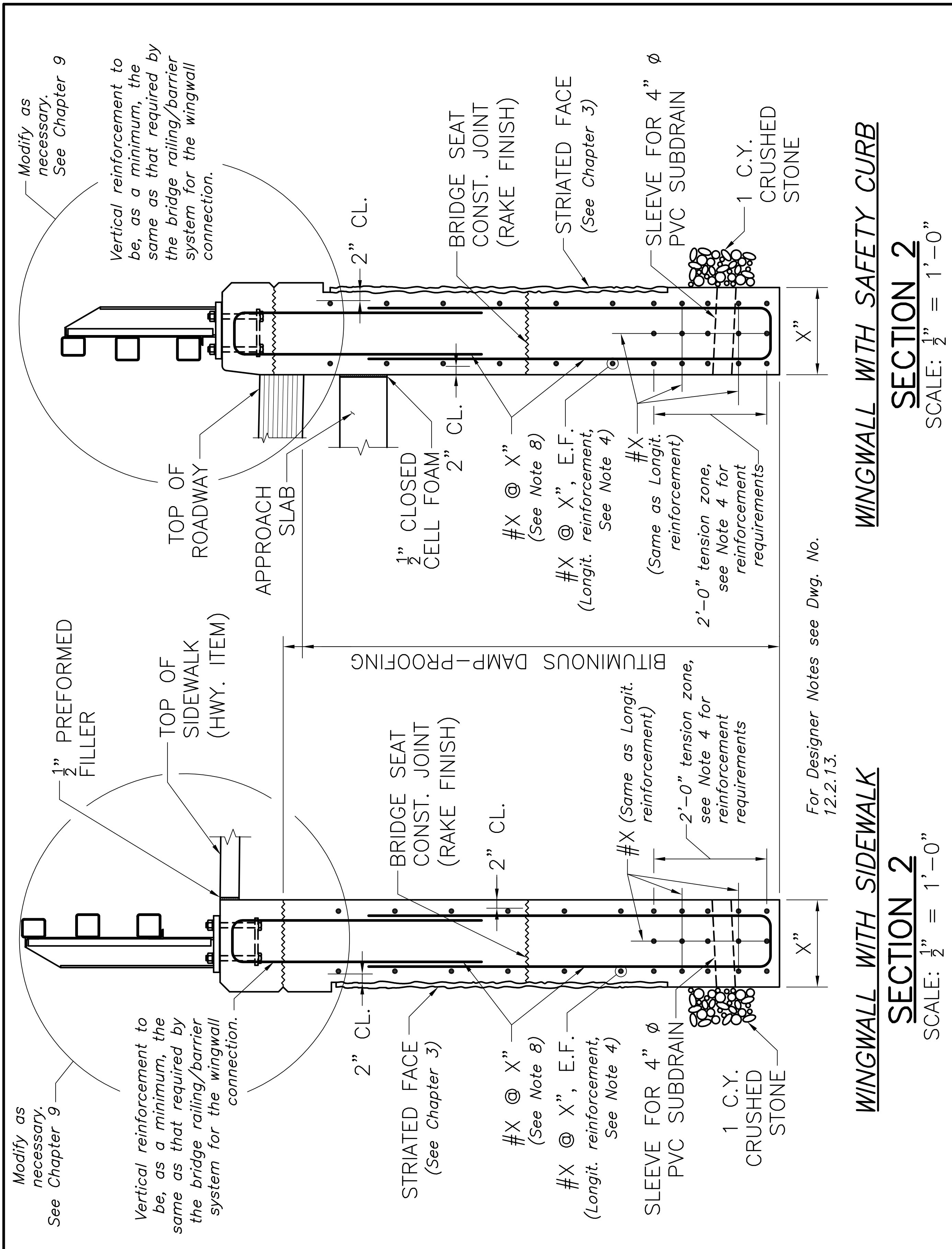
SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

SECTION IS TAKEN BELOW CAP TOP REINFORCEMENT AT BRIDGE SEAT CONSTRUCTION JOINT.

For Designer Notes see Dwg. No. 12.2.13.

MASS HIGHWAY BRIDGE MANUAL	HORIZONTAL SECTION	DATE OF ISSUE: MAY 2005
	INTEGRAL ABUTMENTS	DRAWING NUMBER: 12.2.7



MASS HIGHWAY
BRIDGE MANUAL

INTEGRAL WINGWALL SECTIONS

INTEGRAL ABUTMENTS

DATE OF ISSUE
MAY 2005

DRAWING NUMBER
12.2.8

Place these notes on the Construction Drawing containing the Abutment Section (Dwg. Nos. 12.2.1 thru 12.2.4) and place the Abutment Section Reinforcement drawing (Dwg. No. 12.2.5) on that same sheet. Use the appropriate notes to the particular superstructure type.

CONSTRUCTION NOTES:

1. ALL REINFORCEMENT SHALL BE COATED.

2. DECK SLAB REINFORCEMENT NOT SHOWN FOR CLARITY. CONTINUE DECK SLAB REINFORCEMENT TO BACK OF ABUTMENT.

3. THE CONTRACTOR HAS THE OPTION OF PLACING ALL DECK SLAB AND ABUTMENT DIAPHRAGM CONCRETE WITHOUT TRANSVERSE CONSTRUCTION JOINTS PROVIDED THE INITIAL SET (Fc = 500 psi) DOES NOT OCCUR UNTIL AFTER COMPLETION OF THE PLACEMENT PROCESS. OTHERWISE, THE CONTRACTOR SHALL FOLLOW THE DECK PLACEMENT SEQUENCE AS SHOWN ON THESE PLANS.

4. ALL CONCRETE SHALL CONTAIN SUPERPLASTICIZER TO ENSURE ADEQUATE CONSOLIDATION.

5. BOTH ABUTMENTS SHALL BE BACKFILLED SIMULTANEOUSLY. NO MORE THAN 2 FT OF DIFFERENTIAL BACKFILL HEIGHT SHALL BE PERMITTED. BACKFILLING SHALL NOT BEGIN UNTIL THE ABUTMENT AND DECK CONSTRUCTION IS COMPLETE.

6. ALL UNPAINTED WEATHERING STEEL EMBEDDED IN THE ABUTMENT AND WITHIN 12" OF THE ABUTMENT FACE SHALL BE PAINTED. THE FINISH COAT COLOR SHALL MATCH COLOR CHIP NO. 30045 OF FEDERAL STANDARD 595B.
   (Do not include this note if weathering steel is not used.)

7. THE CONTRACTOR MAY USE MECHANICAL REINFORCING BAR SPLICERS IN LIEU OF TENSION LAP SPLICES TO FACILITATE CONSTRUCTION. HOWEVER, NO ADDITIONAL COMPENSATION WILL BE PROVIDED FOR THE USE OF MECHANICAL REINFORCING BAR SPLICERS.
   (Dimension the length required for a Class "A" Lap Splice. If a Class "A" Lap Splice will not fit into the depth provided, replace Note 7 with the following:)
   MECHANICAL REINFORCING BAR SPLICERS SHALL BE INSTALLED TO MAKE THIS REINFORCEMENT CONTINUOUS.

8. MECHANICAL REINFORCING BAR SPLICERS SHALL BE INSTALLED AT STAGE CONSTRUCTION JOINTS FOR ALL TRANSVERSE REINFORCEMENT.
   (Do not include this note if stage construction is not used.)

9. THE TOP OF THE APPROACH SLAB SHALL MATCH THE TOP OF THE ABUTMENT DIAPHRAGM.

INTEGRAL ABUTMENT PILE NOTES:

These Notes shall be modified, if necessary, based upon the recommendations contained within the Geotechnical Report.

1. PRE–DRILL X" ø HOLE TO EL. XX.X MINIMUM. PRE–DRILLED HOLES SHALL BE PLUMB.

2. AFTER DRIVING PILES FILL HOLE WITH CRUSHED STONE (M2.01.6).

3. ALL SPLICES SHALL HAVE COMPLETE PENETRATION BUTT WELDS. THERE SHALL BE NO SPLICES WITHIN THE TOP 20 FEET OF PILE. SPLICE WELDS SHALL BE 100% UT.

4. THE FACTORED AXIAL LOAD PER PILE IS X KIPS (LFD GROUP X LOAD). *(specify the Group Load Number that produces the highest axial load)* THE FACTORED STRUCTURAL CAPACITY PER PILE IS X KIPS AND IS THE PRODUCT OF THE ULTIMATE STRUCTURAL CAPACITY OF X KIPS, AN ECCENTRICITY FACTOR OF 0.XX *(omit if not applicable)* AND A STRUCTURAL PERFORMANCE FACTOR OF 0.XX.

5. THE FACTORED GEOTECHNICAL DESIGN CAPACITY PER PILE IS X KIPS. THE ESTIMATED TIP ELEVATION IS XXX FEET.
(Use this note only when the Factored Geotechnical Capacity controls the pile axial capacity, such as from friction or friction and end bearing as specified in the Geotechnical Report.)

6a. THE MINIMUM TIP ELEVATION IS XXX FEET.
(Use this note only when the required pile length is not determined by the required axial capacity, i.e., lateral loading, scour resistance, or other factors, as recommended in the Geotechnical Report, determine the pile length.)

6b. PILES SHALL BE DRIVEN TO BEDROCK WITH AN ESTIMATED TIP ELEVATION OF XXX FEET. HEAVY DUTY PILE SHOES SHALL BE INSTALLED ON THE TIPS OF ALL PILES. PREFABRICATED PILE SHOES MAY BE USED IF APPROVED BY THE ENGINEER.
(Include this note only when the Factored Structural Capacity controls the pile axial capacity due to end bearing on rock as specified in the Geotechnical Report.)

6c. DETERMINATION OF THE DRIVEN PILE CAPACITY, PILE DRIVING CRITERIA, AND PILE INTEGRITY SHALL BE PERFORMED USING THE XXXXXXX *(Designer to specify the Formula Method, WEAP, PDA, Static – Cyclic (Express) Load Test, Static Load Test, or other system, as recommended in the Geotechnical Report)* DRIVING/TESTING METHOD WITH A PERFORMANCE FACTOR OF 0.XX. PILES SHALL BE INSTALLED TO ACHIEVE A FACTORED DRIVEN CAPACITY EQUAL TO OR GREATER THAN THE FACTORED AXIAL DESIGN LOAD.

7. THE CONTRACTOR SHALL SUBMIT A PILE SCHEDULE, PILE INSTALLATION, AND PILE DRIVING/TESTING PLAN FOR REVIEW AND APPROVAL OF THE ENGINEER.

8. PILES SHALL CONFORM TO AASHTO M270 GRADE 50.

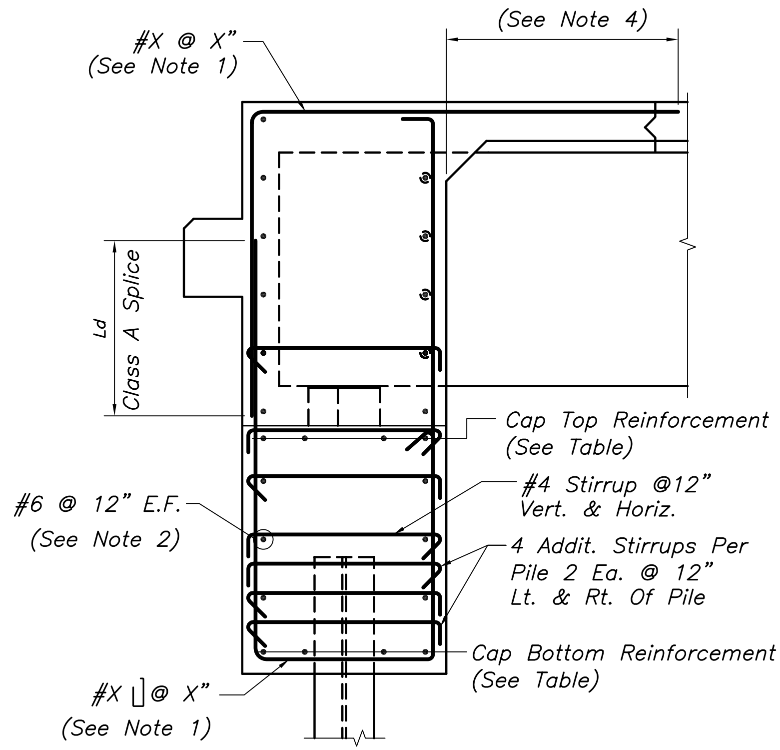
** Specify the Group Load Number which produces the maximum axial load. Include the H–Pile Splice Details as shown on Dwg. No. 3.6.8*

REQUIRED PILE LOCATION TOLERENCES:

1. CONFORMANCE TO THE FOLLOWING TOLERANCES IS OF EXTREME IMPORTANCE TO FOUNDATIONS OF THIS TYPE.

2. PRIOR TO DRIVING, EACH ABUTMENT PILE SHALL BE HELD BY TEMPLATE TO WITHIN 1" OF PLAN LOCATION.

3. AFTER EACH ABUTMENT PILE IS DRIVEN, THE TOP OF THE PILE SHALL BE WITHIN 3" OF PLAN LOCATION.



ABUTMENT REINFORCEMENT

AREA OF PILE CAP REINFORCEMENT AT TOP & BOTTOM OF PILE CAP (in^2)

W	PILE SPACING			
	7 ft	8 ft	9 ft	10 ft
25 k/LF	0.81	1.07	1.35	1.67
30 k/LF	0.98	1.28	1.62	2.01
35 k/LF	1.14	1.49	1.89	2.34
40 k/LF	1.31	1.71	2.17	2.68
45 k/LF	1.47	1.93	2.44	3.02
50 k/LF	1.64	2.14	2.72	3.36

PILE CAP REINFORCEMENT DESIGN ASSUMPTIONS:

The pile cap behaves as a continuous beam supported at the piles and carries a uniform load based on AASHTO (LFD) Load Combination I [W=1.3(DL)+2.17(LL+I)] from both, superstructure and substructure.

The pile cap reinforcement design is based on the following:
- maximum moment;
- pile cap height of 4'–3" and pile cap width as per the Bridge Manual;
- minimum reinforcement as per AASHTO.

As a minimum use 4–#6 bars (As = 1.76 in^2) at the top and bottom of the pile cap.

TABLE A

BEAM DEPTH	24"	30"	36"	42"	48"	54"	60"	66"	72"
AVG. ABUT. HEIGHT	8.0'	8.5'	9.0'	9.5'	10.0'	10.5'	11.0'	11.5'	12.0'
As (in^2)/L.F. OF ABUT.	0.62	0.66	0.70	0.74	0.78	0.82	0.85	0.89	0.93

NOTES:

1. For simple spans up to 100', use the Table A and #5 bars @ 6" as minimum.
2. Maximum pile spacing is equal to 10 feet.
3. Use the combination of beam depth/avg. abutment depth that results in the maximum rebar area.
4. This dimension is equal to (10% of the span + Ld) for simple span bridges. For multispan bridges extend rebar to dead load point of contraflexure + Ld.

PRE–ENGINEERED ABUTMENT REINFORCEMENT

MAXIMUM PILE AXIAL LOAD (Kips) WITH STEEL SUPERSTRUCTURES		
PILE SIZE	HP10X57	HP12X84
0° SKEW	317	352
10° SKEW	246	305
20° SKEW	206	279
30° SKEW	190	203

MAXIMUM PILE AXIAL LOAD (Kips) WITH P/C DECK/BOX BEAM SUPERSTRUCTURES		
PILE SIZE	HP10X57	HP12X84
0° SKEW	343	380
10° SKEW	300	331
20° SKEW	278	306
30° SKEW	272	299

MAXIMUM PILE AXIAL LOAD (Kips) WITH NEBT BEAM SUPERSTRUCTURES		
PILE SIZE	HP10X57	HP12X84
0° SKEW	381	416
10° SKEW	332	362
20° SKEW	304	331
30° SKEW	291	321

PILE SELECTION TABLES

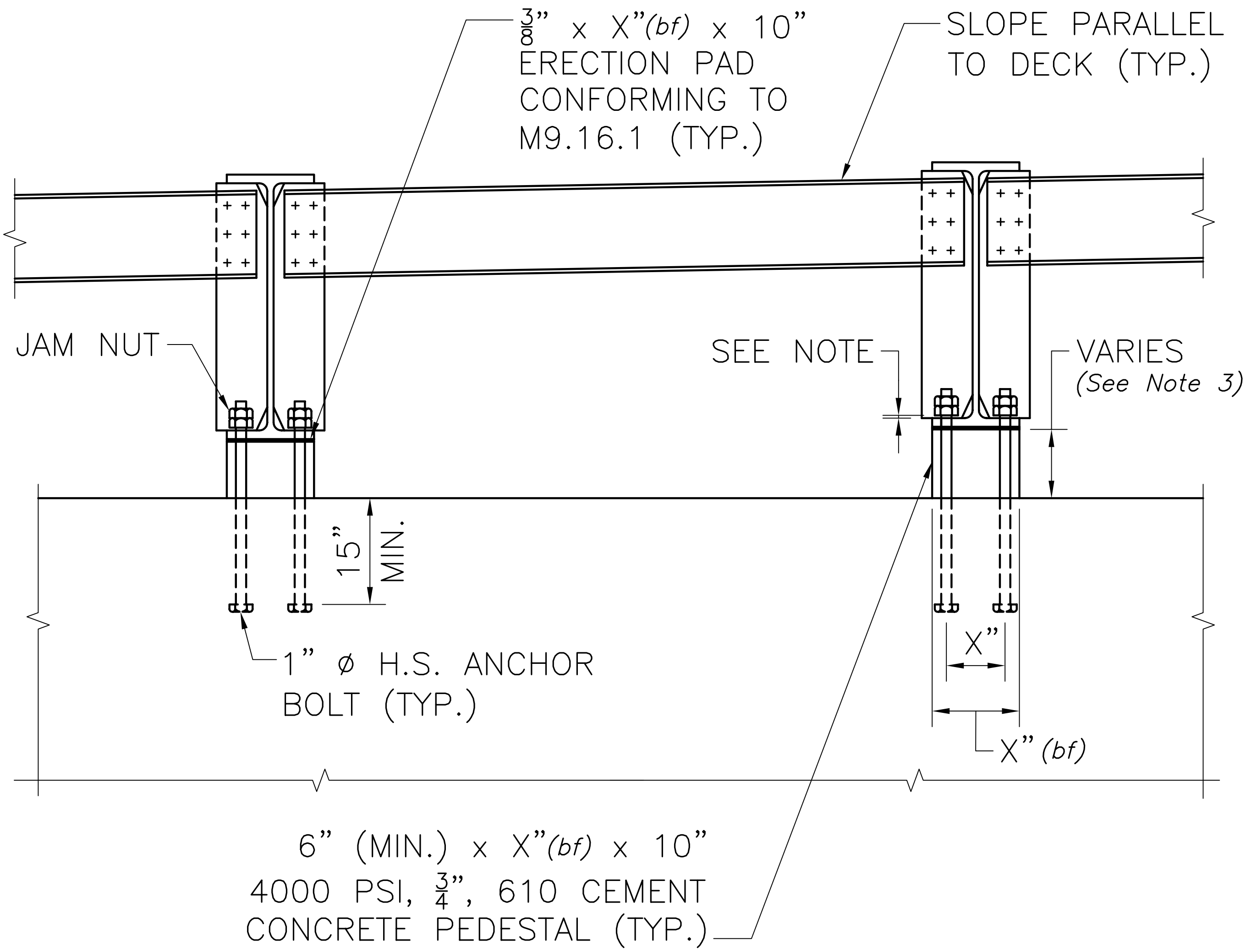
NOTES:

1. The Tables above are for single span bridges with span length up to 100 feet, cross sections with up to 4 traffic lanes, soils that provide adequate lateral support for the pile, and Fy = 50 ksi.
2. Calculate the maximum pile reaction for LFD load combination I and assume the following:
   - —The number of piles are equal or larger than the number of beams;
   - —The superstructure is simply supported;
   - —The live load produces maximum pile reaction;
   - —Dead load from wingwalls and approach slab are included;
   - —The dead and live load is distributed equally to all piles.
3. Utilize the smaller pile size with the desired axial capacity.
4. Interpolate for skews other than the ones shown.
5. The pile length shall be based on the required geotechnical capacity to carry the axial load. The pile's geotechnical capacity usually controls except where the piles are driven/installed into sound rock.

MASS HIGHWAY BRIDGE MANUAL	PRE-ENGINEERED PILE SELECTION TABLES INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 / DRAWING NUMBER 12.2.12

NOTES:

1. Select the required reinforcement from the tables on Dwg. No. 12.2.11 if the analysis assumptions are satisfied. Otherwise, the Designer shall design the reinforcement.
2. Provide the same bars and spacing as the Vertical flexural reinforcement.
3. Check constructability of NEBT integral abutment bridges on skew. Ensure sufficient clearance between flanges and the back of the abutment for placement of reinforcement and consolidation of concrete. The minimum clear cover between flanges and the back of the abutment shall be 4". The abutment thickness may be increased to accommodate these requirements. Box and Deck Beam ends shall be skewed for this purpose.
4. The integral wingwall longitudinal reinforcement, as well as the abutment end cap reinforcement shall be designed in accordance with Section 3.9.8. of Part I of the Manual. The minimum bar size shall be #6, the maximum bar size should be limited to #9. The Tension reinforcement should be as well distributed throughout the tension zone as is practical, the minimum bar spacing shall be 4". The longitudinal reinforcement should be placed at a 12" spacing. Specify the same bars and spacing for the fillet reinforcement as for the longitudinal reinforcement. The minimum reinforcement shall be #6 at 12" E.F..
5. Deck drains shall be specified for all integral abutment bridges with HMA wearing surface and shall be located in relation to the abutment diaphragm as shown on Dwg. No. 7.3.1.
6. Continue stirrups to bridge seat construction joint or to a level just below approach slab support bracket, whichever is higher. Specify same spacings as horizontal and vertical bars.
7. Dimension a Class "C" Tension Lap Splice. It shall be the same at all four (4) corners.
8. Reinforcement configuration shown is conceptual. The Designer shall modify the arrangement as necessary by design.



NOTE:

PROVIDE $\frac{3}{16}$" GAP BETWEEN NUT AND TOP OF BOTTOM FLANGE.

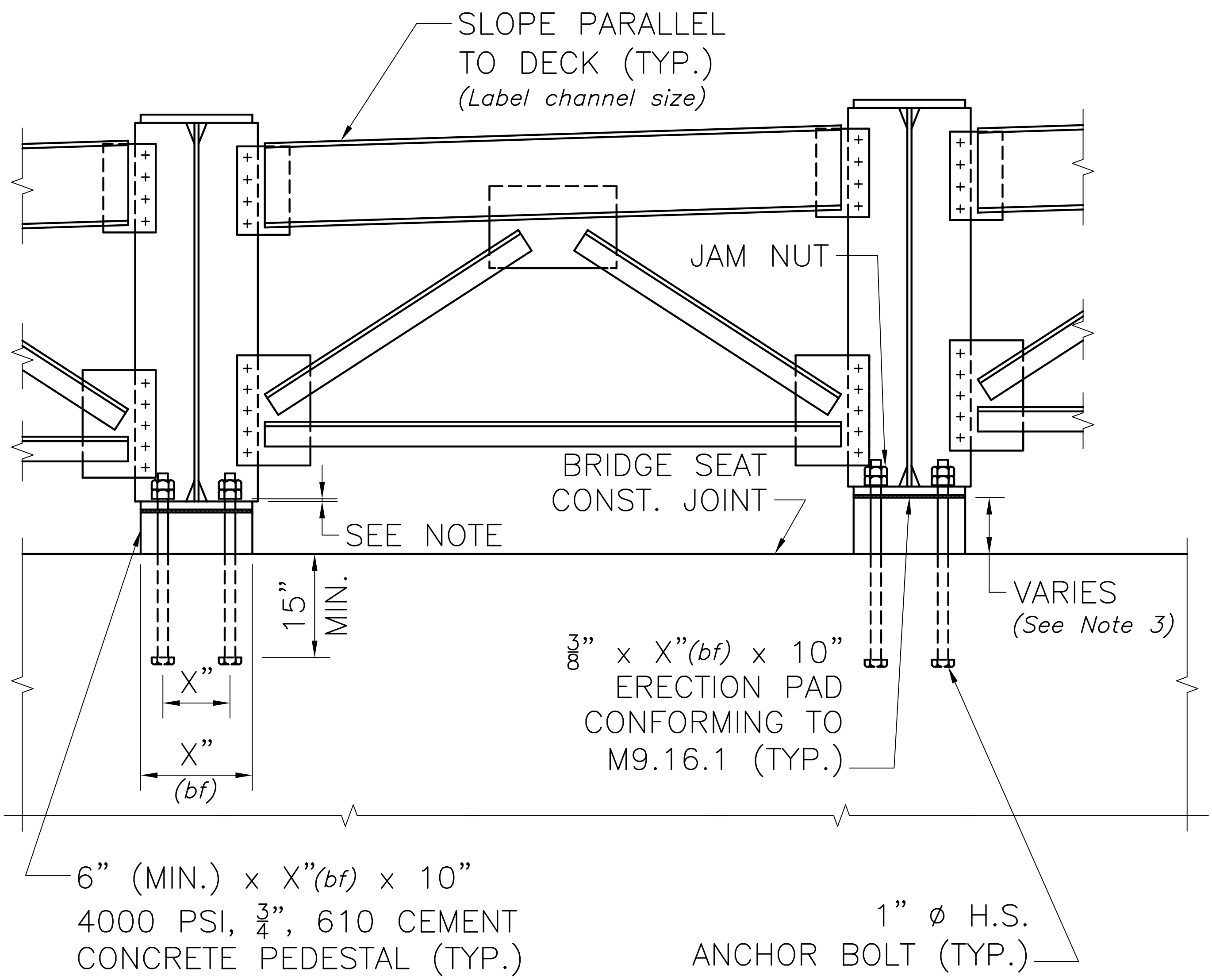
BEAM END DETAILS

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Provide End Diaphragm Details as shown on Dwg. No. 5.1.4.*
2. *End diaphragms shall be placed parallel to the centerline of abutment as shown in the Framing Plan.*
3. *Minimum pedestal height shall be 6"; maximum shall be 12" excluding pad thickness. Steps in bridge seat construction joint may be used to accommodate bridge cross slope. Use only the minimum number of steps necessary.*

MASS HIGHWAY BRIDGE MANUAL	BEAM END DETAILS ROLLED BEAMS INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.3.1**



NOTE:

PROVIDE $\frac{3}{16}$" GAP BETWEEN NUT AND TOP OF BOTTOM FLANGE.

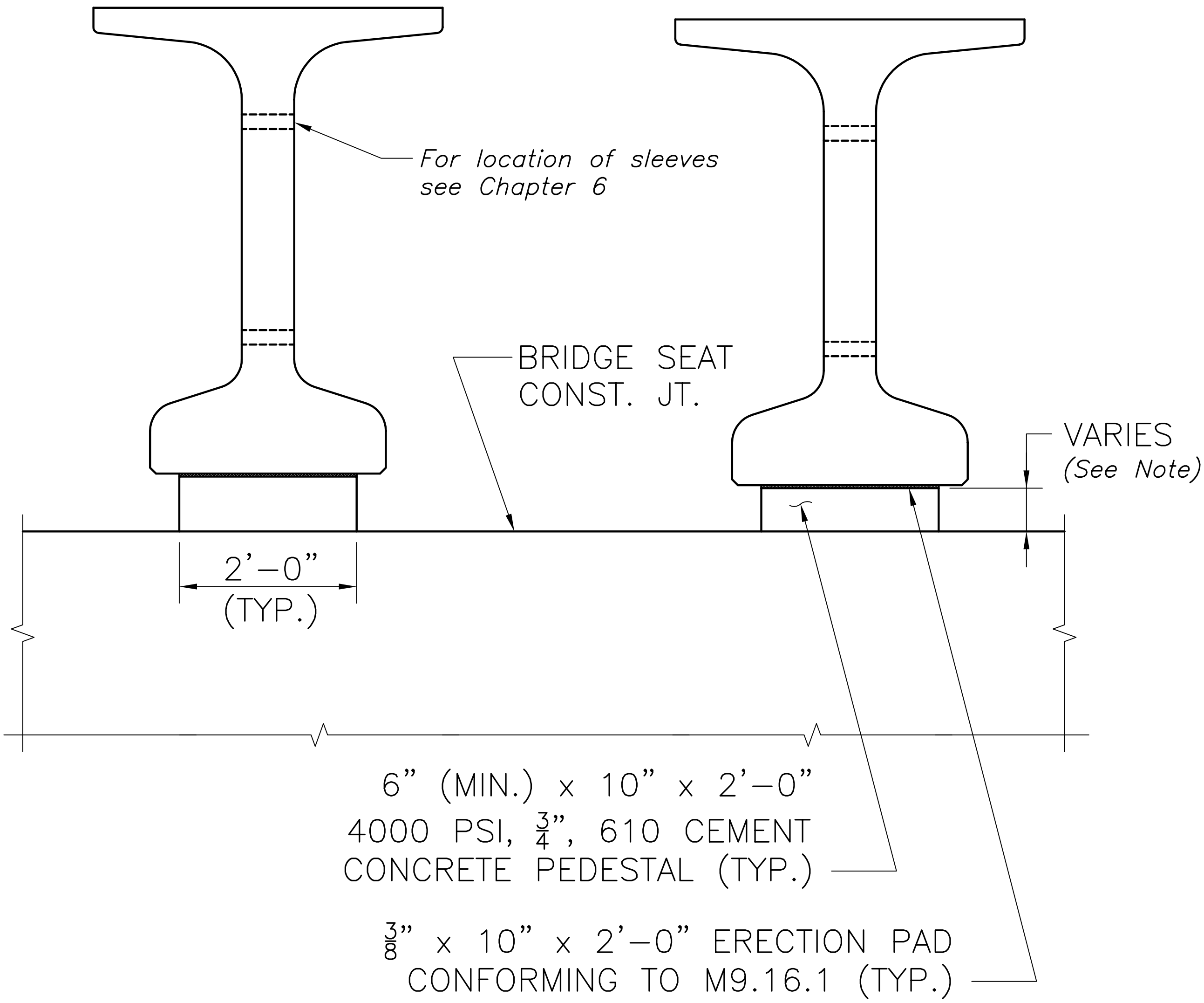
BEAM END DETAILS

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Provide End Cross Frame Details as shown on Dwg. No. 5.2.7.*
2. *End frame shall be placed parallel to the centerline of abutment shown in the Framing Plan.*
3. *Minimum pedestal height shall be 6"; maximum shall be 12" excluding pad thickness. Steps in bridge seat construction joint may be use to accommodate bridge cross slope. Use only the minimum number of steps necessary.*

MASS HIGHWAY BRIDGE MANUAL	BEAM END DETAILS PLATE GIRDERS INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 / DRAWING NUMBER 12.3.2



NOTE:

THE LATERAL STABILITY OF THE BEAMS SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR DURING ERECTION AND CONSTRUCTION. A LATERAL SUPPORT SYSTEM SHALL BE DESIGNED BY THE CONTRACTOR IN ACCORDANCE WITH DIVISIONS I AND II OF THE CURRENT AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES WITH THE LATEST INTERIMS. ALLOWABLE STRESS DESIGN SHALL BE THE DESIGN METHOD USED.

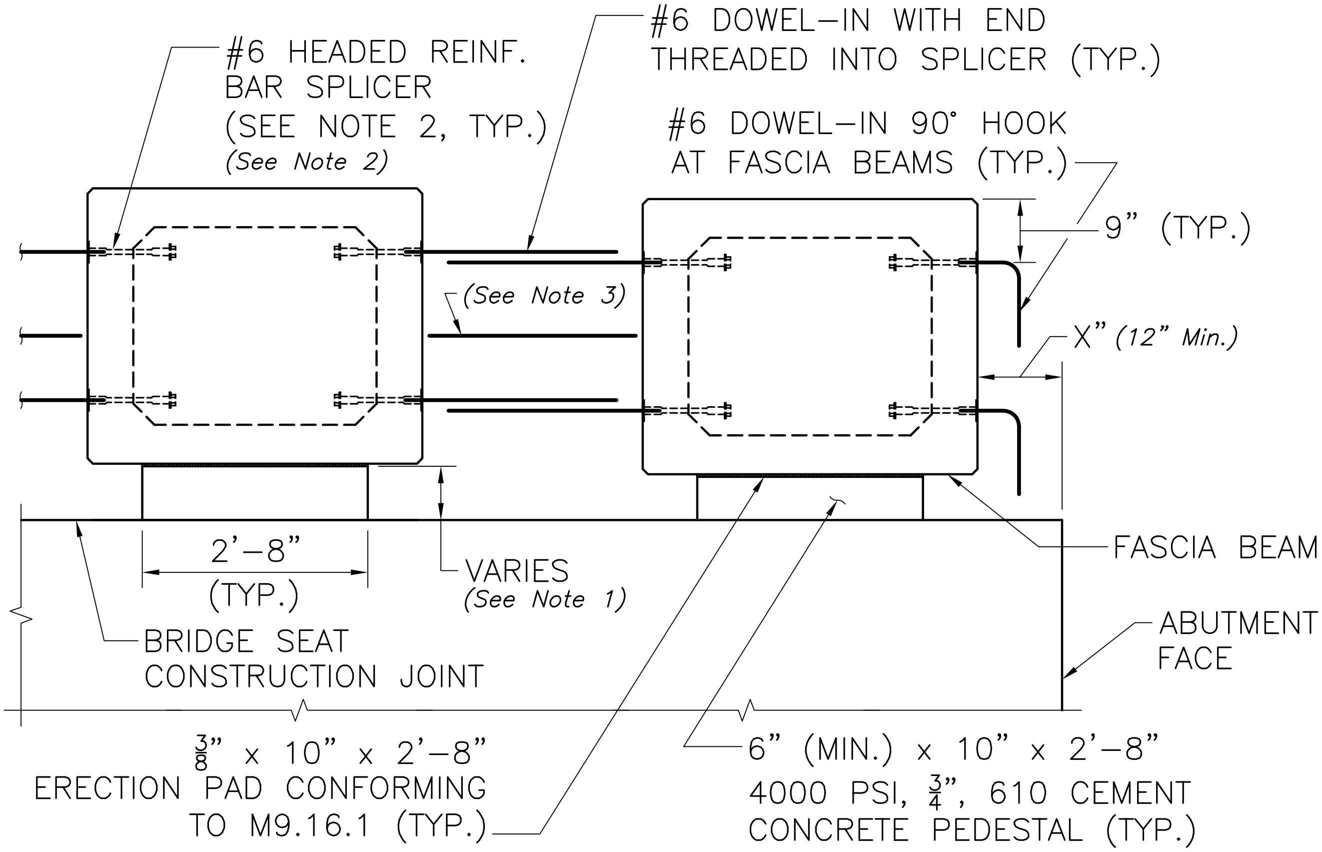
BEAM END DETAILS

SCALE: $\frac{1}{2}$" = 1'–0"

NOTE:

Minimum pedestal height shall be 6" and maximum shall be 12", excluding erection pad thickness. Steps in bridge seat construction joint may be used to accommodate bridge cross slope. Use only the minimum number of steps necessary.

MASS HIGHWAY BRIDGE MANUAL	BEAM END DETAILS NEBT BEAMS INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.3.3**



NOTES:

1. THE LATERAL STABILITY OF THE BEAMS SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR DURING ERECTION AND CONSTRUCTION. A LATERAL SUPPORT SYSTEM SHALL BE DESIGNED BY THE CONTRACTOR IN ACCORDANCE WITH DIVISIONS I AND II OF THE CURRENT AASHTO STANDARD SPECIFICATIONS FOR THE HIGHWAY BRIDGES WITH THE LATEST INTERIMS. ALLOWABLE STRESS DESIGN SHALL BE THE DESIGN METHOD USED.

2. #6 HEADED REINFORCEMENT BAR SPLICERS SHALL BE CAST-IN-PLACE IN THE PRECAST BEAMS BY THE FABRICATOR. THE #6 HEADED REINFORCEMENT BAR SPLICERS SHALL BE EMBEDDED AS REQUIRED TO PROVIDE A MINIMUM ULTIMATE TENSILE CAPACITY OF 39.6 KIPS AS SPECIFIED BY THE MANUFACTURER.

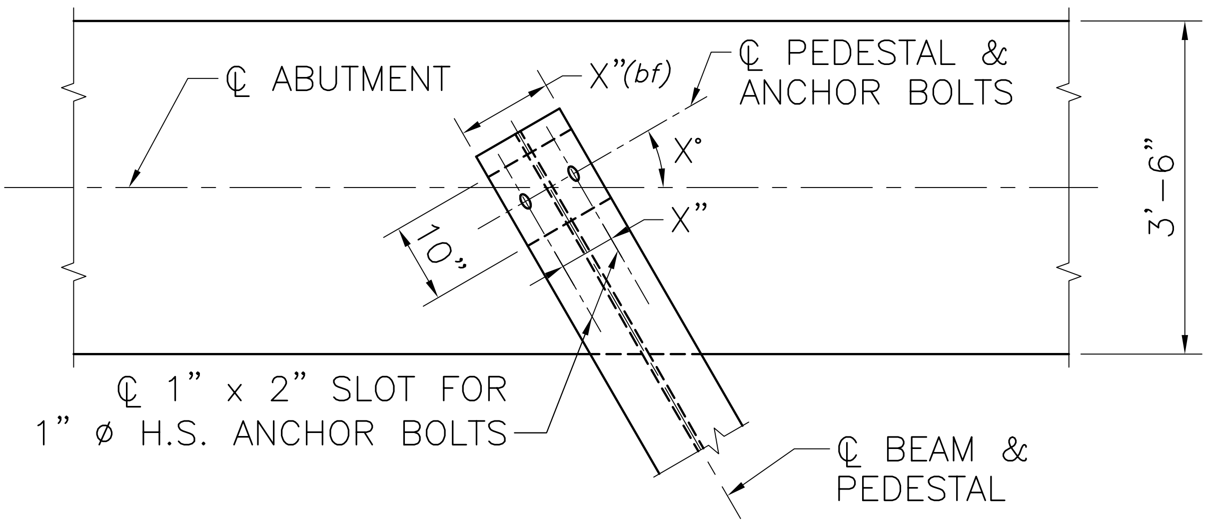
BEAM END DETAILS

SCALE: $\frac{1}{2}$" = 1'-0"

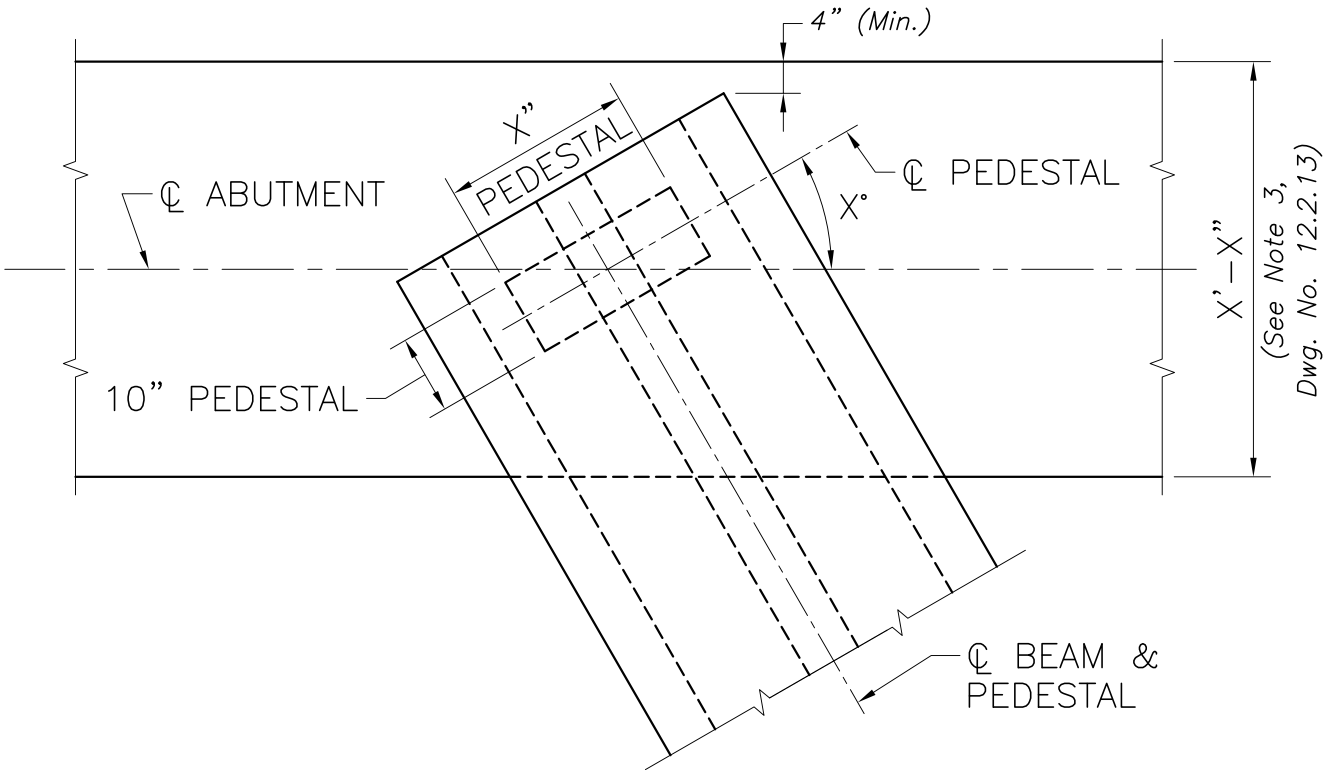
NOTES:

1. *Minimum pedestal height shall be 6"; maximum shall be 12" excluding pad thickness. Steps in bridge seat construction joint may be used to acommodate bridge cross slope; use only the minimum number of steps necessary.*
2. *Provide #6 headed splicers by beam depth as follows:*
   Beam depth 28" and less: 1 headed splicer at mid depth of beam;
   Beam depth greater than 28": 2 headed splicers as shown.
3. *Provide #6 intermediate reinforcing bars by beam depth as follows:*
   Beam depth 32" and less: no intermediate bar;
   Beam depth greater than 32": 1 intermediate bar midway between splicers.
4. *Modify detail as required for Deck Beam stringer bridges.*

MASS HIGHWAY BRIDGE MANUAL	BEAM END DETAILS SPREAD BOX/DECK BEAMS INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.3.4**



ROLLED BEAMS/PLATE GIRDERS

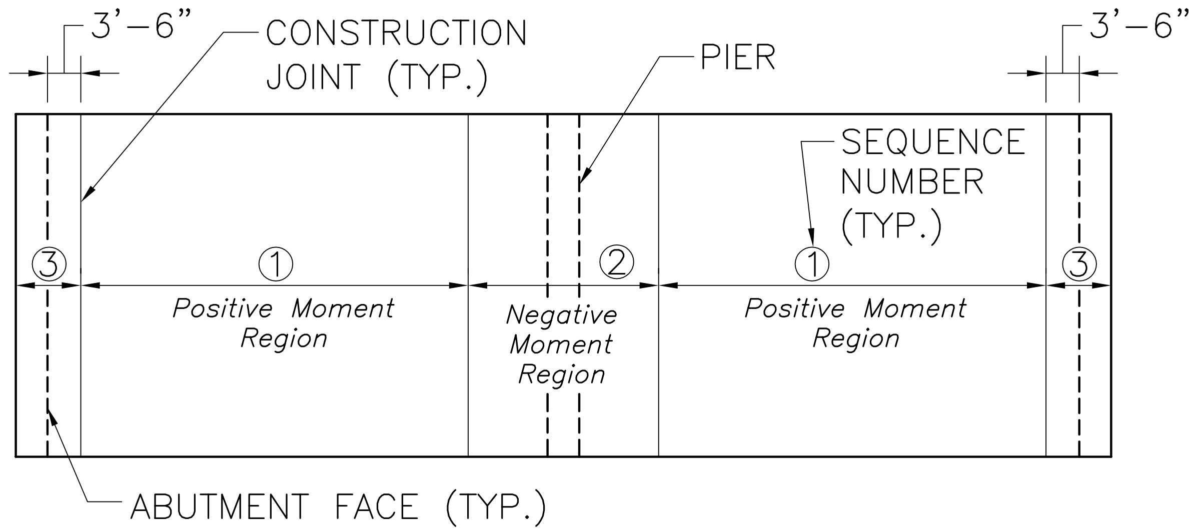


NEBT/SPREAD BOX AND DECK BEAMS

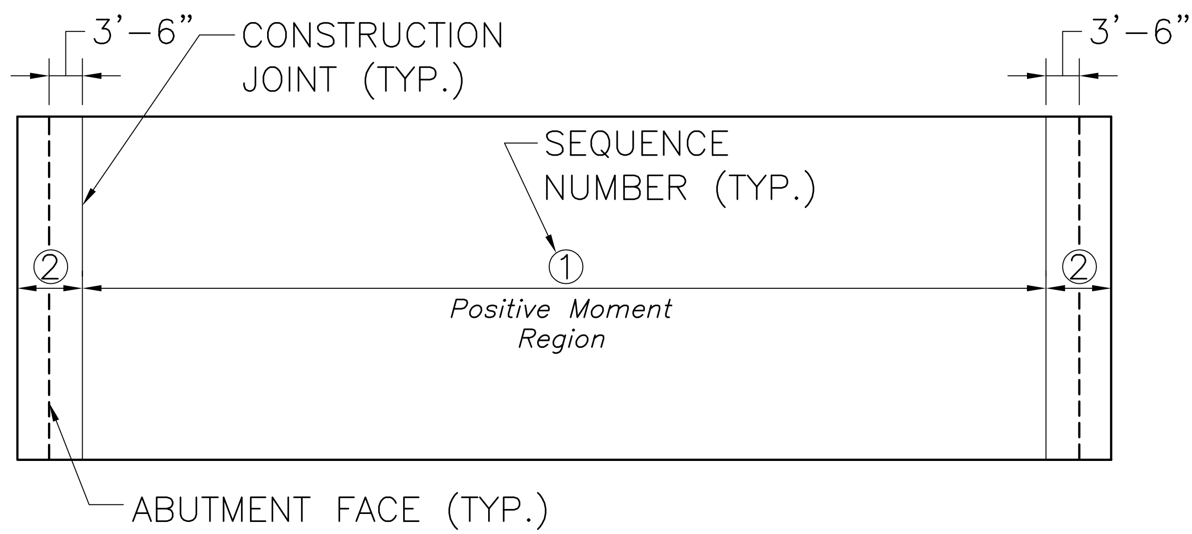
PEDESTAL PLAN

SCALE: $\frac{1}{2}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	PEDESTAL PLAN INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.3.5**



MULTIPLE SPAN BRIDGE

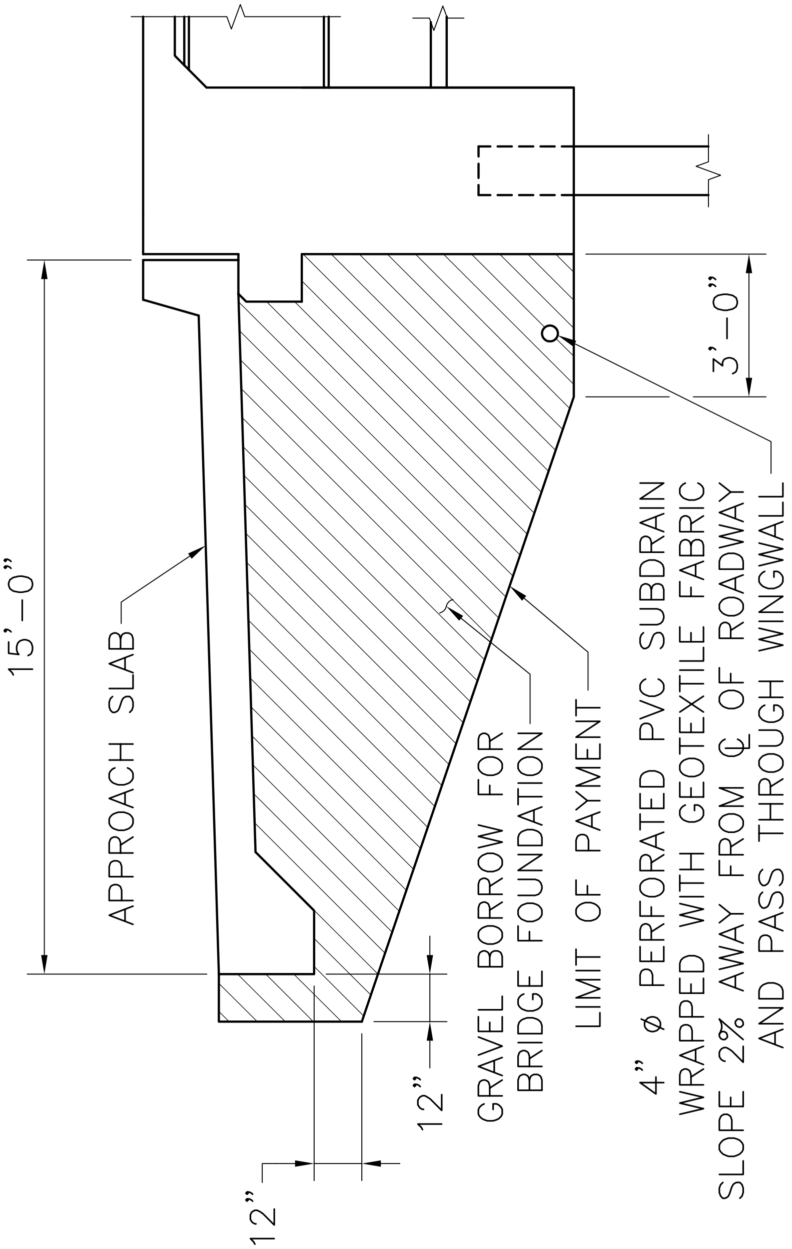


SINGLE SPAN BRIDGE

DECK PLACEMENT SEQUENCE

SCALE: 1" = 20'–0"

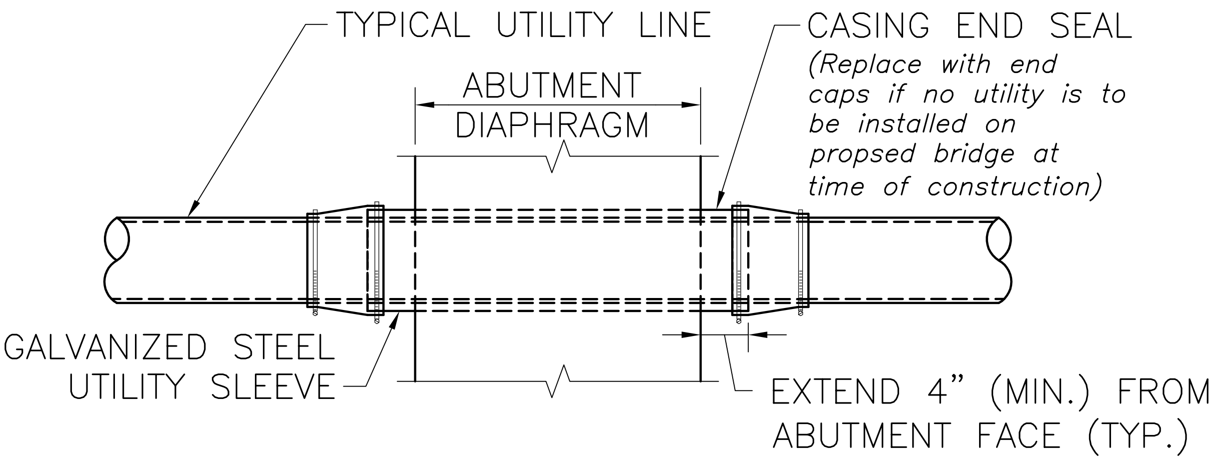
MASS HIGHWAY BRIDGE MANUAL	DECK PLACEMENT SEQUENCE INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.4.1**



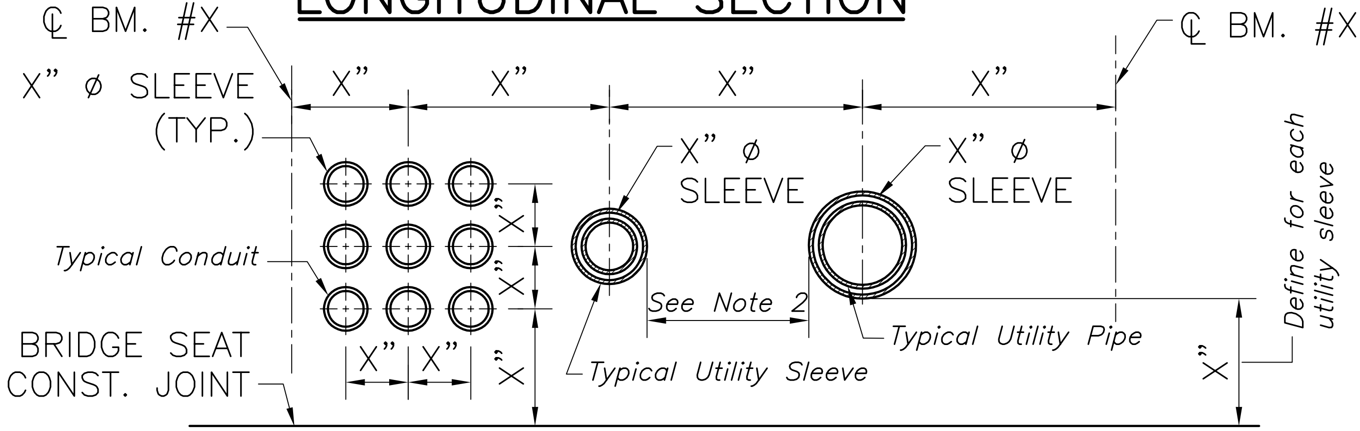
INTEGRAL ABUTMENT BACKFILL

SCALE: $\frac{1}{4}$" = 1'–0"

MASS HIGHWAY BRIDGE MANUAL	ABUTMENT BACKFILL INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.4.2**



LONGITUDINAL SECTION



NOTES:

1. DIMENSIONS ARE SQUARE TO BEAMS.

2. UTILITY SLEEVES SHALL BE STEEL PIPE CONFORMING TO ASTM A–53, TYPE S, GRADE B, STANDARD WEIGHT, PLAIN ENDS, HOT–DIP GALVANIZED AND SHALL BE SET IN THE FORMS PRIOR TO PLACING ABUTMENT DIAPHRAGM CONCRETE.

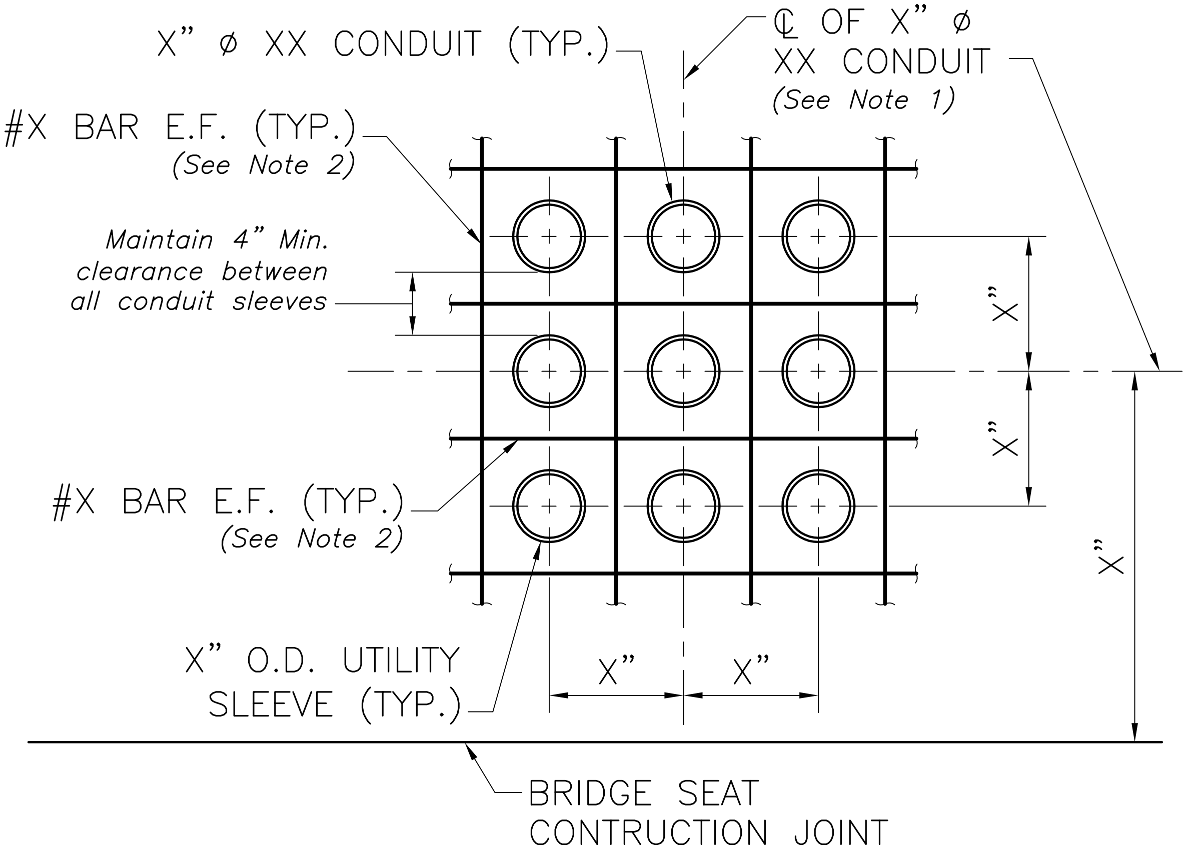
UTILITY DETAILS AT ABUTMENT

SCALE: $\frac{1}{2}$" = 1'–0"

NOTES:

1. *Designer shall contact the respective utility owners and send copies of all correspondence to the MHD Utility Engineer regarding which utilities are to be carried by the structure and what the required sleeve diameters shall be.*
2. *Minimum clearances between the outsides of the sleeves shall be 4".*
3. *Label all utilities and utility pipe diameters.*
4. *For those bridges which do not carry Interstate Highways and are not currently required to support a utility, provide a single 16" ø sleeve in the bay under the sidewalk, as a provision for future utility placement.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY DETAILS AT ABUTMENT INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.4.3**



NOTE:

ALL REINFORCEMENT PASSING THROUGH CONDUIT BANK SHALL BE LAPPED WITH TYPICAL ABUTMENT REINFORCEMENT USING CLASS "C" TENSION LAP SPLICES.

UTILITY DETAILS FOR CONDUIT BANK

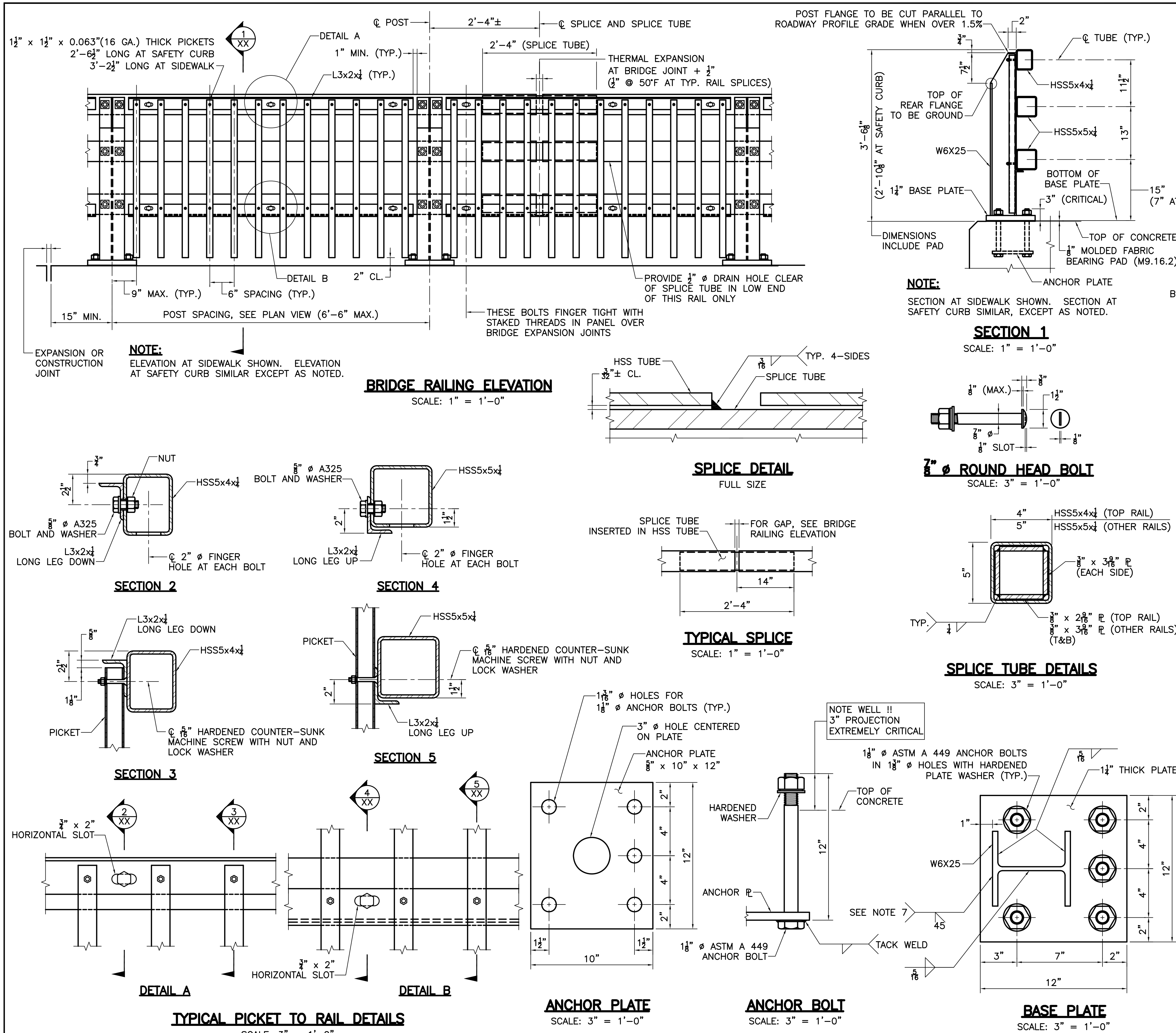
SCALE: 1" = 1'-0"

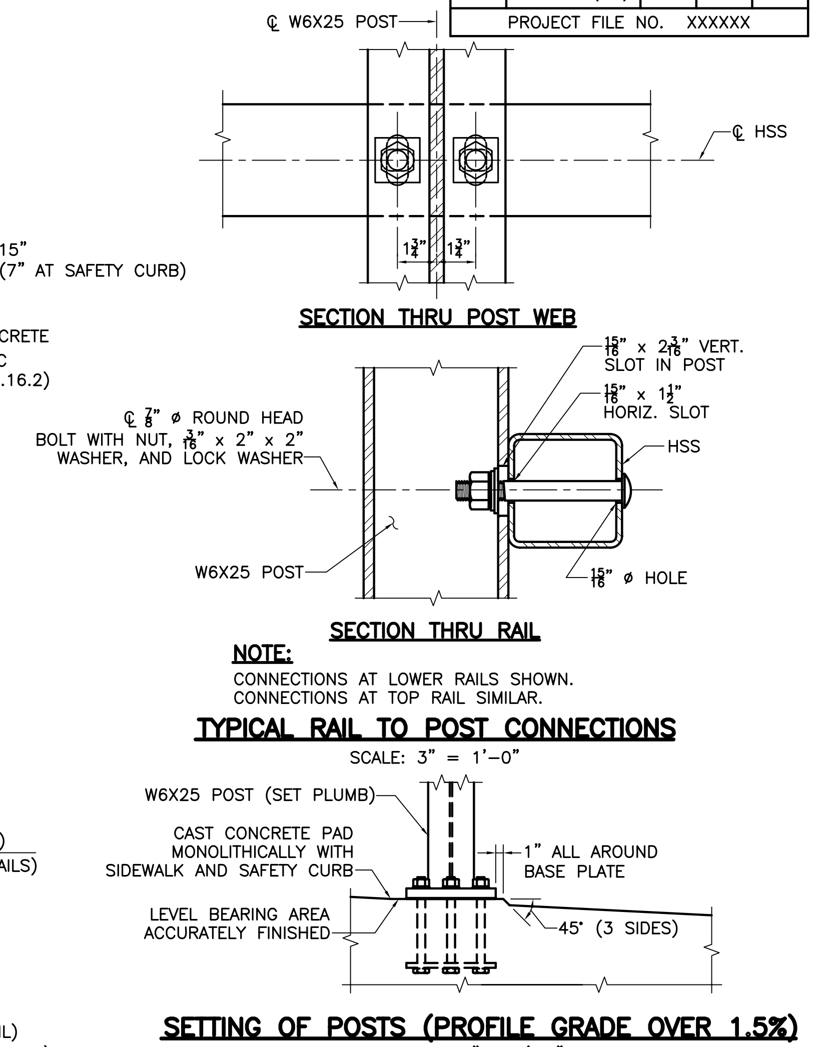
NOTES:

1. *Specify the number and type of utility conduits, i.e. electrical, cable, telephone, etc.*
2. *Specify reinforcement bars that will provide at a minimum the same As (in^2/ft) as required for the typical abutment reinforcement.*

MASS HIGHWAY BRIDGE MANUAL	UTILITY DETAILS FOR CONDUIT BANK INTEGRAL ABUTMENTS	DATE OF ISSUE MAY 2005 DRAWING NUMBER **12.4.4**

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				





RAILING NOTES:

1. RAIL POST AND BASE PLATES SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M 270 GRADE 50. HOLLOW RAILING STRUCTURAL TUBING (HSS) SHALL CONFORM TO THE REQUIREMENTS OF ASTM A 500 WITH A CERTIFIED Fy = 50 KSI MINIMUM. THE MINIMUM HORIZONTAL BENDING RADII OF THE HSS TUBING SHALL BE 8 FEET. PICKET CARRIER ANGLES, ANCHOR PLATES, AND SPLICE TUBE PLATES SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M 270 GRADE 36. PICKET TUBING SHALL CONFORM TO ASTM A 513 WITH Fy = 36 KSI MIN. OR A 500 GRADE B.
2. ALL STEEL (EXCEPT THE ⅝" ANCHOR PLATE AND FASTENERS) SHALL BE GALVANIZED AND PAINTED DARK BRONZE (FEDERAL STD. 595B COLOR NO. 10045). ANCHOR PLATE SHALL BE GALVANIZED ONLY. HEADS OF ⅞" ø ROUND HEAD BOLTS SHALL BE PAINTED TO MATCH RAIL.
3. ANCHOR BOLTS SHALL BE SET WITH TEMPLATES. THE NUT SECURING THE POST BASE PLATE TO THE CONCRETE SHALL BE TIGHTENED TO A SNUG FIT AND GIVEN AN ADDITIONAL 1/8 TURN AFTER STEEL IS IN PLACE.
4. RAILS SHALL BE CONTINUOUS OVER A MINIMUM OF FOUR (4) POSTS WITHOUT SPLICES WHERE POSSIBLE. RAILS SHALL BE SPLICED IN THE PANELS OVER EXPANSION JOINT.
5. ENDS OF TUBE SECTIONS SHALL BE SAWED. GRIND SMOOTH EXPOSED EDGES. ALL CUT ENDS SHALL BE TRUE AND SMOOTH.
6. ALL POSTS TO BE PLUMB WHEN PROFILE GRADE EXCEEDS 1.5%. FOR PROFILE GRADES LESS THAN 1.5%, POSTS SHALL BE SET PERPENDICULAR TO GRADE.
7. POST FLANGE WELD DOES NOT REQUIRE MAGNETIC PARTICLE TESTING. WELD SHALL BE BACK-GOUGED ON BACK SIDE EXCEPT AT WEB. WELD IS THE SAME ON BOTH FLANGES.
8. ⅞" ø ROUND HEAD BOLTS SHALL CONFORM TO THE CHEMICAL AND PHYSICAL REQUIREMENTS OF AASHTO M 164.

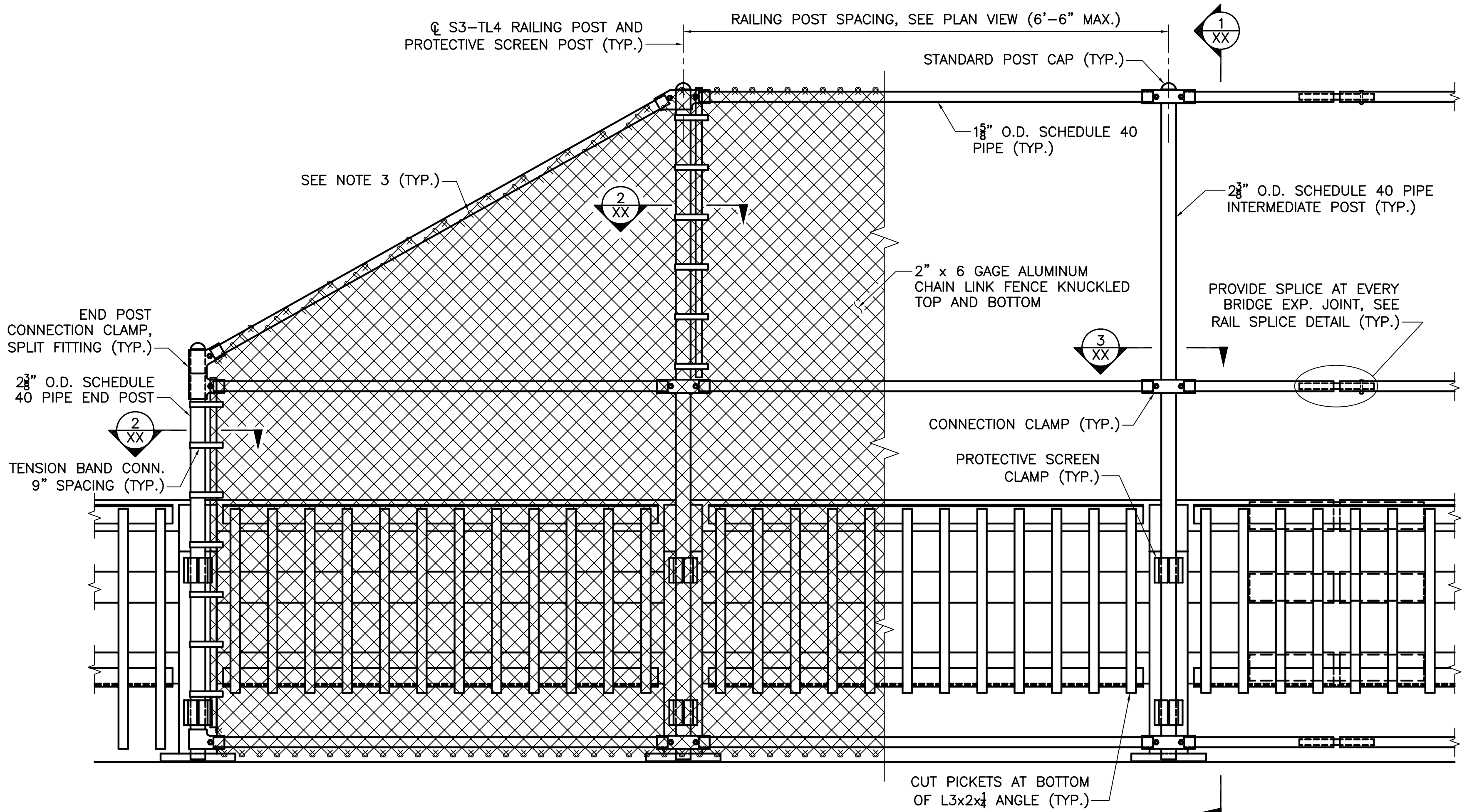
S3-TL4 BRIDGE RAILING DETAILS

MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

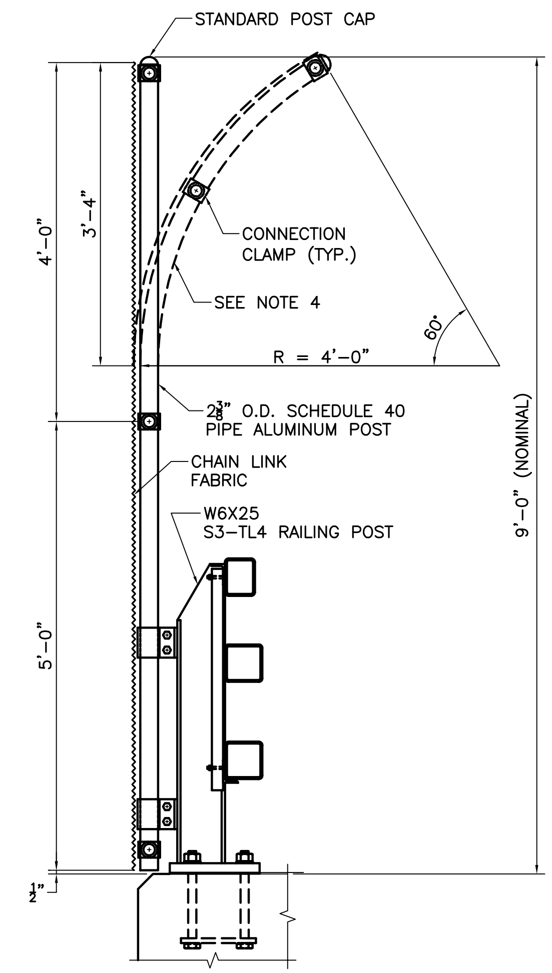
SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: February 7, 2007

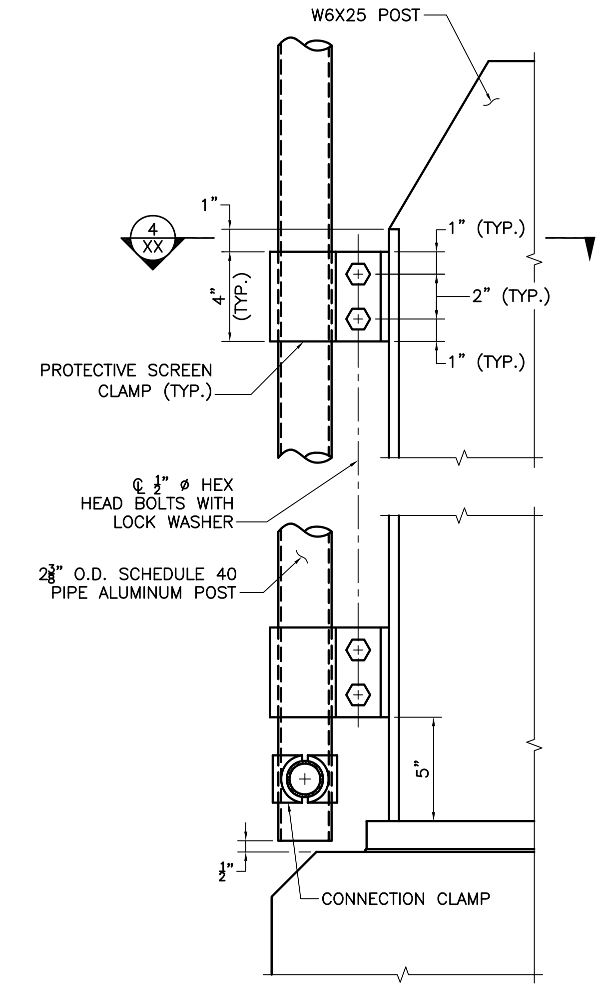
STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



ELEVATION
SCALE: 1" = 1'-0"



SECTION 1
SCALE: 1" = 1'-0"



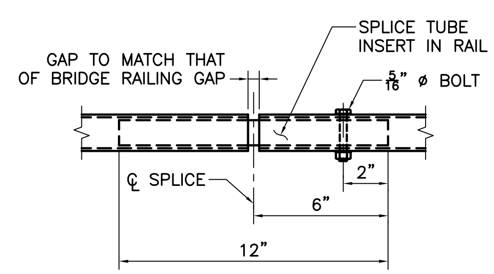
ELEVATION–PROTECTIVE SCREEN CLAMPS
SCALE: 3" = 1'-0"

GENERAL NOTES:

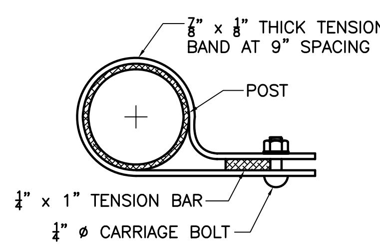
1. USE 6 GAGE TIES AT 12" O.C. TO ALL POSTS AND TOP 2 RAILS OR 3 RAILS (CURVED TOP). SPACE TIES TO BOTTOM RAIL AT 6" O.C.
2. ALL ALUMINUM, INCLUDING HARDWARE AND FABRIC, SHALL RECEIVE A 4±1 MIL POLYESTER POWDER COAT FINISH. THE COLOR SHALL MATCH THE COLOR OF THE S3-TL4 RAILING.
3. THE CHAIN LINK FABRIC SHALL BE SECURED BY KNUCKLING TOGETHER THE CUT ENDS OF THE FABRIC WIRE IN A MANNER SIMILAR TO THE ORIGINALLY MANUFACTURED END.
4. THE SCREEN TREATMENT TO BE USED (CURVED OR STRAIGHT TOP) IS SPECIFIED ELSEWHERE ON THE CONSTRUCTION DRAWINGS.
5. PICKETS ARE REQUIRED FOR CRASH SAFETY.

MATERIALS:

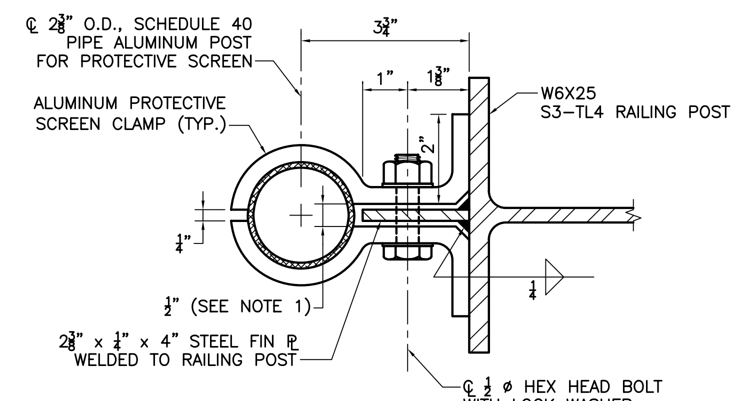
POST AND RAILS	ASTM B 221, ALLOY 6061-T6, SCHEDULE 40 PIPE
TENSION BARS, RAIL SPLICES, WASHERS, AND POST CONN. CLAMPS	ASTM B 221, ALLOY 6061-T6
FABRIC AND TIES	AASHTO M 181 TYPE III, ALLOY 6061-T89 OR T94; 6 GAGE
TENSION BANDS	ASTM B 221, ALLOY 6063-T5
BOLTS	ASTM B 316, ALLOY 2024-T4
NUTS	ASTM B 316, ALLOY 6061-T6
PROTECTIVE SCREEN CLAMPS	ASTM B 221, ALLOY 6061-T6



RAIL SPLICE
SCALE: 3" = 1'-0"



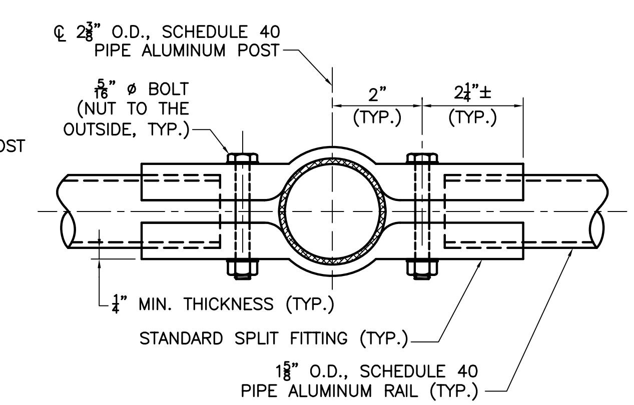
SECTION 2
TENSION BAND CONNECTION
SCALE: 6" = 1'-0"



NOTES:

1. DRAW FOR FABRICATION TO ENSURE CLAMPING ACTION.
2. SLIGHT VARIATIONS IN EXTRUSION DIMENSIONS MAY BE SUBMITTED FOR APPROVAL.

SECTION 4
SCALE: 6" = 1'-0"



SECTION 3
POST CONNECTION CLAMP
SCALE: 6" = 1'-0"

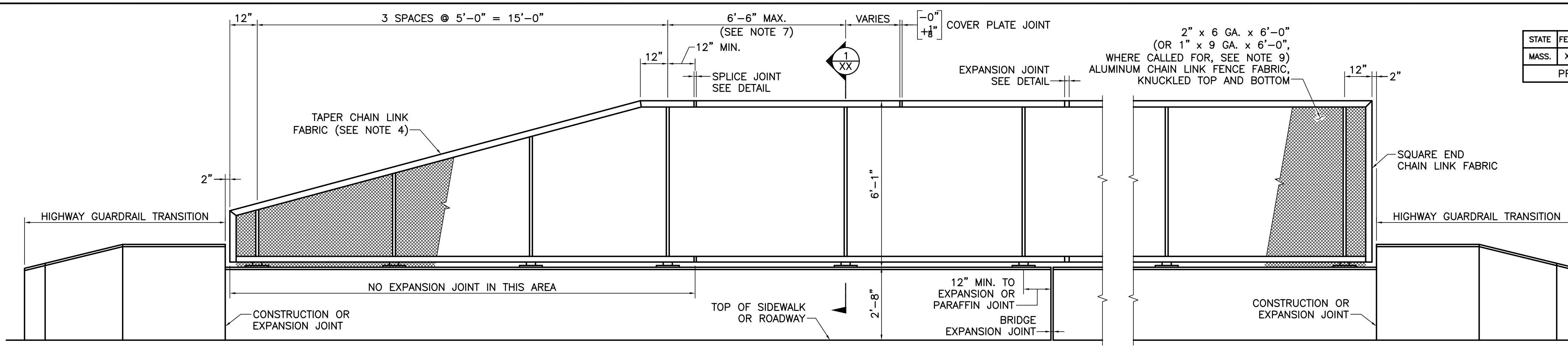
PROTECTIVE SCREEN TYPE I

MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

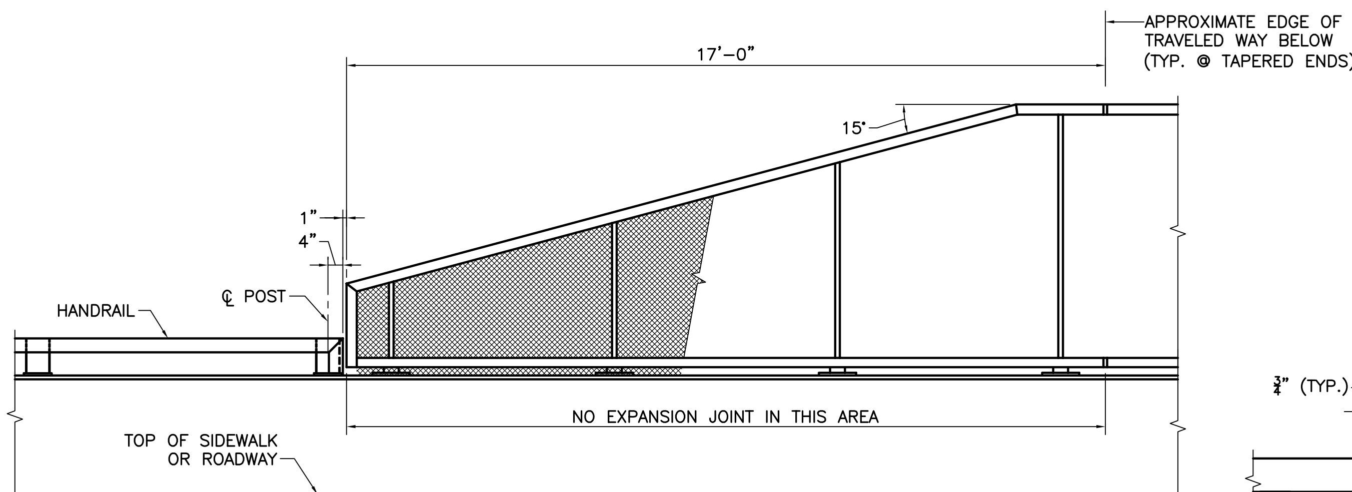
Date: July 19, 2007

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



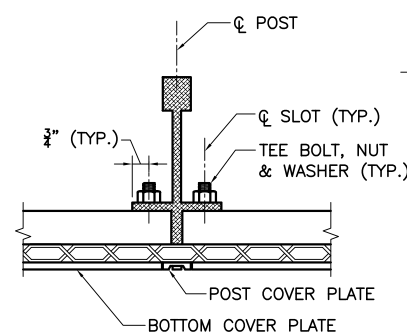
PROTECTIVE SCREEN ELEVATION

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



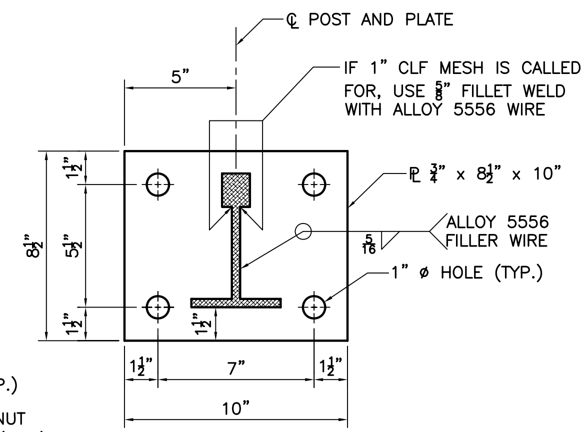
DETAIL AT HANDRAIL

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



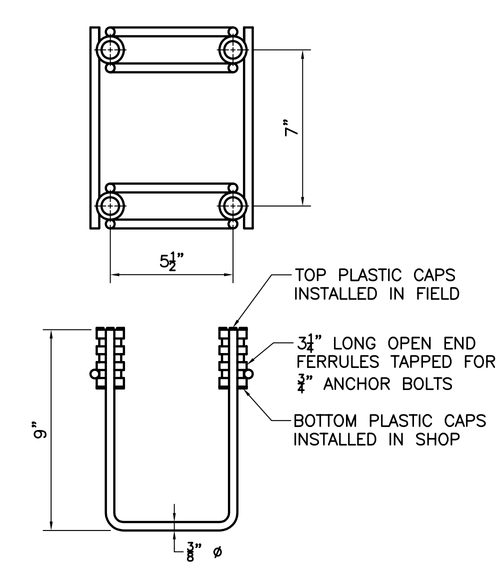
SECTION 2

SCALE: 3" = 1'-0"



BASE PLATE DETAIL

SCALE: 3" = 1'-0"

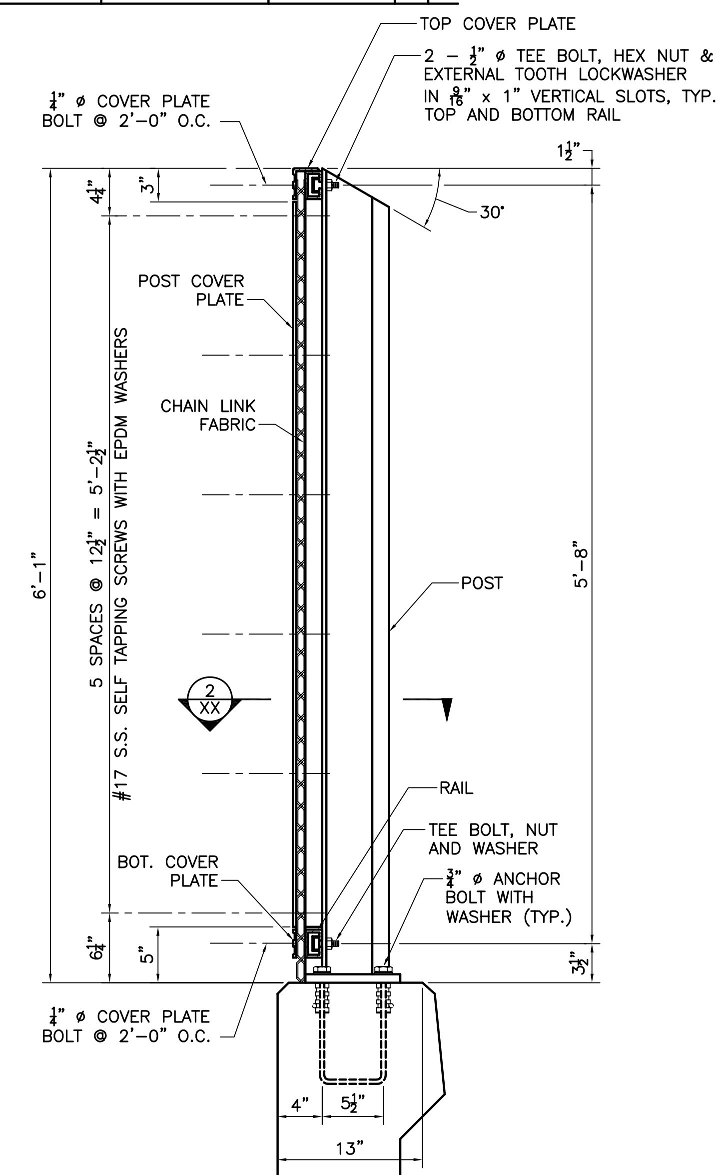


NOTE:

GALVANIZED OR ELECTROPLATE FINISH.

ANCHOR CAGE

SCALE: 3" = 1'-0"



SECTION 1

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

GENERAL NOTES:

1. RAILS SHALL BE CONTINUOUS OVER A MINIMUM OF FOUR POSTS, IF POSSIBLE.
2. RAILS SHALL HAVE AN EXPANSION JOINT IN THE PANEL OVER A BRIDGE EXPANSION JOINT AND AT 30 FOOT MAXIMUM SPACING ELSEWHERE.
3. BOTTOM OF POST BASE PLATE TO BE SET ON A 1/8" MOLDED FABRIC BEARING PAD (M9.16.2). THE THICKNESS OF THE PAD SHALL BE IGNORED BY THE DETAILER.
4. THE CHAIN LINK FABRIC SHALL BE SECURED BY KNUCKLING TOGETHER THE CUT ENDS OF THE FABRIC WIRE IN A MANNER SIMILAR TO THE ORIGINALLY MANUFACTURED END.
5. WHERE THE R.O.W. FENCE MUST MEET THE SCREEN, USE THE SQUARE END TO HIGHWAY GUARDRAIL TRANSITION DETAIL.
6. THE SCREEN END TREATMENT TO BE USED (SQUARE OR TAPERED) IS SPECIFIED ELSEWHERE ON THE CONSTRUCTION DRAWINGS.
7. POST SPACING SHALL BE UNIFORM BETWEEN TAPERED ENDS.
8. SET POSTS PERPENDICULAR TO GRADE FOR GRADES UP TO 1.5%. SET POSTS PLUMB FOR GRADES GREATER THEN 1.5%.
9. USE 2" x 6 GA. FABRIC EXCEPT OVER MBTA RAPID TRANSIT LINES WHERE 1" x 9 GA. FABRIC SHALL BE USED.

FINISHES:

1. POSTS, RAILS, COVER PLATES AND SPLICE PLATES SHALL RECEIVE A DARK BRONZE ANODIZED FINISH.
2. CHAIN LINK FABRIC SHALL RECEIVE A 4±1 MIL POLYESTER POWDER COAT FINISH. THE COLOR SHALL BE DARK BRONZE TO MATCH COLOR OF ANODIZED ALUMINUM FRAMEWORK.
3. #17 SELF TAPPING SCREWS AND 1/4" ø COVER PLATE BOLTS TO BE COLORED TO MATCH THE ANODIZED EXTRUSIONS.

MATERIALS:

EXTRUSIONS & PLATES	ASTM B 221, ALLOY 6061-T6
CHAIN LINK FABRIC	AASHTO M 181 TYPE III (ALLOY 6061-T89 OR T94)
SELF TAPPING SCREWS	TYPE 304 STAINLESS STEEL WITH 1/4" THICK EPDM (ETHYLENE PROPYLENE DIENE MONOMER) WASHERS
ANCHOR BOLTS	AASHTO M 164 GALVANIZED (ROTATION CAPACITY TEST NOT REQUIRED)
TEE BOLTS	ASTM A 307 GALVANIZED OR TYPE 304 STAINLESS STEEL
COVER PLATE BOLTS	TYPE 304 STAINLESS STEEL WITH OVERSIZED STAINLESS WASHER AND STAINLESS NUT WITH NYLON INSERT

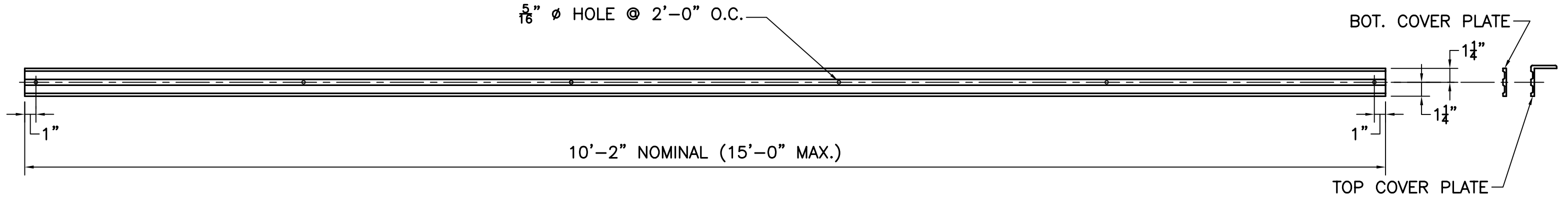
PROTECTIVE SCREEN TYPE II
SHEET 1 OF 2

MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: May 10, 2007

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				

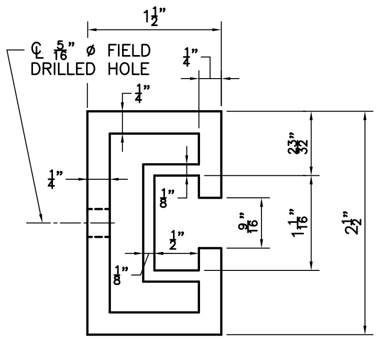


TOP AND BOTTOM COVER PLATE

SCALE: 1½" = 1'-0"

COVER PLATE NOTES:

1. COVER PLATES MAY BE CONTINUOUS OVER A RAIL SPLICE. COVER PLATES SHALL BE FIELD CUT AS REQUIRED TO CLEAR THE EXPANSION JOINT. SEE DETAIL AT EXPANSION JOINT.
2. FIELD DRILL 5/16" ø HOLE 1" FROM THE FIELD CUT END OF A COVER PLATE, UNLESS THERE IS AN EXISTING HOLE WITHIN 6" FROM THE COVER PLATE END.
3. FIELD PAINT THE FIELD CUT ENDS OF THE COVER PLATES TO MATCH THE ANODIZED COLOR.

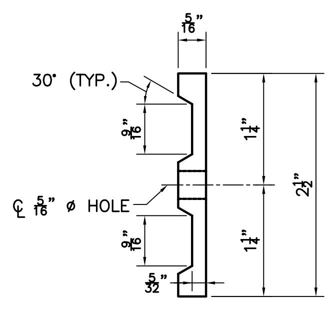


NOTE:

OTHER CONFIGURATIONS OF THE INTERNAL WALLS OF THE RAIL EXTRUSION MAY BE SUBMITTED FOR APPROVAL.

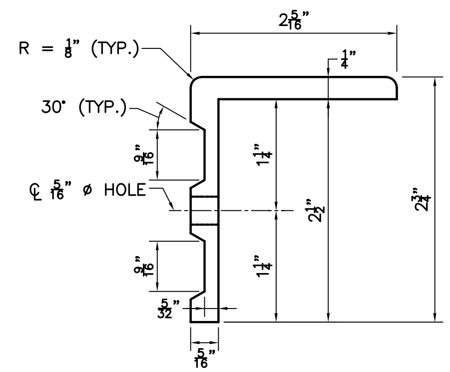
RAIL EXTRUSION

FULL SIZE



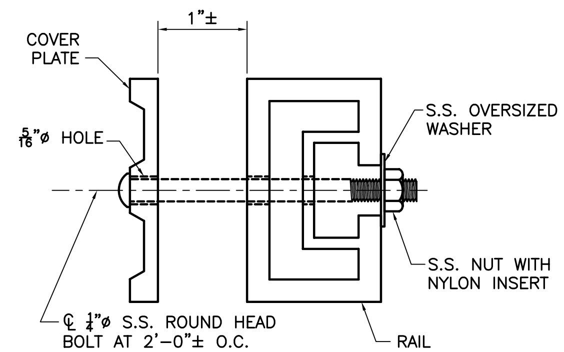
BOTTOM COVER PLATE EXTRUSION

FULL SIZE



TOP COVER PLATE EXTRUSION

FULL SIZE

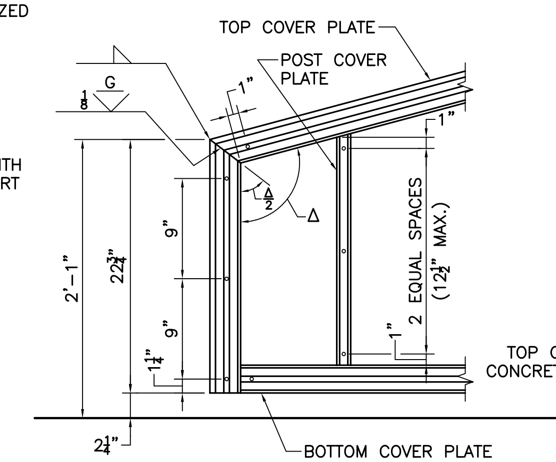


NOTE:

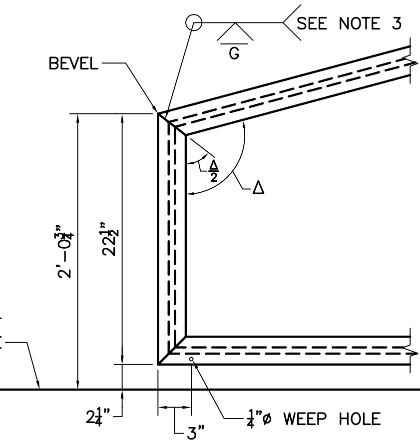
BOLTS SHALL BE TYPE 304 WITH A DRIVE HEAD TO BE COLORED TO MATCH ANODIZING.

RAIL & COVER ℙ DETAIL

FULL SIZE



COVER PLATE DETAILS



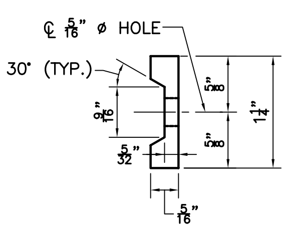
RAIL DETAILS

NOTES:

1. WELDING OF TOP COVER PLATE AND RAILS OF NON-TAPERED END IS SIMILAR.
2. WELDS AND MITERING TYPICAL FOR ALL ANGLED CORNERS.
3. WELD TYPICAL FOR TOP AND BOTTOM END CORNERS OF RAIL. INTERRUPT WELD AT SLOT IN BACK OF RAIL.

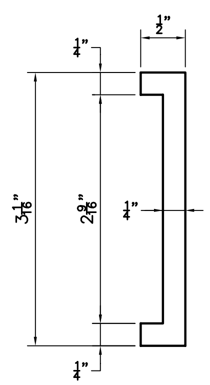
TAPERED END DETAILS

SCALE: 1½" = 1'-0"



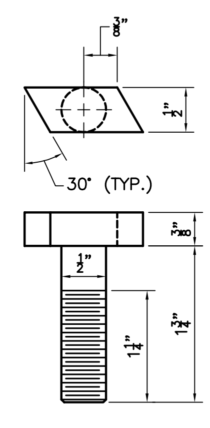
POST COVER PLATE EXTRUSION

FULL SIZE



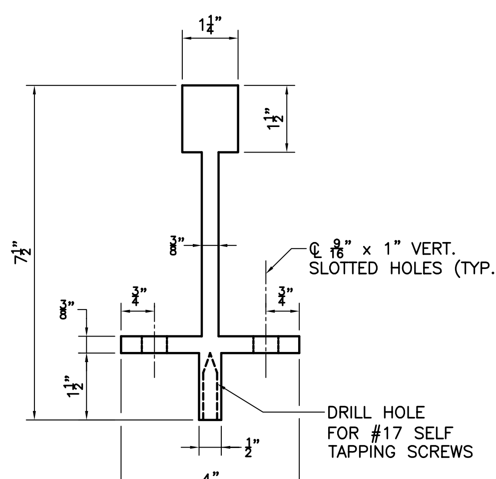
SPLICE PLATE EXTRUSION

FULL SIZE



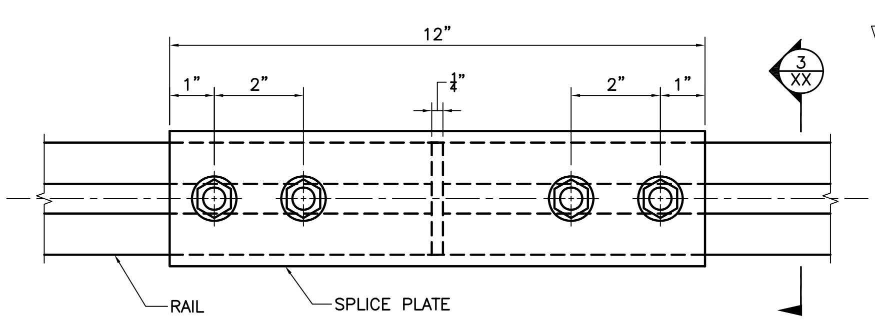
TEE BOLT

FULL SIZE



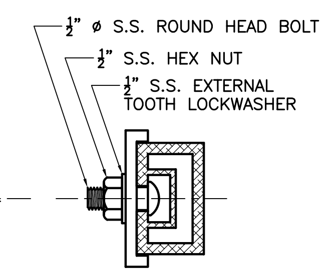
POST EXTRUSION

SCALE: 6" = 1'-0"



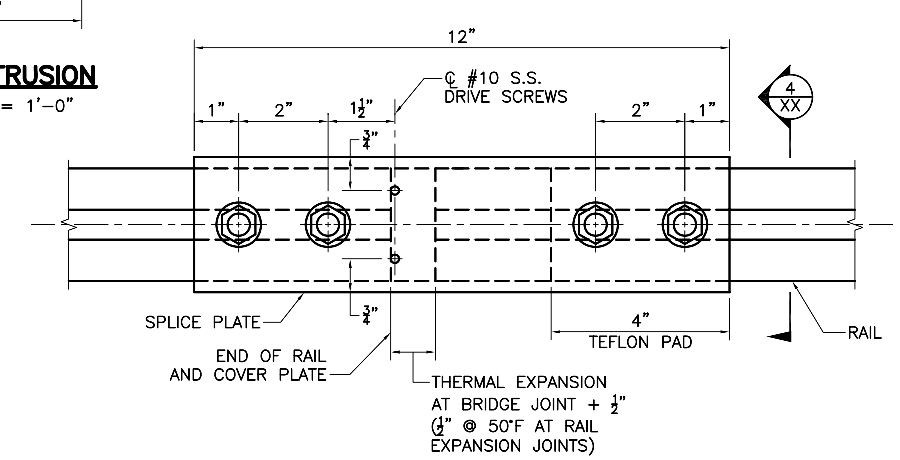
DETAIL AT SPLICE JOINT

SCALE: 6" = 1'-0"



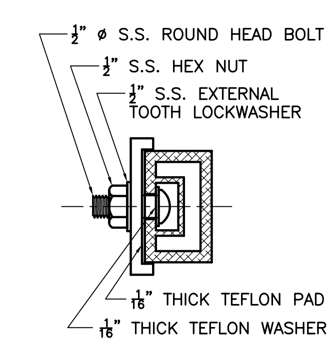
SECTION 3

SCALE: 6" = 1'-0"



DETAIL AT EXPANSION JOINT

SCALE: 6" = 1'-0"



SECTION 4

SCALE: 6" = 1'-0"

PROTECTIVE SCREEN TYPE II
SHEET 2 OF 2

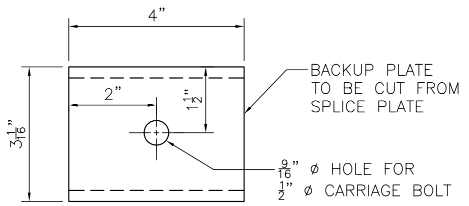
DATE	DESCRIPTION
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
USE ONLY PRINTS OF LATEST DATE	

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: May 10, 2007

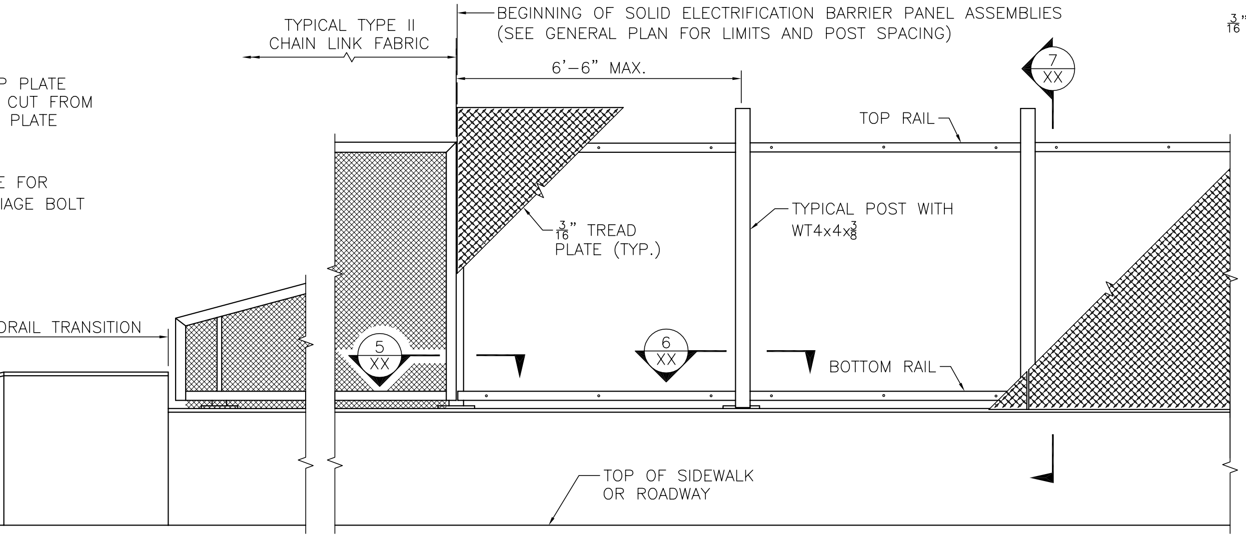
STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX

PROJECT FILE NO. XXXXXX



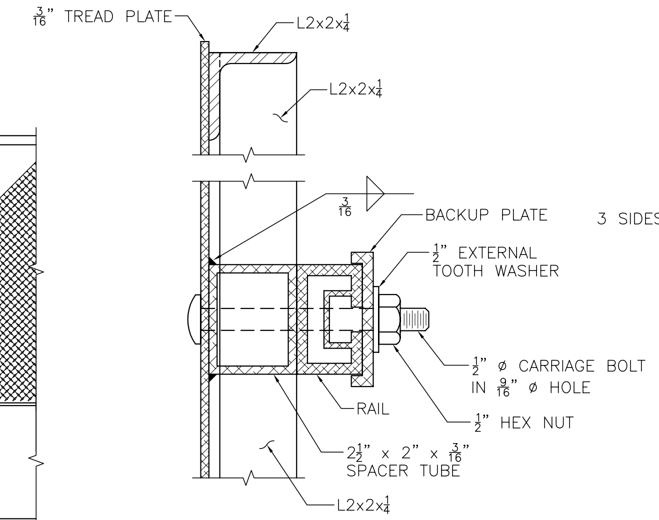
BACKUP PLATE

SCALE: 6" = 1'-0"



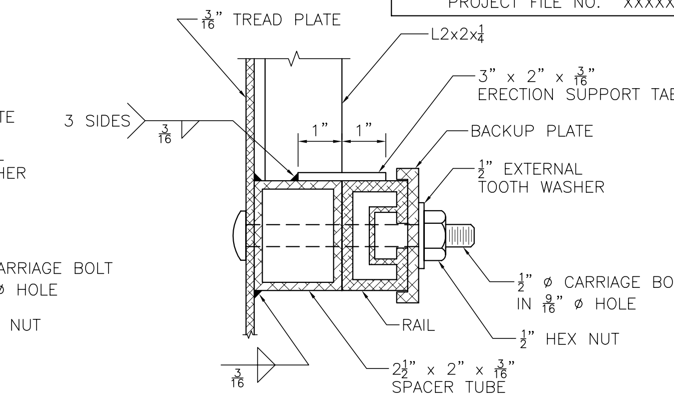
TYPE II ELECTRIFICATION BARRIER ELEVATION

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



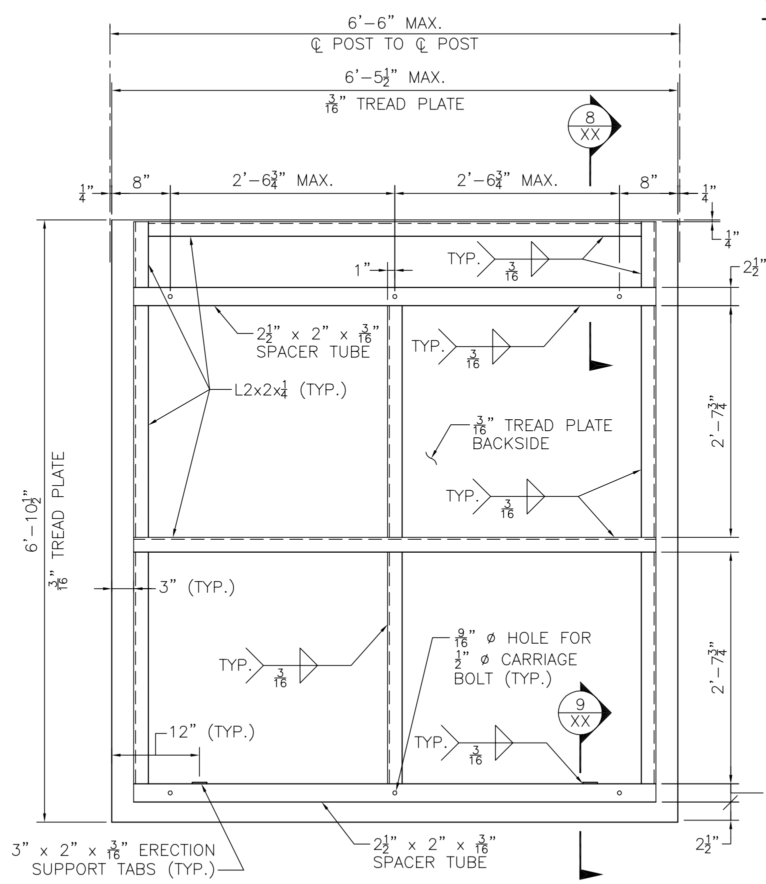
SECTION 8

SCALE: 6" = 1'-0"



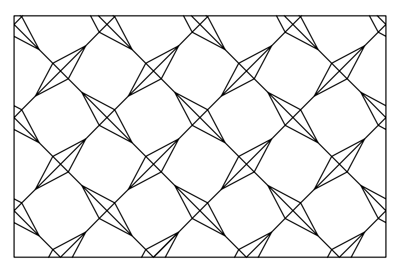
SECTION 9

SCALE: 6" = 1'-0"



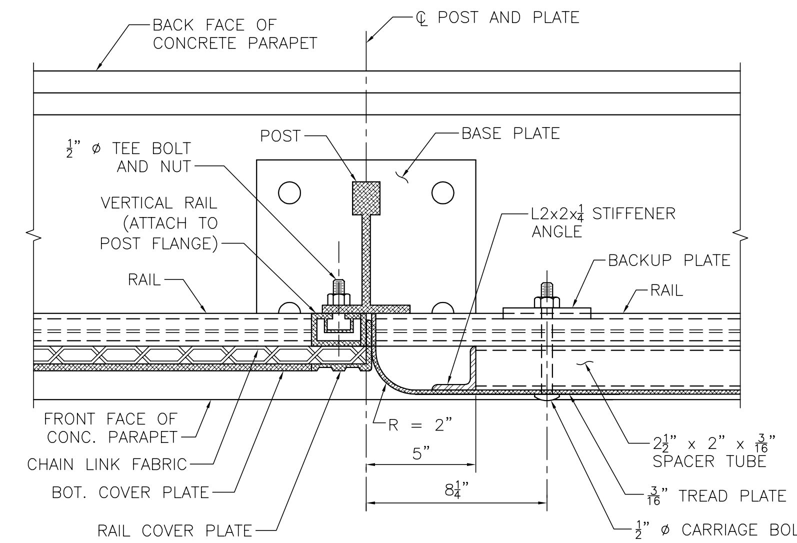
TREAD PLATE SUPPORT FRAMING ELEVATION

SCALE: 1" = 1'-0"



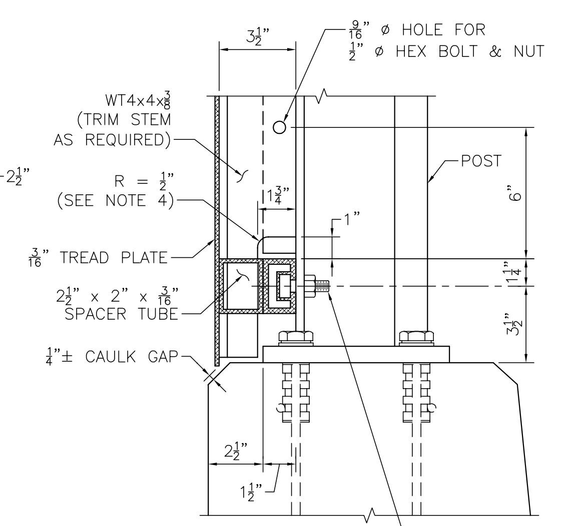
STANDARD 3/16" TREAD PLATE DETAIL

SCALE: 6" = 1'-0"



SECTION 5 – CHAIN LINK FENCE TO SOLID TREAD PLATE POST DETAIL

SCALE: 3" = 1'-0"

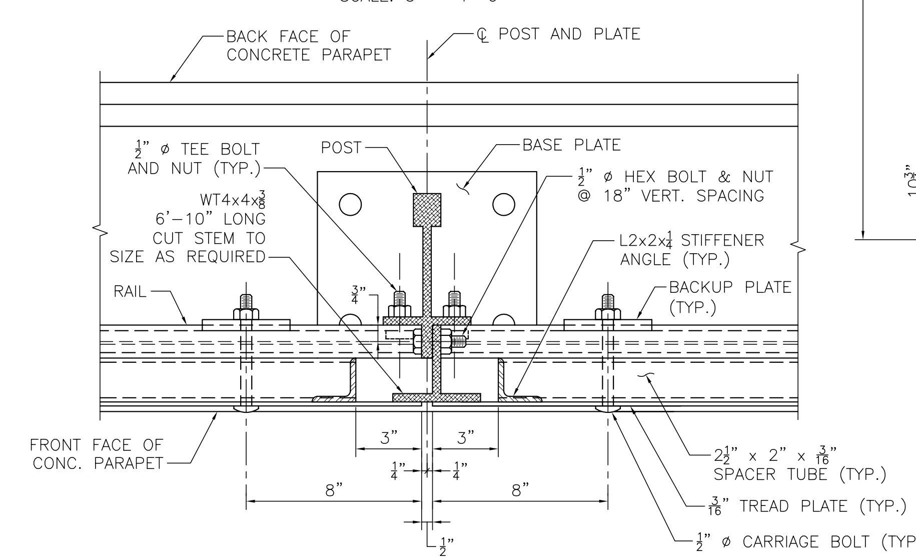


NOTE:

VERTICAL L2x2x1/4 NOT SHOWN FOR CLARITY.

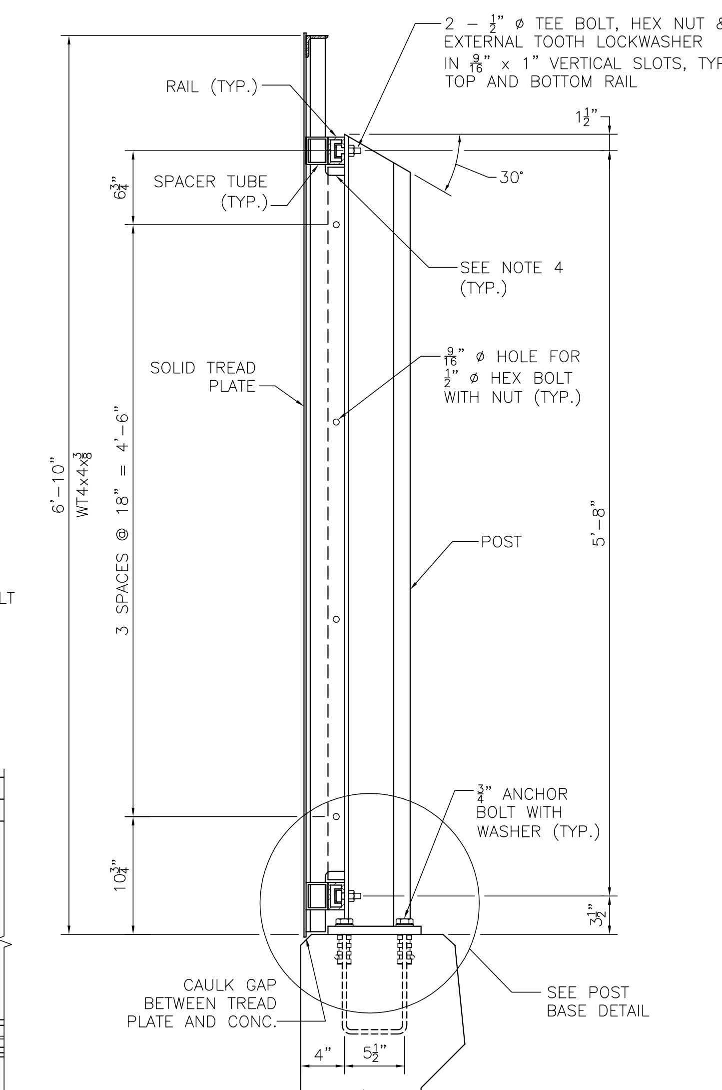
POST BASE DETAIL

SCALE: 3" = 1'-0"



SECTION 6 – TYPICAL POST DETAIL

SCALE: 3" = 1'-0"



NOTE:

VERTICAL L2x2x1/4 NOT SHOWN FOR CLARITY.

SECTION 7

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

ELECTRIFICATION BARRIER NOTES:

1. ELECTRIFICATION BARRIER PANEL ASSEMBLIES SHALL BE MOUNTED ON A TYPE II SCREEN FRAME. FOR TYPE II SCREEN DETAILS, GENERAL NOTES, MATERIAL REQUIREMENTS AND FINISHES, SEE SHEETS XX AND XX. THE ELECTRIFICATION BARRIER REQUIRES THE POST TO BASE WELD DETAIL SPECIFIED FOR THE 1" CHAIN LINK MESH.
2. 1/2" ø HEX BOLTS AND CARRIAGE BOLTS SHALL BE TYPE 304 STAINLESS STEEL. EXTRUSIONS, PLATES AND SHAPES SHALL BE ASTM B 221, ALLOY 6061-T6.
3. PANEL ASSEMBLIES SHALL RECEIVE A 4±1 MIL POLYESTER POWDER COAT FINISH. COLOR SHALL MATCH EXTRUSION ANODIZING. THE HEADS OF THE CARRIAGE BOLTS SHALL BE PAINTED TO MATCH THE COLOR OF THE POWDER COAT FINISH.
4. COPE WT4x4x3/8 AS SHOWN TO FIT AROUND TOP AND BOTTOM RAILS.
5. THE 9/16" ø HOLES FOR THE 1/2" ø CARRIAGE BOLTS SHALL BE FIELD DRILLED THROUGH THE TOP AND BOTTOM RAIL EXTRUSIONS. THE BARRIER PLATE ASSEMBLY SHALL BE USED TO DETERMINE THE EXACT LOCATION OF THE HOLES.

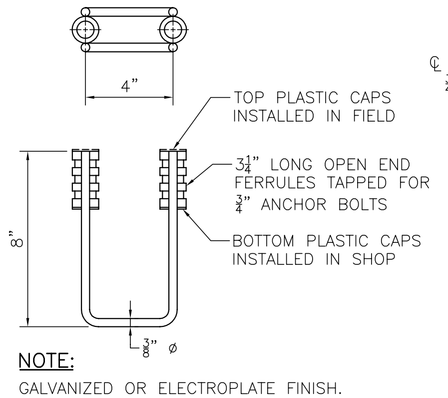
TYPE II ELECTRIFICATION BARRIER – DETAILS

MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

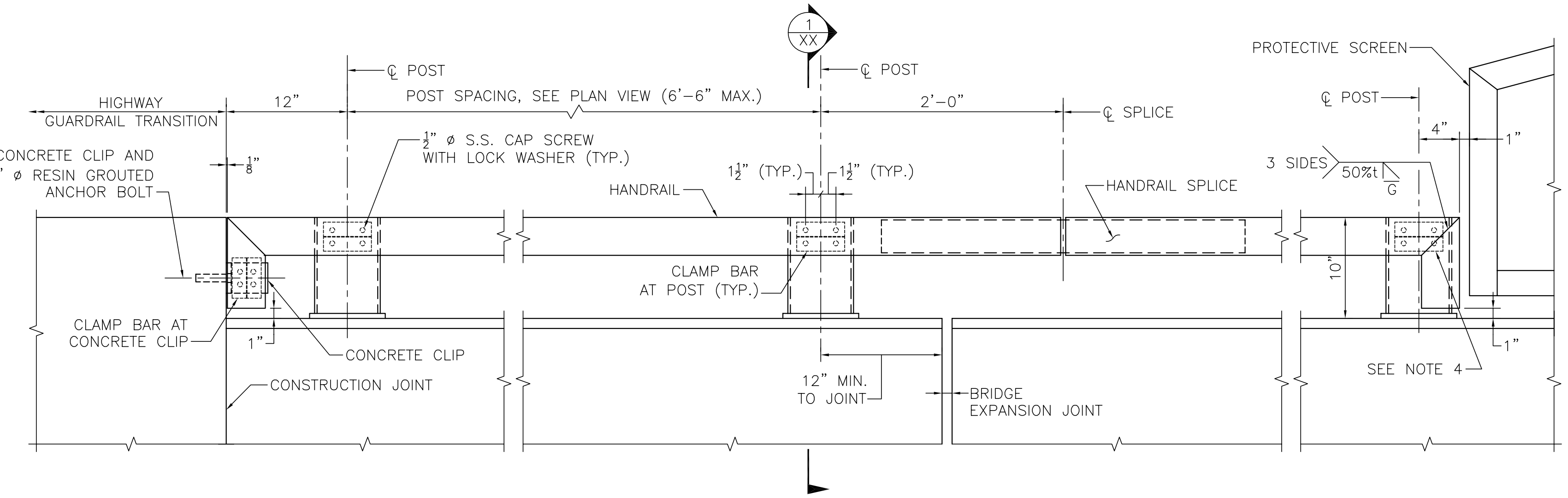
Date: August 2, 2005

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				

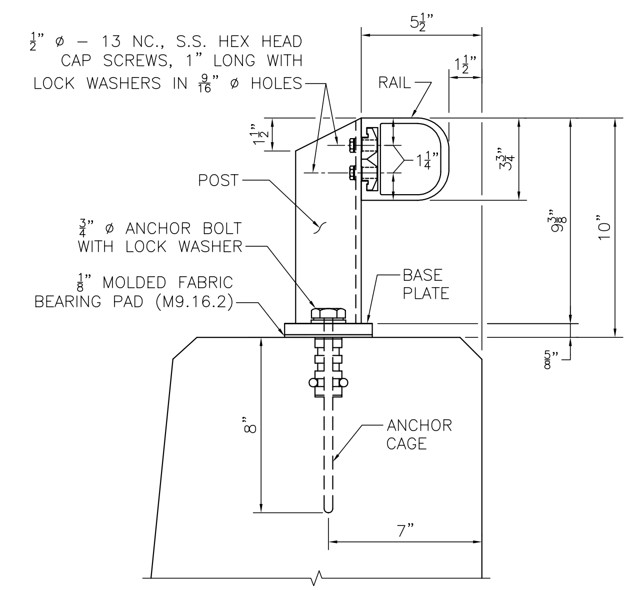


NOTE:
GALVANIZED OR ELECTROPLATE FINISH.

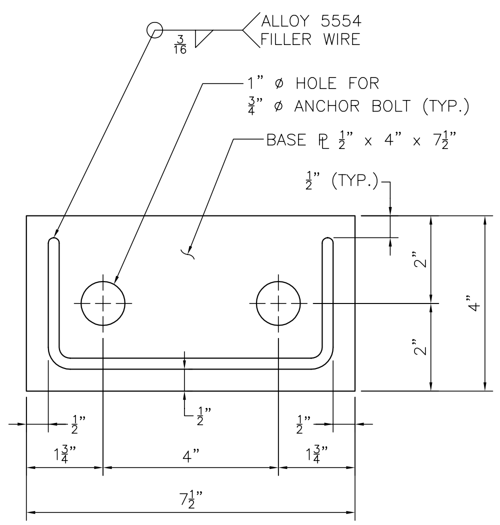
ANCHOR CAGE
SCALE: 3" = 1'-0"



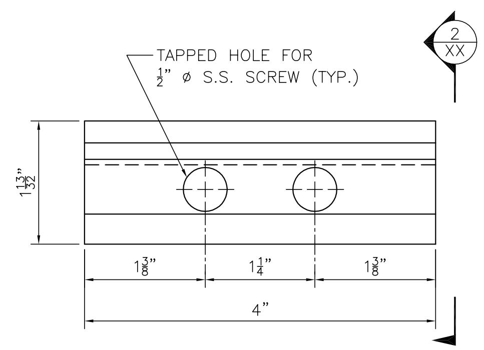
HANDRAIL ELEVATION
SCALE: 1½" = 1'-0"



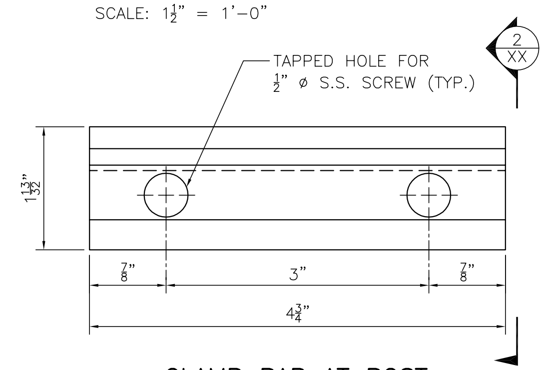
SECTION 1
SCALE: 3" = 1'-0"



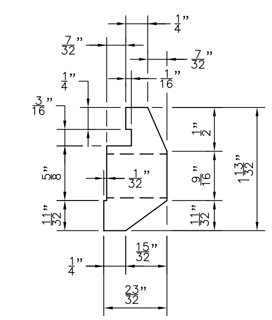
BASE PLATE DETAIL
SCALE: 6" = 1'-0"



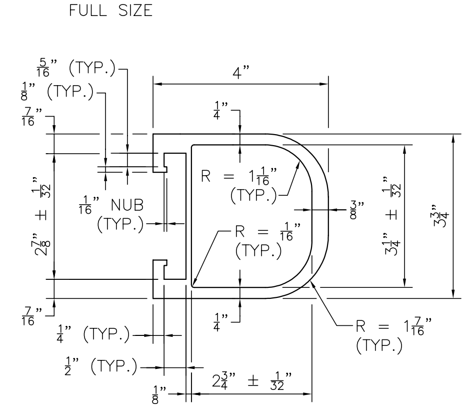
CLAMP BAR AT CONCRETE CLIP
FULL SIZE



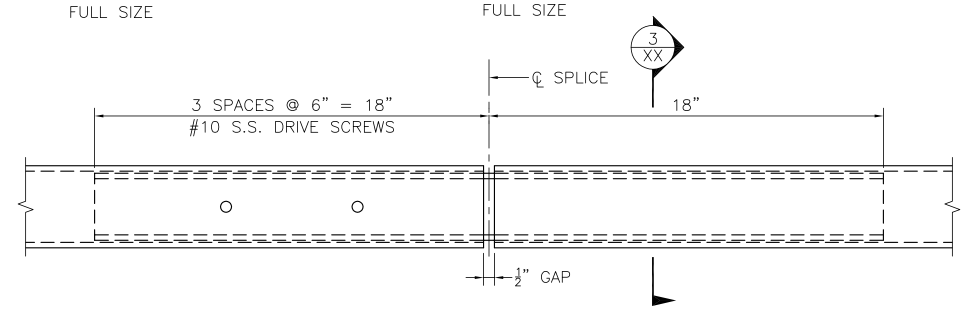
CLAMP BAR AT POST
FULL SIZE



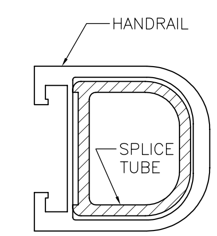
SECTION 2
FULL SIZE



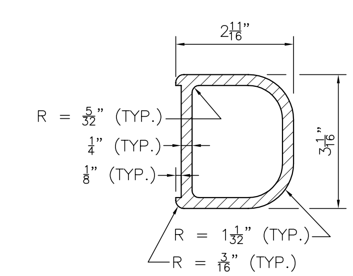
RAIL DETAIL
SCALE: 6" = 1'-0"



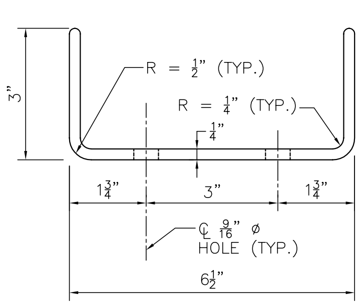
HANDRAIL SPLICE
SCALE: 3" = 1'-0"



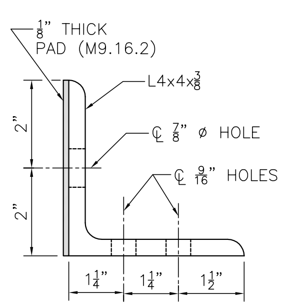
SECTION 3
SCALE: 6" = 1'-0"



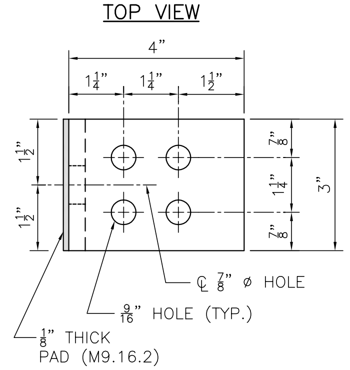
SPLICE TUBE
SCALE: 6" = 1'-0"



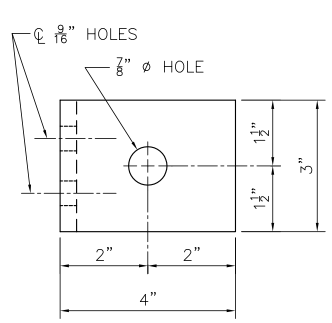
POST DETAIL
SCALE: 6" = 1'-0"



TOP VIEW



ELEVATION



SIDE VIEW

CONCRETE CLIP
SCALE: 6" = 1'-0"

FINISH:

POSTS, RAILS, BASE PLATES, CONCRETE CLIP AND SPLICE TUBE SHALL RECEIVE A DARK BRONZE ANODIZED FINISH.

MATERIALS:

RAIL, POST AND BASE PLATE	ASTM B 221, ALLOY 6061-T6
CLAMP BAR, RAIL SPLICE AND CONC. CLIP	ASTM B 221, ALLOY 6061-T6
S.S. FASTENERS	ASTM A 193 GRADE B8 (TYPE 403)
ANCHOR BOLTS	AASHTO M 164 GALVANIZED (ROTATION CAPACITY TEST NOT REQUIRED)
ALUMINUM WASHERS	ASTM B 209 ALLOY ALCLAD 2024-T4

GENERAL NOTES:

1. RAILS SHALL BE CONTINUOUS OVER A MINIMUM OF FOUR POST, IF POSSIBLE.
2. RAILS SHALL HAVE A HANDRAIL SPLICE IN THE PANEL OVER A BRIDGE EXPANSION JOINT. ½" GAP SHALL BE INCREASE AS REQUIRED.
3. OTHER CONFIGURATIONS OF THE INTERNAL WALLS OF THE RAIL EXTRUSION MAY BE SUBMITTED FOR APPROVAL.
4. AT 45° MITRES, TRIM OFF 1/16" NUB ON VERTICAL RAIL SECTION AS NEEDED TO ALLOW BOTTOM HORIZONTAL CLAMP BAR TO PROPERLY ENGAGE THE HORIZONTAL RAIL.

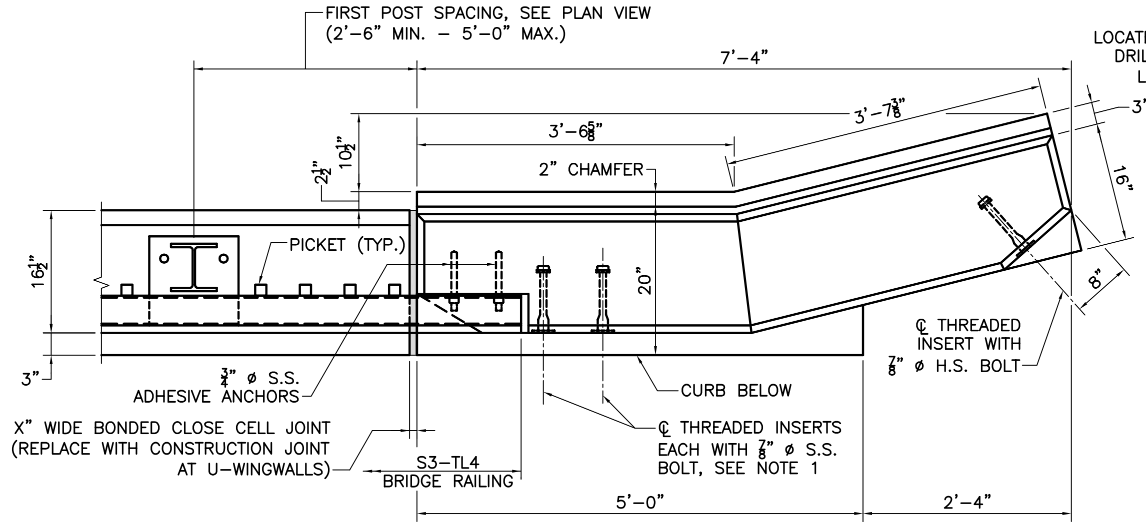
HANDRAIL

MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

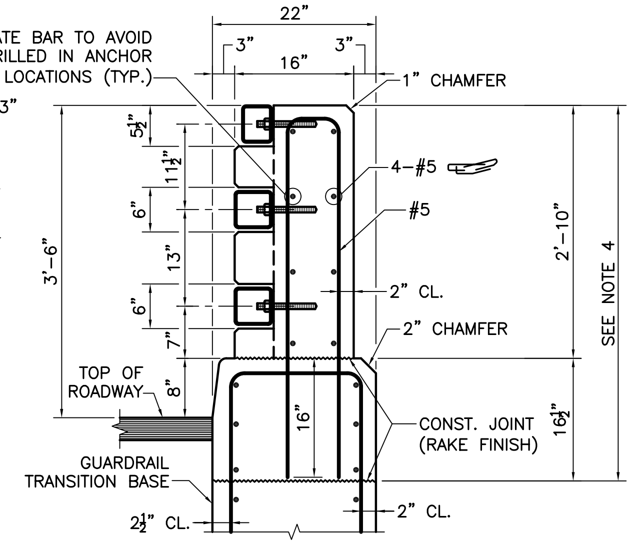
SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: August 2, 2005

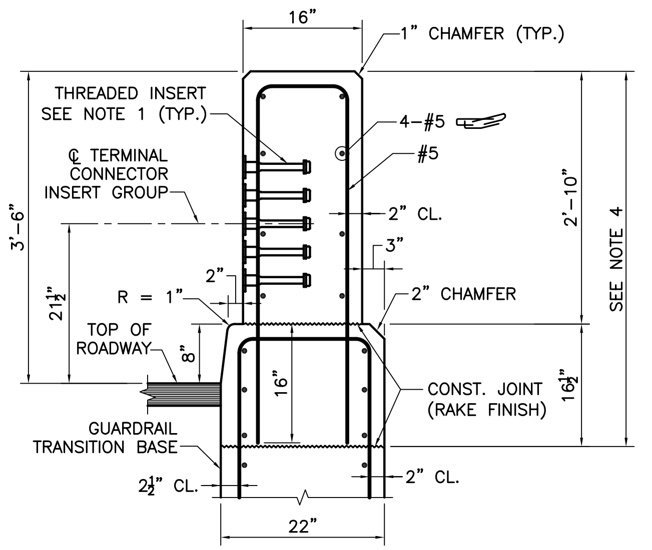
STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



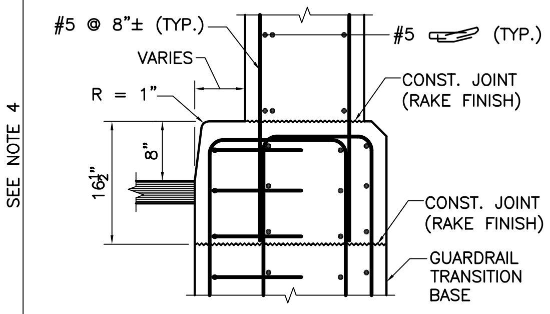
PLAN AT SAFETY CURB
SCALE: 1" = 1'-0"



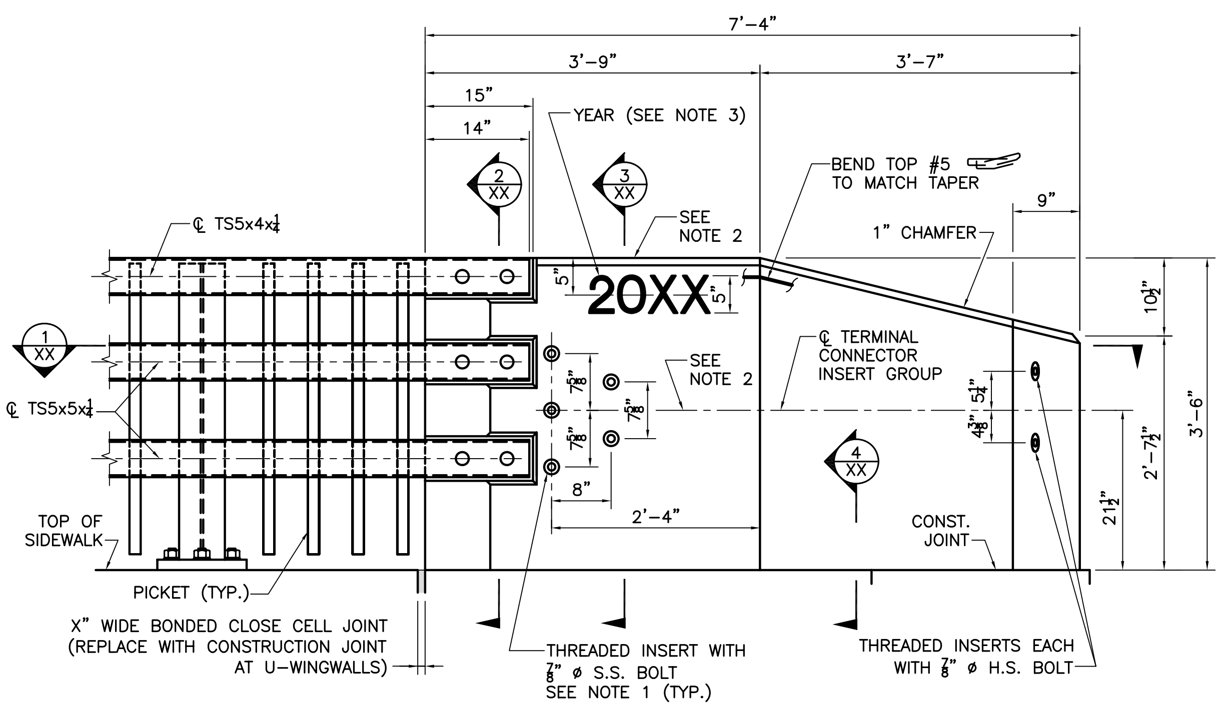
SECTION 2 AT SAFETY CURB
SCALE: 1" = 1'-0"



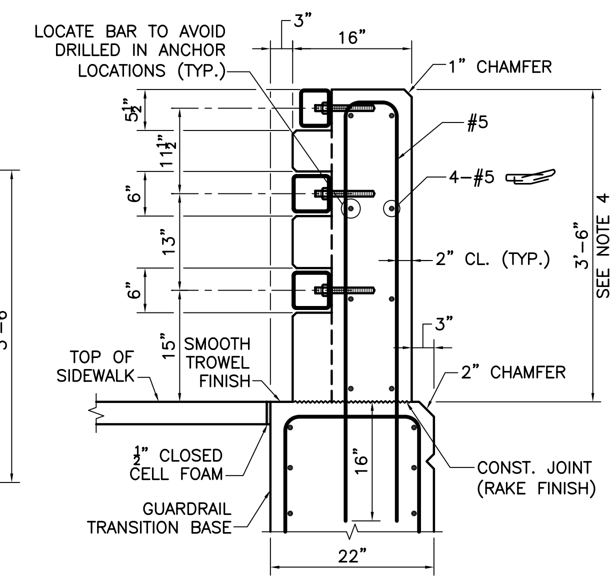
SECTION 3 AT SAFETY CURB
SCALE: 1" = 1'-0"



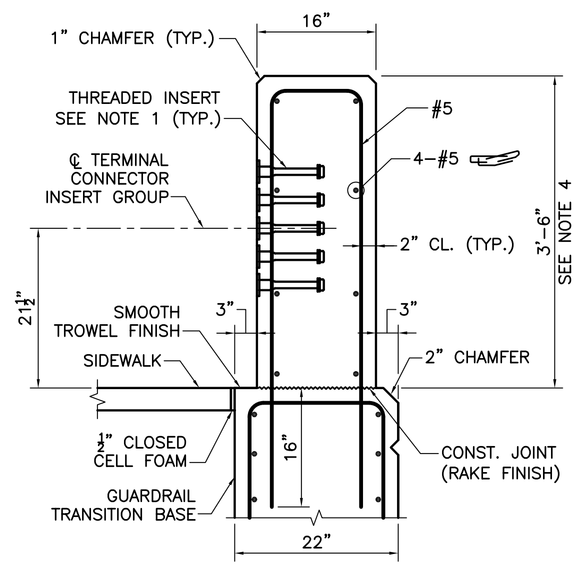
SECTION 4 AT SAFETY CURB
SCALE: 1" = 1'-0"



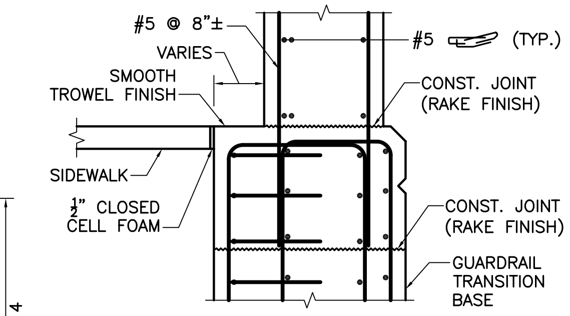
ELEVATION AT SIDEWALK
SCALE: 1" = 1'-0"



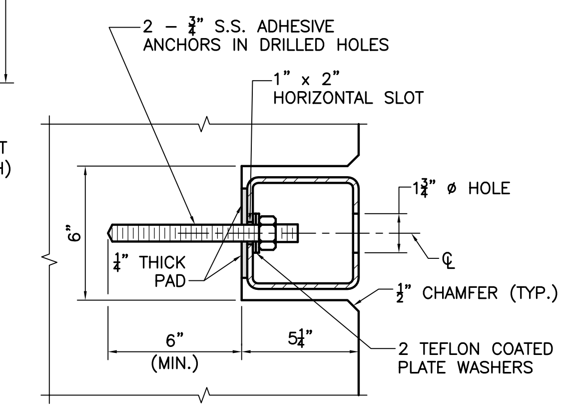
SECTION 2 AT SIDEWALK
SCALE: 1" = 1'-0"



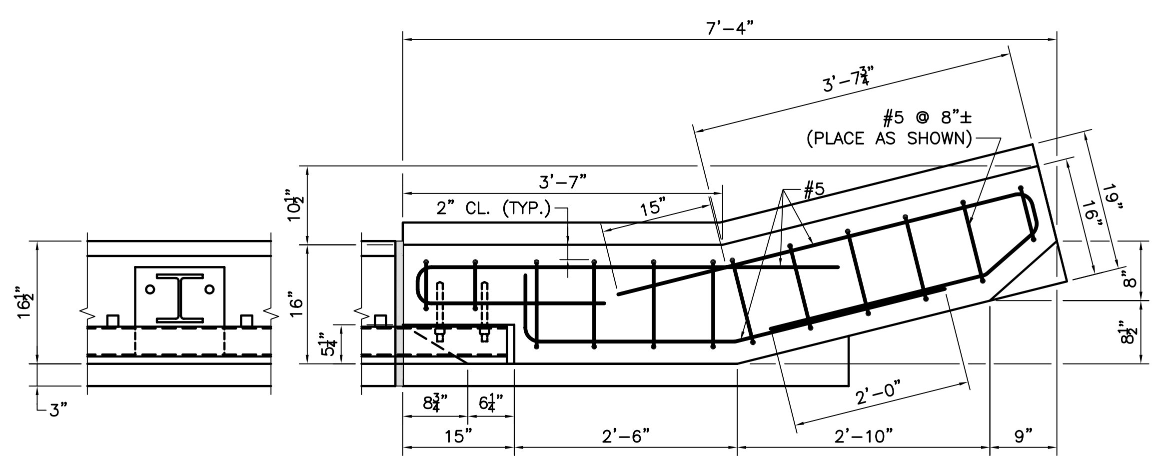
SECTION 3 AT SIDEWALK
SCALE: 1" = 1'-0"



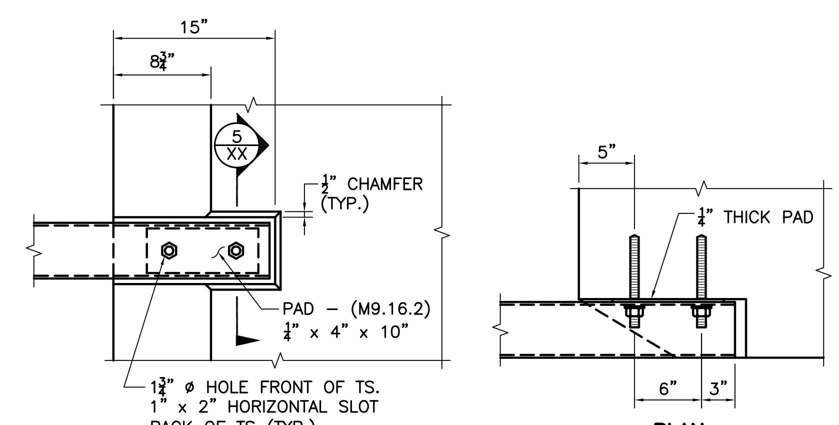
SECTION 4 AT SIDEWALK
SCALE: 1" = 1'-0"



SECTION 5
SCALE: 3" = 1'-0"



SECTION 1
SCALE: 1" = 1'-0"



ELEVATION

PLAN

RAIL ATTACHMENT
SCALE: 1½" = 1'-0"

NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING AN ULTIMATE SHEAR CAPACITY OF 20 KIPS PER ⅞" ø S.S. BOLT. S.S. BOLTS SHALL BE ⅞" ø x 1½" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR ⅞" ø S.S. BOLTS SHALL BE CAST-IN-PLACE AND GALVANIZED.
2. TOP OF GUARDRAIL TRANSITION, TERMINAL CONNECTOR INSERT GROUP, AND RAIL POCKETS SHALL BE SLOPED TO MATCH THE PROFILE GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, ¾", 685 HP CEMENT CONCRETE.

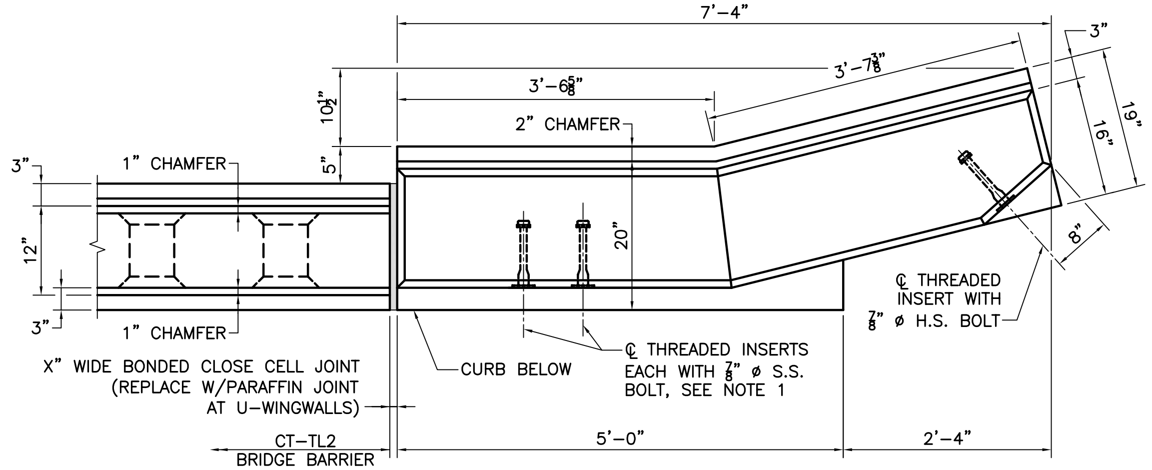
DATE	DESCRIPTION
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
USE ONLY PRINTS OF LATEST DATE	

HIGHWAY GUARDRAIL TRANSITION – S3-TL4 RAILING

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

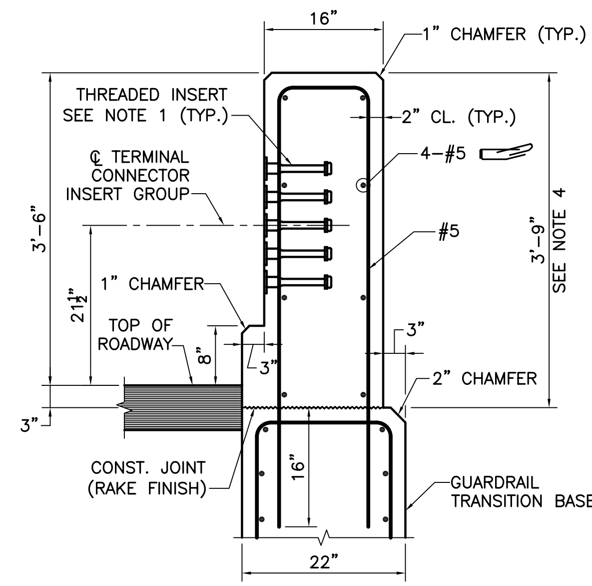
Date: August 7, 2007

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



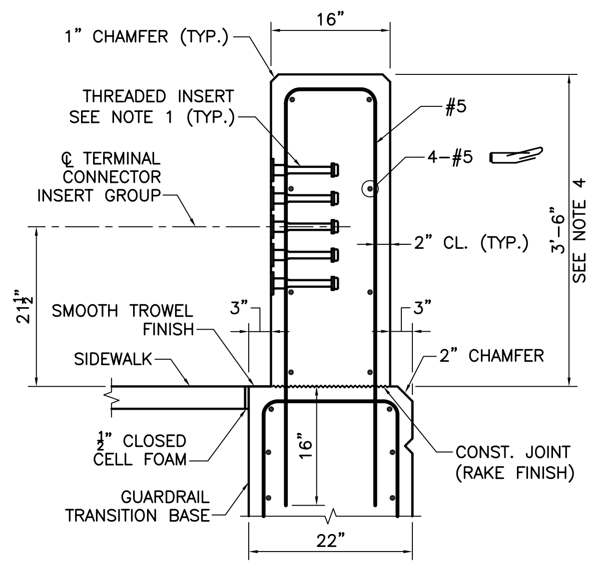
PLAN AT SAFETY CURB

SCALE: 1" = 1'-0"



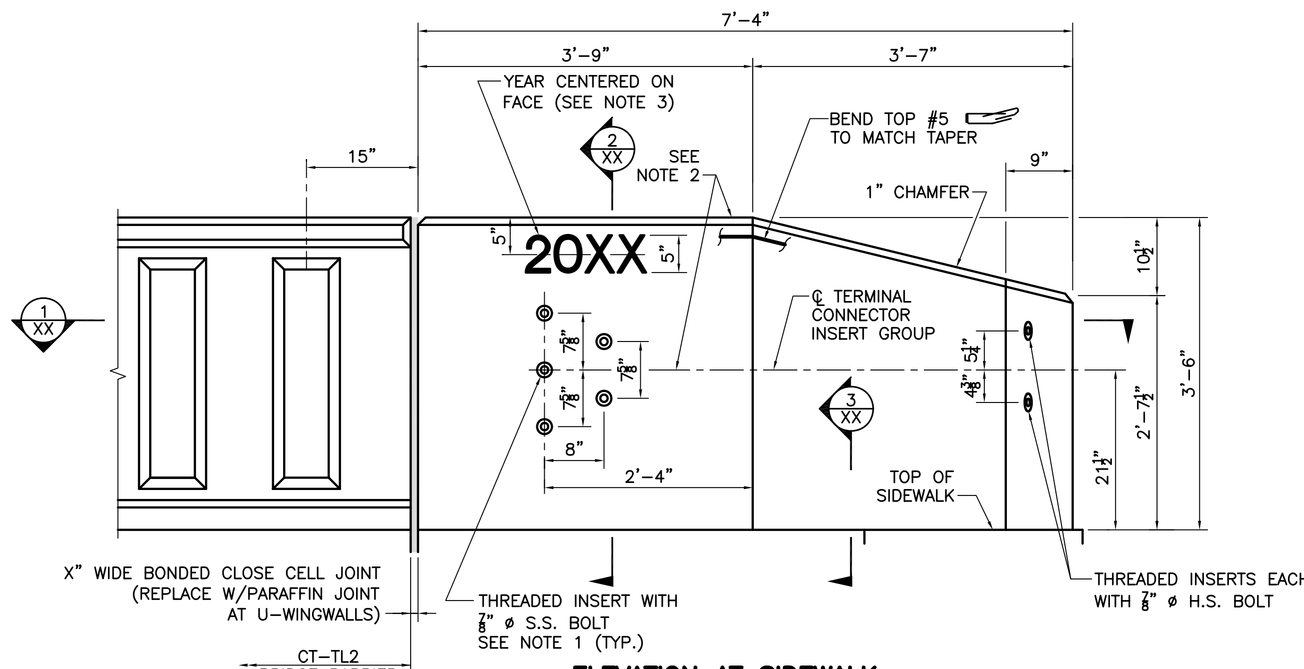
SECTION 2 AT SAFETY CURB

SCALE: 1" = 1'-0"



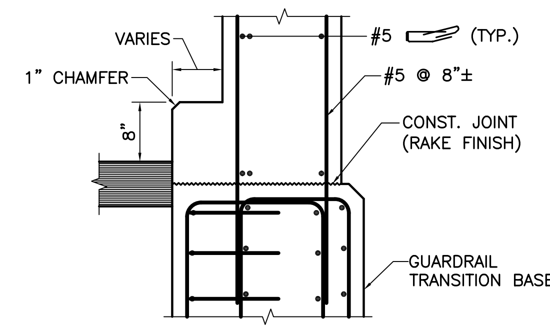
SECTION 2 AT SIDEWALK

SCALE: 1" = 1'-0"



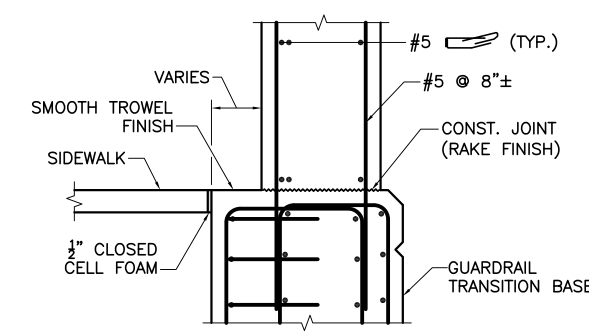
ELEVATION AT SIDEWALK

SCALE: 1" = 1'-0"



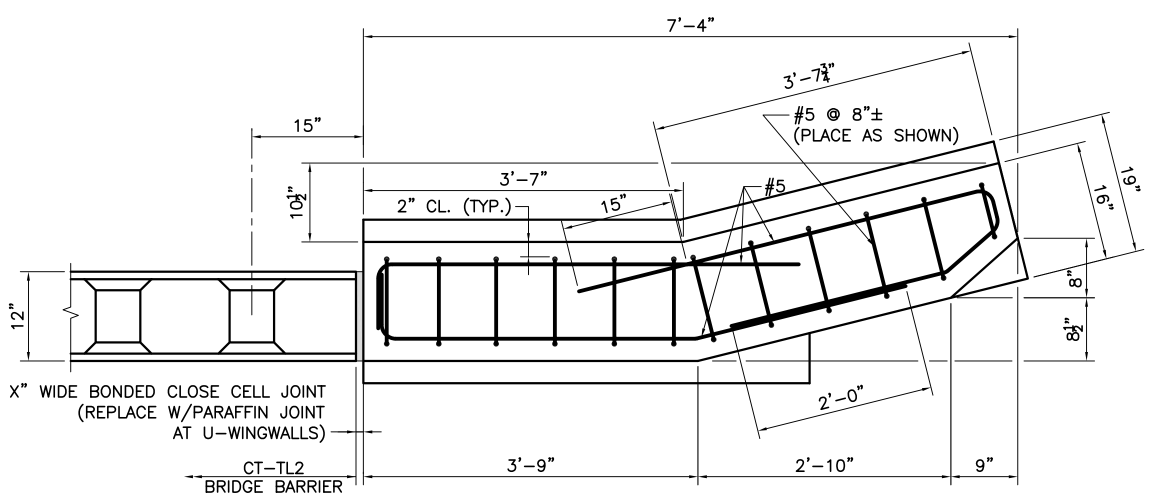
SECTION 3 AT SAFETY CURB

SCALE: 1" = 1'-0"



SECTION 3 AT SIDEWALK

SCALE: 1" = 1'-0"



SECTION 1

SCALE: 1" = 1'-0"

NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING AN ULTIMATE SHEAR CAPACITY OF 20 KIPS PER ⅞" ø S.S. BOLT. S.S. BOLTS SHALL BE ⅞" ø x 1½" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR ⅞" S.S. BOLTS SHALL BE CAST-IN-PLACE AND GALVANIZED.
2. TOP OF GUARDRAIL TRANSITION AND TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO MATCH THE PROFILE GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, ¾", 685 HP CEMENT CONCRETE.

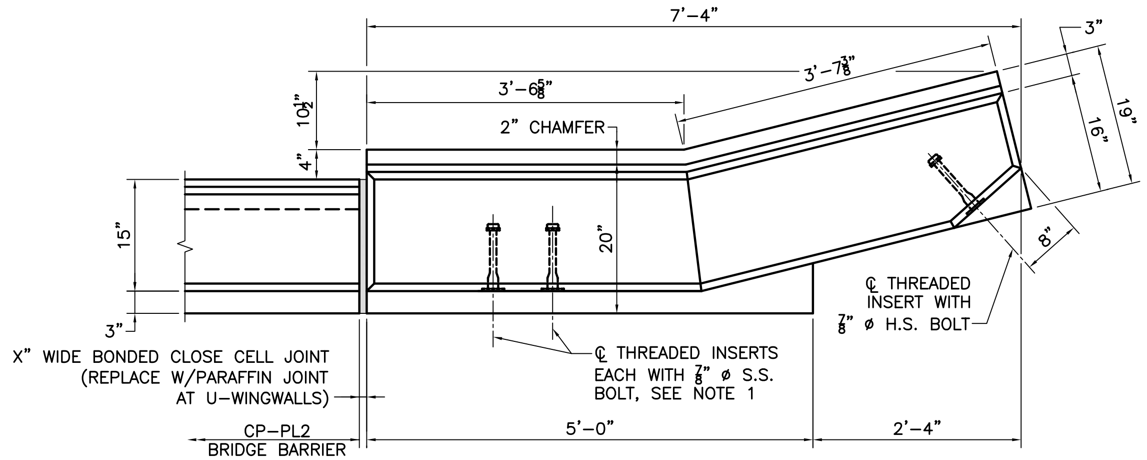
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
DATE	DESCRIPTION
USE ONLY PRINTS OF LATEST DATE	

HIGHWAY GUARDRAIL TRANSITION – CT–TL2

SHEET XX OF XX SHEETS BRIDGE NO. X–XX–XXX (XXX)

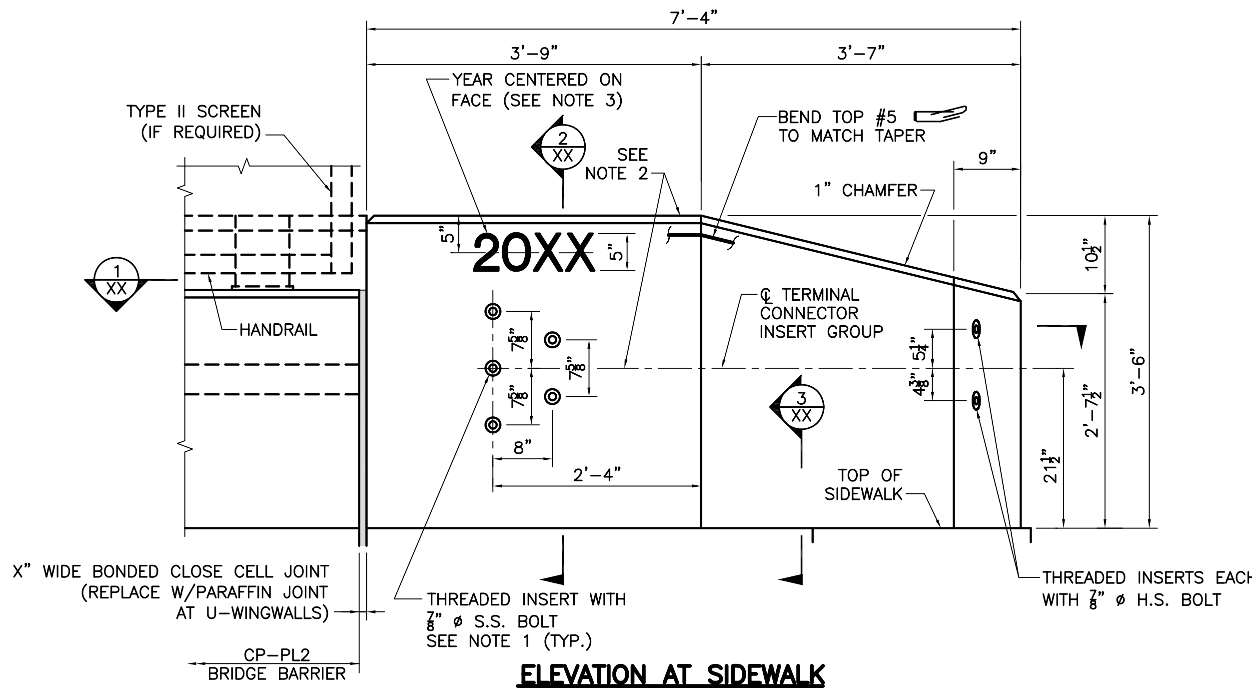
Date: August 7, 2007

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



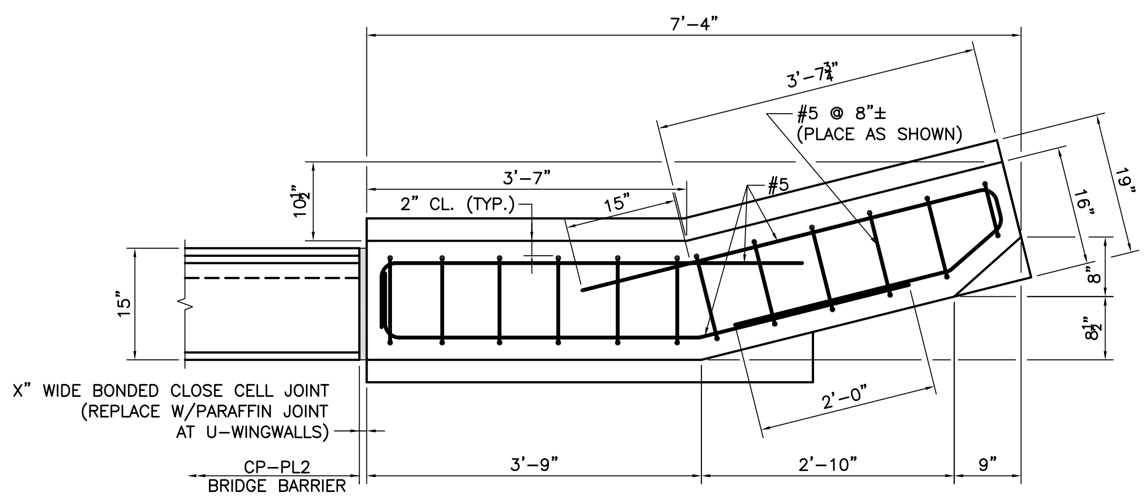
PLAN AT SAFETY CURB

SCALE: 1" = 1'-0"



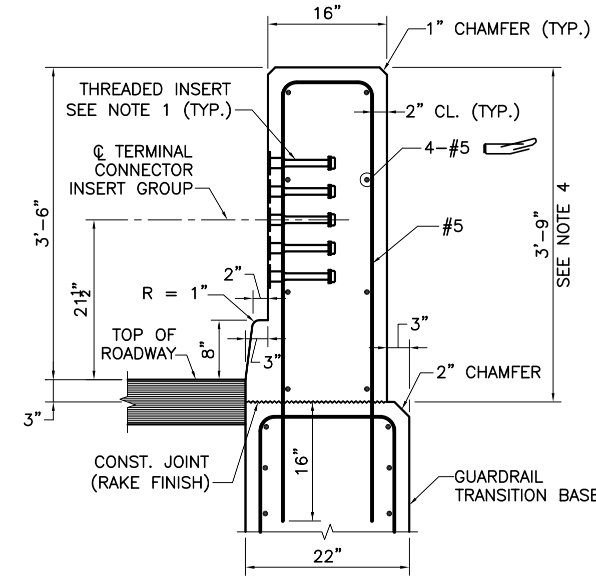
ELEVATION AT SIDEWALK

SCALE: 1" = 1'-0"



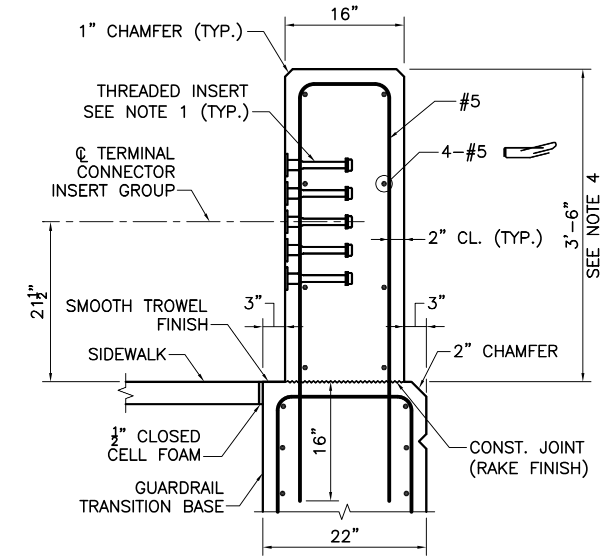
SECTION 1

SCALE: 1" = 1'-0"



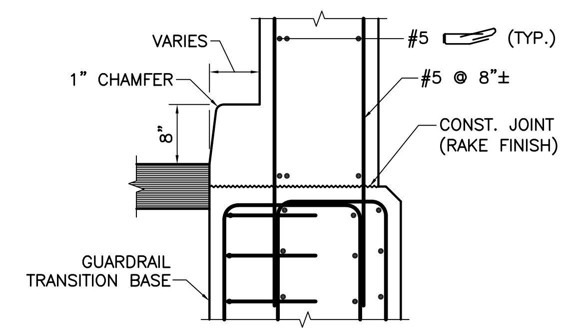
SECTION 2 AT SAFETY CURB

SCALE: 1" = 1'-0"



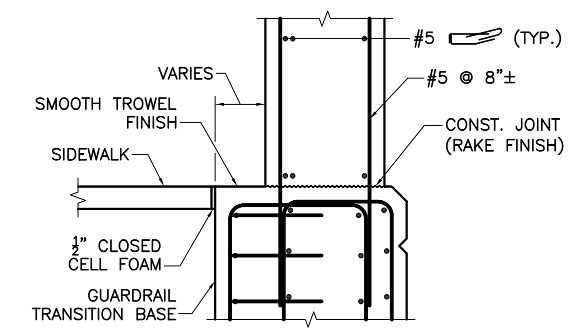
SECTION 2 AT SIDEWALK

SCALE: 1" = 1'-0"



SECTION 3 AT SAFETY CURB

SCALE: 1" = 1'-0"



SECTION 3 AT SIDEWALK

SCALE: 1" = 1'-0"

NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING AN ULTIMATE SHEAR CAPACITY OF 20 KIPS PER 7/8" ø S.S. BOLT. S.S. BOLTS SHALL BE 7/8" ø x 1 1/2" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR 7/8" S.S. BOLTS SHALL BE CAST-IN-PLACE AND GALVANIZED.
2. TOP OF GUARDRAIL TRANSITION AND TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO MATCH THE PROFILE GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, 3/4", 685 HP CEMENT CONCRETE.

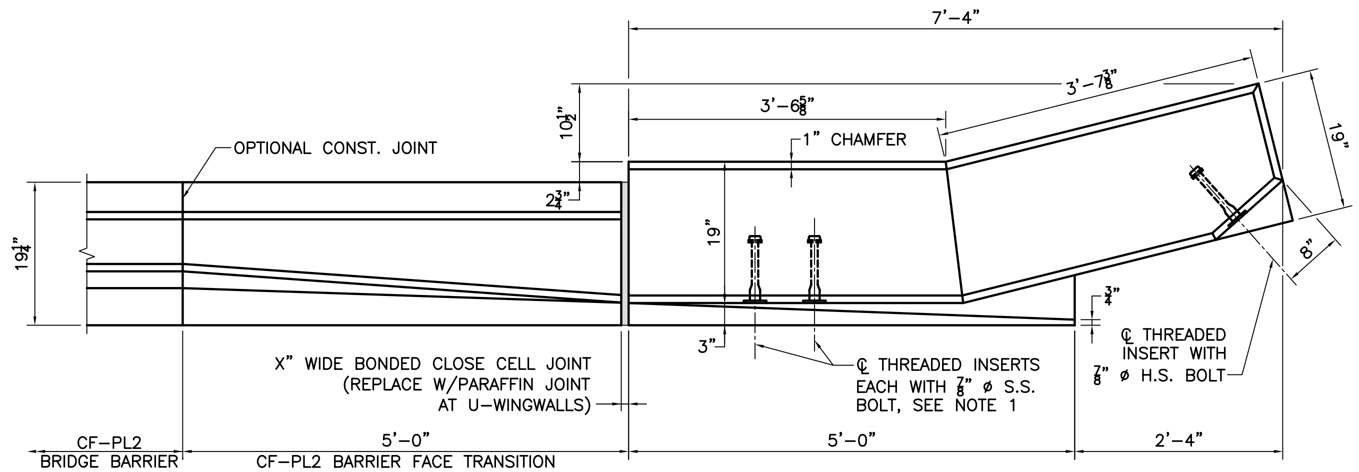
DATE	DESCRIPTION
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
USE ONLY PRINTS OF LATEST DATE	

HIGHWAY GUARDRAIL TRANSITION – CP-PL2 WITH HANDRAIL OR TYPE II SCREEN

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

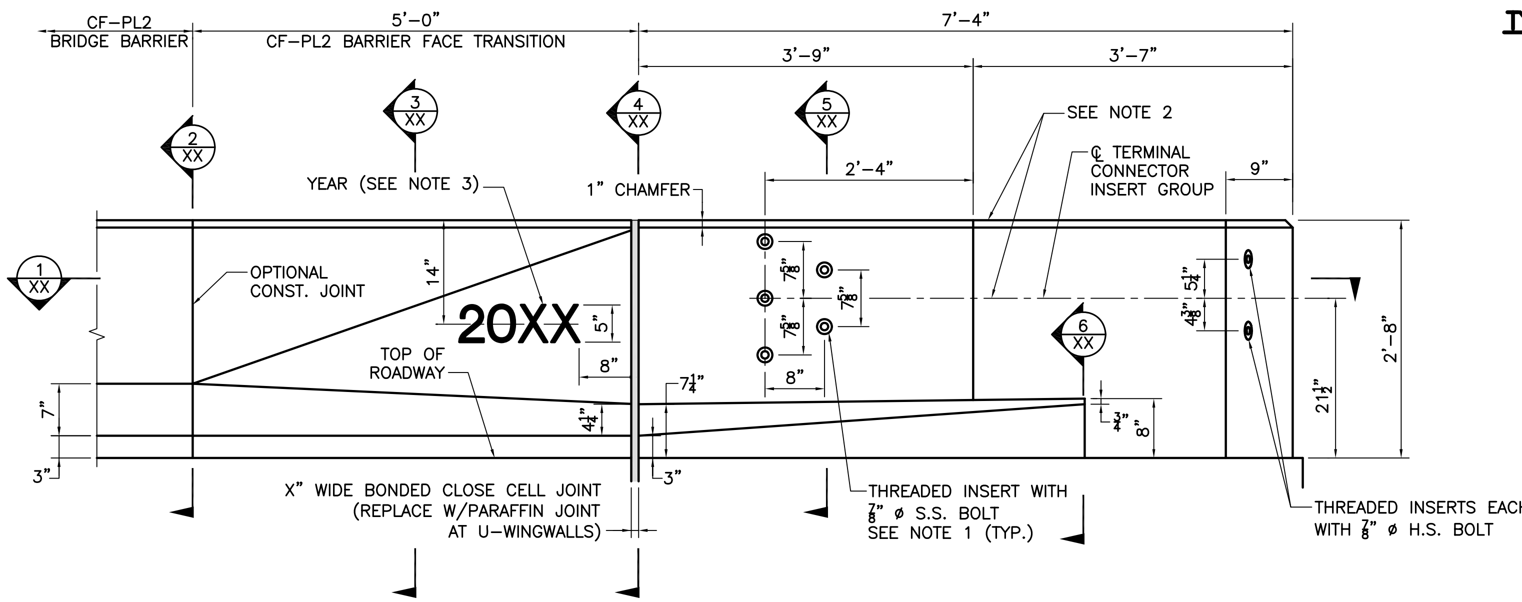
Date: August 7, 2007

STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



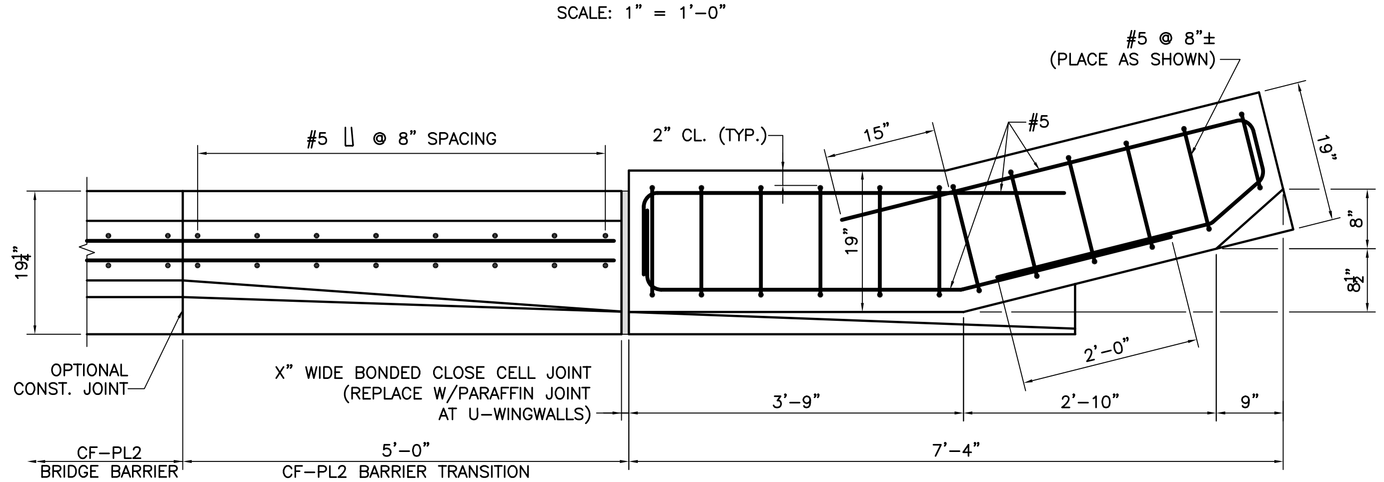
PLAN

SCALE: 1" = 1'-0"



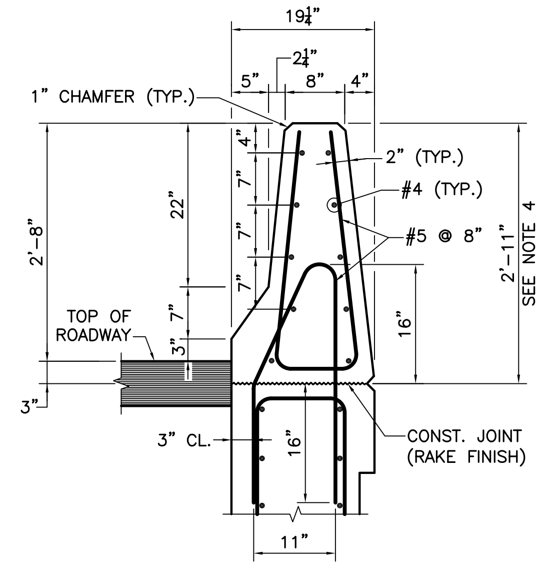
ELEVATION

SCALE: 1" = 1'-0"



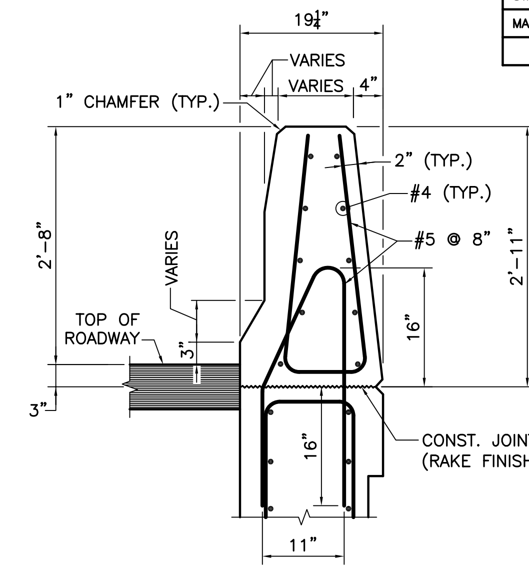
SECTION 1

SCALE: 1" = 1'-0"



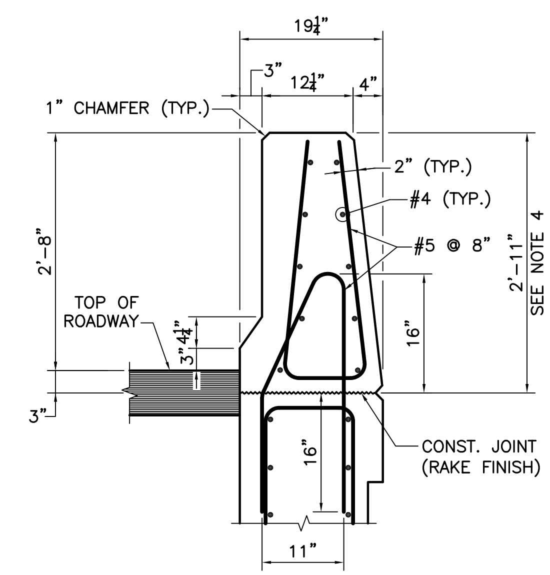
SECTION 2
TYPICAL CF-PL2 BRIDGE BARRIER

SCALE: 1" = 1'-0"



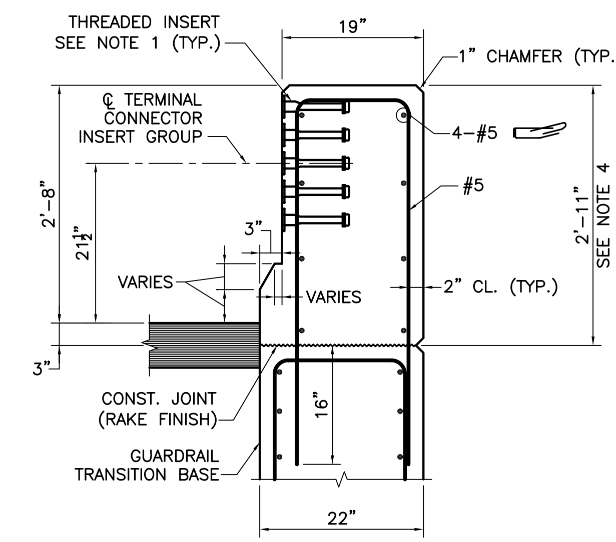
SECTION 3

SCALE: 1" = 1'-0"



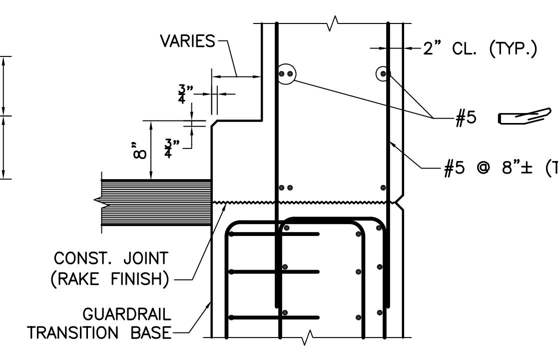
SECTION 4

SCALE: 1" = 1'-0"



SECTION 5

SCALE: 1" = 1'-0"



SECTION 6

SCALE: 1" = 1'-0"

NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING AN ULTIMATE SHEAR CAPACITY OF 20 KIPS PER ⅞" ø S.S. BOLT. S.S. BOLTS SHALL BE ⅞" ø x 1½" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR ⅞" S.S. BOLTS SHALL BE CAST-IN-PLACE AND GALVANIZED.
2. TOP OF GUARDRAIL TRANSITION AND TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO MATCH THE PROFILE GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, ¾", 685 HP CEMENT CONCRETE.

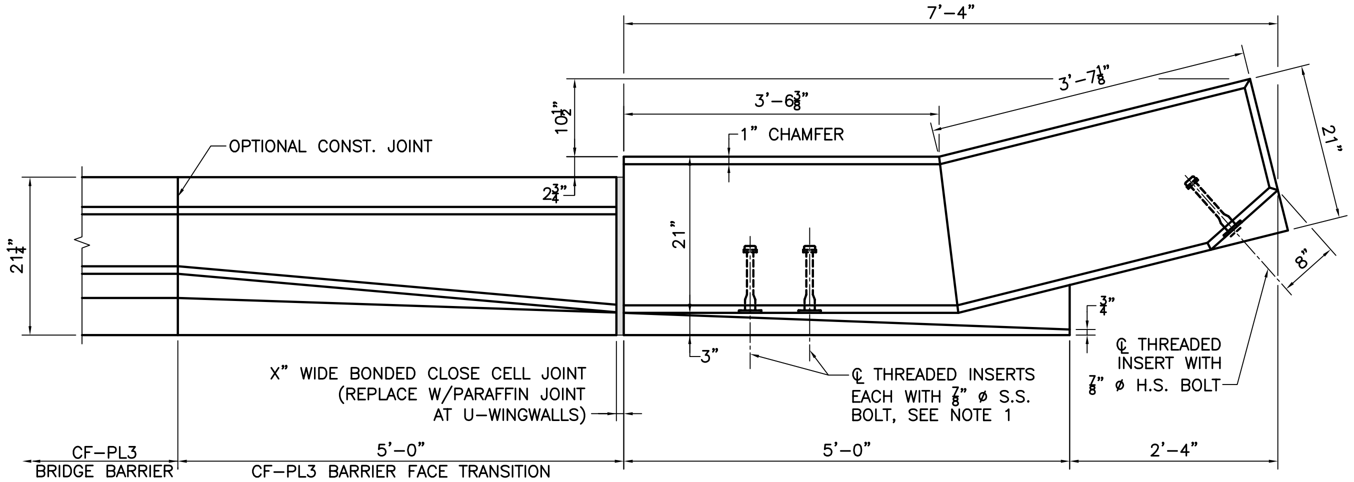
HIGHWAY GUARDRAIL TRANSITION – CF-PL2

DATE	DESCRIPTION
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION
USE ONLY PRINTS OF LATEST DATE	

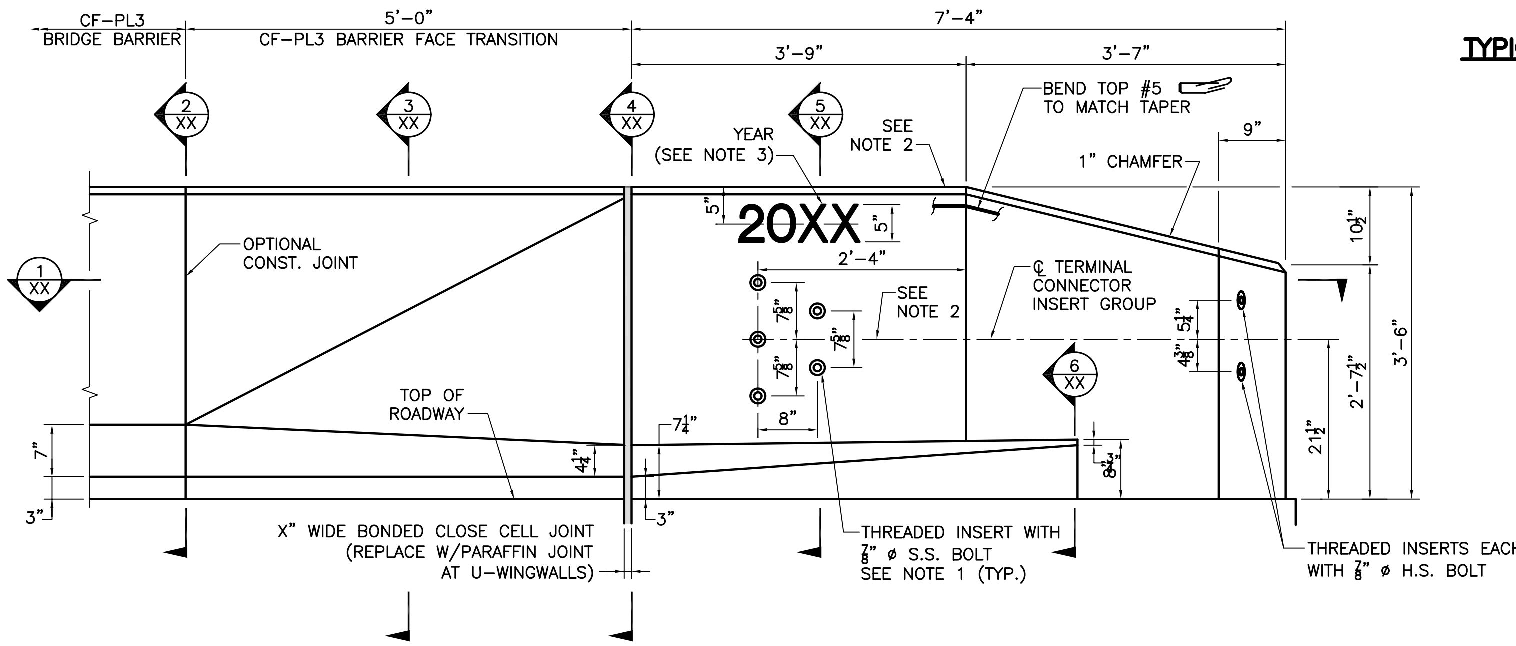
SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: August 7, 2007

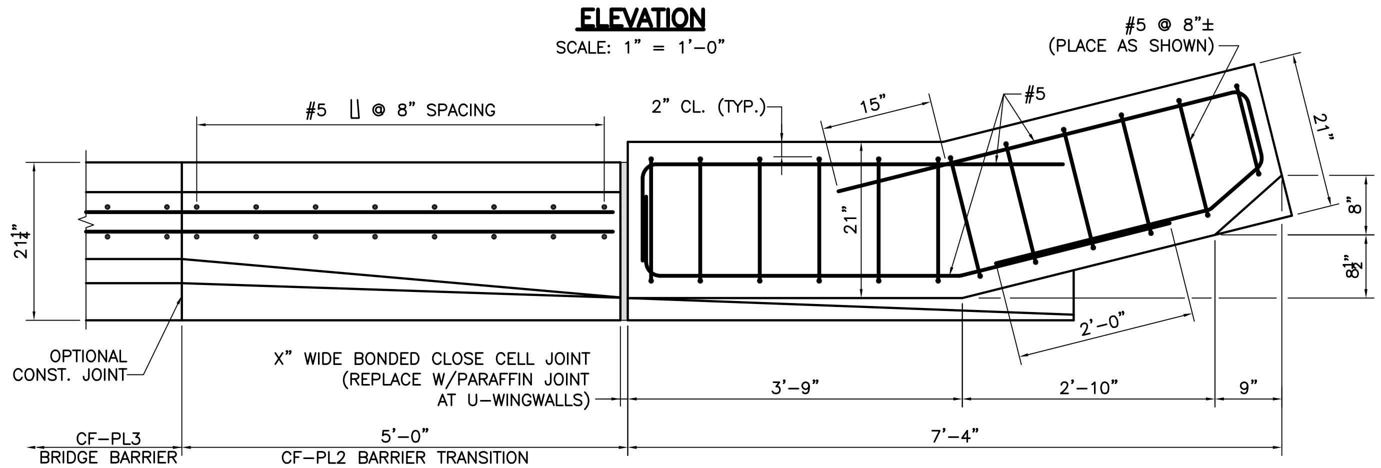
STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
MASS.	XXX-XXXX (XXX)	200X	XX	XX
PROJECT FILE NO. XXXXXX				



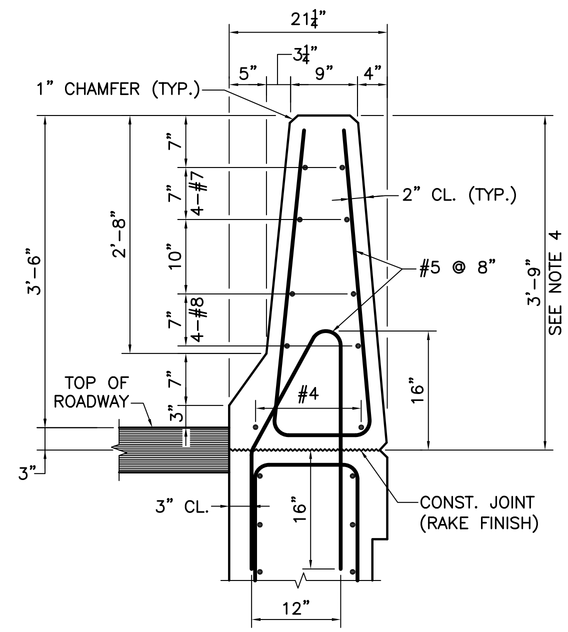
PLAN
SCALE: 1" = 1'-0"



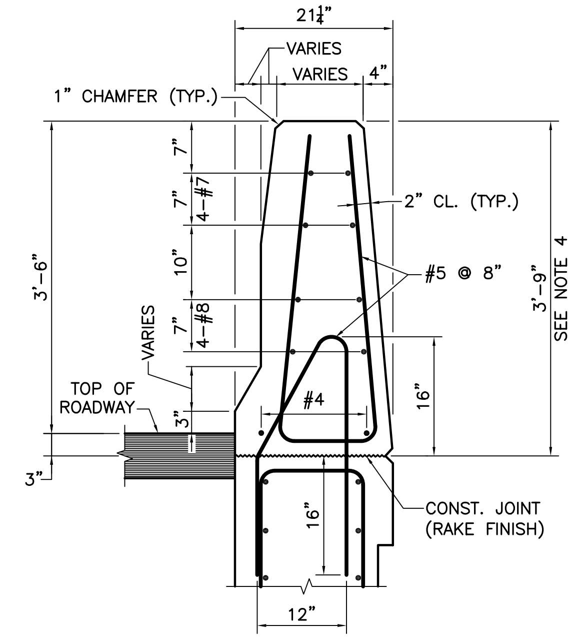
ELEVATION
SCALE: 1" = 1'-0"



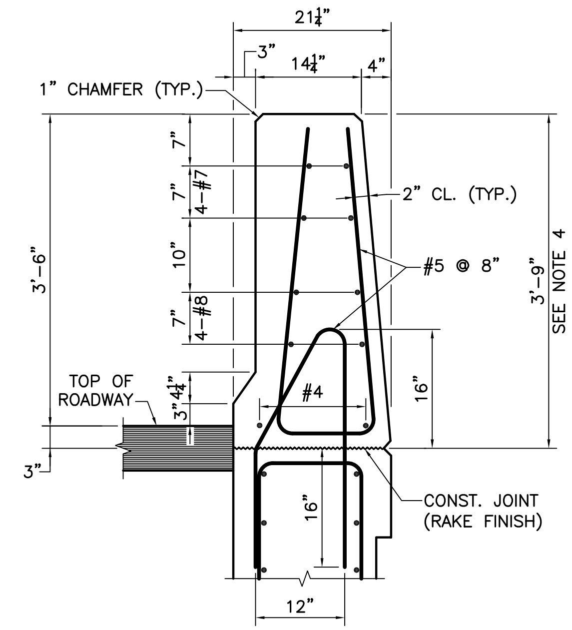
SECTION 1
SCALE: 1" = 1'-0"



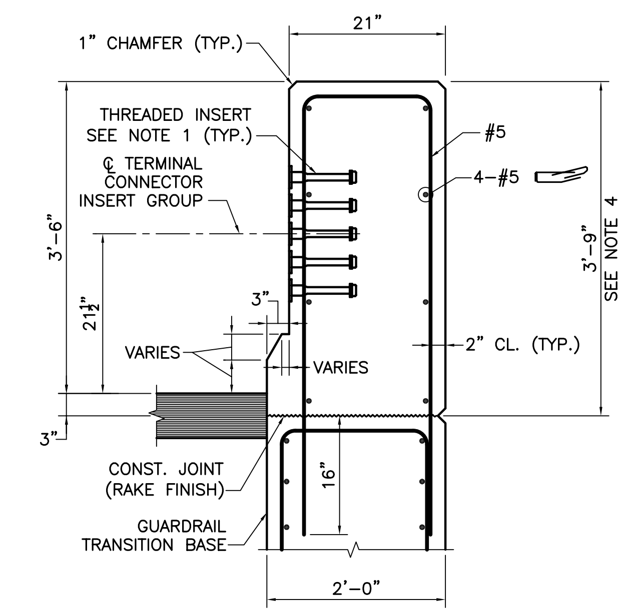
SECTION 2
TYPICAL CF-PL3 BRIDGE BARRIER
SCALE: 1" = 1'-0"



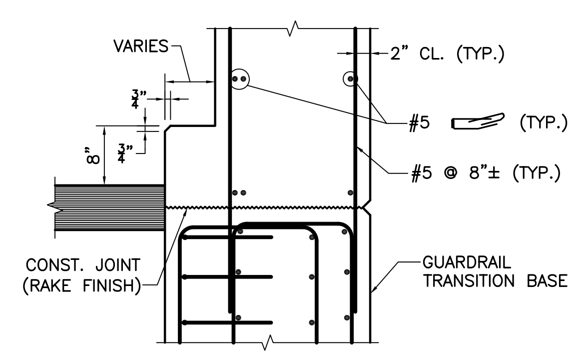
SECTION 3
SCALE: 1" = 1'-0"



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



SECTION 5
SCALE: 1" = 1'-0"



SECTION 6
SCALE: 1" = 1'-0"

NOTES:

1. THREADED INSERTS SHALL BE PREQUALIFIED BY THE MANUFACTURER AS BEING CAPABLE OF DEVELOPING AN ULTIMATE SHEAR CAPACITY OF 20 KIPS PER 7/8" ø S.S. BOLT. S.S. BOLTS SHALL BE 7/8" ø x 1 1/2" LONG FULLY THREADED AISI TYPE 304N STAINLESS STEEL. INSERTS FOR 7/8" S.S. BOLTS SHALL BE CAST-IN-PLACE AND GALVANIZED.
2. TOP OF GUARDRAIL TRANSITION AND TERMINAL CONNECTOR INSERT GROUP SHALL BE SLOPED TO MATCH THE PROFILE GRADE.
3. USE LATEST CONTRACT COMPLETION YEAR IN EFFECT WHEN THE FIRST GUARDRAIL TRANSITION IS CAST. USE THIS YEAR FOR ALL GUARDRAIL TRANSITIONS.
4. ALL CONCRETE FOR THE HIGHWAY GUARDRAIL TRANSITION SHALL BE 5000 PSI, 3/4", 685 HP CEMENT CONCRETE.

HIGHWAY GUARDRAIL TRANSITION – CF-PL3

DATE	DESCRIPTION
MONTH DD, YYYY	ISSUED FOR CONSTRUCTION

USE ONLY PRINTS OF LATEST DATE

SHEET XX OF XX SHEETS BRIDGE NO. X-XX-XXX (XXX)

Date: August 7, 2007