

The seal of the State of Connecticut Department of Transportation is a circular emblem. It features a central shield with a landscape scene, including a bridge and a body of water. The shield is surrounded by a circular border containing the text "CONNECTICUT DEPARTMENT OF TRANSPORTATION".

BRIDGE DESIGN MANUAL

2003 Edition
(U.S. Customary Units)

State of Connecticut
Department of Transportation

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PREFACE

The Connecticut Department of Transportation *Bridge Design Manual* has the following Divisions and Sections:

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INTRODUCTION

This *Manual* was prepared for the guidance of engineers in the Department and for Consulting Engineering firms designing bridges and highway related structures in the State of Connecticut.

This *Manual*, supplemented by other Department manuals, Bridge Design Standard Practices and Policy Statements, is the vehicle by which the design and rehabilitation of bridges and highway related structures is implemented. Presented is a compilation of design, detail and plan presentation practices, specification interpretations and guidelines which constitute the standard practices of the Department.

The design practices in this *Manual* have been established primarily for application to short and medium span bridges and other highway related structures using conventional construction methods. These practices are subject to re-examination and may not, in some cases, be applicable to long spans, major river crossings or multi-level interchange complexes. For design requirements not described in this *Manual*, the designer should refer to the AASHTO *Standard Specifications and Guide Specifications*.

While this *Manual* attempts to unify and clarify standard practices for design, it does not preclude justifiable exceptions, subject to the approval of the Department, provided the exceptions are based on sound engineering principles. Good design practice will always require a combination of basic engineering principles, experience and judgment in order to furnish the best possible design within reasonable economic limitations.

To reflect changes to standard practices, revisions to this *Manual* will be issued periodically. Recommendations for changes to this *Manual* are welcome, and should be submitted in writing to the Department via the Transportation Engineering Administrator. This *Manual* as well as other information regarding the Department can be accessed via the Internet at the Department's Home Page located at <http://www.state.ct.us/dot>.

Additional printed copies of this *Manual* may be purchased in person from:

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DIVISION I

STANDARD DESIGN PRACTICES
AND
PROCEDURES

Section 1
GENERAL DESIGN REQUIREMENTS

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Section 1
GENERAL DESIGN REQUIREMENTS

1.1 DESIGN SPECIFICATIONS

The design and details of all structures and structure components shall conform to the requirements set forth in the latest editions, including the interim or updated specifications, of the following publications, as modified and amended by this and other Department manuals and publications:

1.1.1 State of Connecticut, Department of Transportation:

- *Standard Specifications for Roads, Bridges and Incidental Construction, Form* (latest)
- *Highway Design Manual*
- *Drainage Manual*
- *Soils and Foundations Guide for Design for Consultant Engineers*
- *Recurring Special Provisions*

1.1.2 American Association of State Highway and Transportation Officials (AASHTO):

- *Standard Specifications for Highway Bridges*
- *Standard Specifications for Movable Highway Bridges*
- *Manual for Maintenance Inspection of Bridges*
- *Manual for Condition Evaluation of Bridges*
- *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*
- *LRFD Bridge Design Specifications*
- *A Policy on Design Standards - Interstate System*
- *Guide Specifications for Horizontally Curved Steel Girder Highway Bridges*
- *Guide Specifications for Design and Construction of Segmental Concrete Bridges*
- *Guide Specifications for Seismic Isolation Design*
- *Guide Specifications for Fatigue Design of Steel Bridges*

- *Guide Specifications for Fatigue Evaluation of Existing Steel Bridges*
- *Guide Specifications and Commentary for Vessel Collision Design of Highway Bridges*
- *Guide Specifications for the Design of Stress-Laminated Wood Decks*
- *Guide Specifications for Distribution of Loads for Highway Bridges*
- *Guide Specifications for Bridge Railings*
- *A Guide to Standardized Highway Barrier Hardware*
- *Guide Specifications for Structural Design of Sound Barriers*
- *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*
- *Guide Design Specification for Bridge Temporary Works*

1.1.3 American Railroad Engineering and Maintenance-of-Way Association (AREMA):

- *Manual for Railway Engineering*

1.1.4 American Welding Society (AWS):

- *Bridge Welding Code* ANSI/AASHTO/AWS D1.5
- *Structural Steel Welding Code* ANSI/AWS D1.1
- *Structural Welding Code - Aluminum* ANSI/AWS D1.2
- *Structural Welding Code - Reinforcing Steel* ANSI/AWS D1.4
- *Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and Their Alloys and Composites* ANSI/AWS C2.18

1.1.5 American Society for Testing and Materials (ASTM):

- Annual Book of ASTM Standards

1.1.6 Federal Highway Administration (FHWA):

- FHWA Technical Advisory T5140.32, Uncoated Weathering Steel in Structures, dated October 3, 1989

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- FHWA-RD-94-052, Seismic Retrofitting Manual for Highway Bridges, dated May 1995
- FHWA-IP-87-6, Seismic Design and Retrofit Manual for Highway Bridges, dated May 1987
- FHWA-IP-89-016, Design of Riprap Revetments, Hydraulic Engineering Circular No. 11 (HEC-11), March 1989
- FHWA-NHI-01-002, Stream Stability at Highway Structures, Hydraulic Engineering Circular No. 20 (HEC-20), 2001
- FHWA-NHI-01-001, Evaluating Scour at Bridges, Hydraulic Engineering Circular No. 18 (HEC-18), 2001
- FHWA-SA-92-010, Bridge Deck Drainage System, Hydraulic Engineering Circular No. 21 (HEC-21), May 1993

1.1.7 Prestressed Concrete Institute (PCI):

- Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products MNL-116

1.1.8 Steel Structures Painting Council (SSPC):

- Steel Structures Painting Manual, Vol. 1, Good Painting Practice
- Steel Structures Painting Manual, Vol. 2, Systems and Specifications

1.1.9 Abbreviated References

The following is a list of abbreviated references used in this *Manual* for the preceding design specifications:

<u>Design Specification</u>	<u>Abbreviated Reference</u>
<i>Standard Specifications for Roads, Bridges and Incidental Construction</i>	<i>Standard Specifications</i>
<i>Standard Specifications for Highway Bridges.....</i>	<i>AASHTO Specifications</i>
<i>AASHTO LRFD Bridge Design Specifications</i>	<i>AASHTO LRFD Specifications</i>
<i>Manual for Railway Engineering.....</i>	<i>AREMA Specifications</i>

1.2 DESIGN FEATURES

1.2.1 General Features of Design

1.2.1.1 Width

Generally, the curb to curb width of highway bridges shall match the approach roadway (including shoulders). For highway bridges with off or on ramps, the curb to curb width shall match the geometry required for the roadway. Greater bridge widths may be necessary to meet sight distance requirements, to facilitate the maintenance of traffic and stage construction requirements or to accommodate standard width structural members.

Per Section 13a-86 of the *Connecticut General Statutes*, any bridge constructed or reconstructed on a State maintained highway with two or more lanes shall have a clear width of roadway of not less than 28'-0", exclusive of the width of any sidewalk, unless in the judgment of the Commissioner a lesser width is warranted.

1.2.1.2 Sidewalks

Sidewalks shall be provided on bridges in accordance with Policy Statement HWYS-19. The minimum sidewalk width shall be 5'-0". Sidewalk widths may be increased in areas of heavy pedestrian traffic, on designated bike routes, or at locations requiring additional sight distance.

Sidewalks should be carried across a bridge if the approach roadway has sidewalks or sidewalk areas. Elsewhere, one or two sidewalks may be provided as warranted by current developments, anticipated area growth, traffic or pedestrian studies, etc.

Sidewalk curb heights on structures shall match the exposed height of the approach curbing. Where curbs are not provided on the approaches, the exposed curb height on the structure shall be six inches.

Generally, the curb-to-curb width of pedestrian bridges shall match the approach pathway width.

1.2.1.3 Cross Section

Generally, deck cross slopes in both the travel lanes and the shoulders of highway bridges shall conform to the roadway cross slopes found in the Department's *Highway Design Manual*. Mechanical screeds, used when placing cast-in-place concrete decks, can accommodate multiple cross slope breaks. On bridges with precast components, such as precast adjacent box beams, the bituminous concrete overlay may be placed to match the approach roadway cross section.

1.2.1.4 *Profile*

The profile for highway bridges shall match the approach roadway. Preferably, the profile grade of all bridges shall provide for longitudinal surface drainage.

1.2.1.5 *Clearances*

1.2.1.5.1 Structures Adjacent to or Crossing over Roadways

The minimum horizontal and vertical clearance for any structure adjacent to or crossing over a roadway shall conform to the Department's *Highway Design Manual*. The provisions of the "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges" should be considered when the clearances specified in the Highway Design Manual cannot be achieved, and a Design Exception is required to allow a lesser clearance.

The lowest portion of a structure mounted sign support shall be a minimum of twelve inches above the lowest component of the fascia member of the bridge to which it is attached.

1.2.1.5.2 Structures Crossing over a Waterways

Navigational clearances, both horizontal and vertical, shall conform to the requirements of the U.S. Coast Guard. Permits for construction of a bridge over navigable waterways shall be obtained from the U.S. Coast Guard and/or other agencies having jurisdiction.

The waterway opening shall be consistent with the hydraulic characteristics of the waterway. For additional information, see Article 1.4.

1.2.1.5.3 Structures Adjacent to or Crossing over Railroads

The minimum horizontal clearance for any structure adjacent to or crossing over a railroad shall conform to the AREMA specifications. The horizontal clearance for any structure adjacent to or crossing over a railroad shall be in accordance with standards established and used by the affected railroad in its normal practice. The determination of the horizontal clearance shall also consider the economics and constructability of the structure, influence of railroad loads on the structure, site conditions, drainage and utility requirements, railroad access and future track expansion.

The minimum vertical clearance for any structure crossing over railroad tracks is limited by Section 13b-251 of the *Connecticut General Statutes*. The minimum vertical clearance for any structure crossing over railroad tracks shall be 20'-6" (measured from the top of the rail to the bottom of the structure). The minimum vertical clearance for any structure crossing over railroad tracks on which trains

are operated by means of overhead electrical wires (electrified tracks) shall be 22'-6" (measured from the top of the rail to the bottom of the structure). If the construction work includes only deck replacement (the removal and replacement of the bridge deck and supporting members) or minor widening of the structure, and the existing piers or abutments remain in place, the minimum vertical clearance shall be the structure's existing overhead clearance or 18'-6", whichever is greater.

1.2.1.5.4 Through-Truss Highway Bridges

The minimum vertical clearance from the roadway to the overhead cross bracing of a through-truss highway bridge should not be less than 17'-6".

1.2.1.5.5 Railway Bridges

Railway bridge clearances, both horizontal and vertical, shall conform to the AREMA specifications.

1.3 TRANSPORTATION OF STRUCTURAL MEMBERS AND COMPONENTS

1.3.1 Background

In general, the length, width, height and weight of a prefabricated structural member or component for use in a highway, pedestrian or railway structure is limited by the ability to ship the item over State highways and bridges.

These physical properties are indirectly limited by the vehicle regulations in the *Connecticut General Statutes*. The *General Statutes* include the following limitations on the dimensions of vehicles using State highways without the need for a permit:

- Vehicle Width (Section 14-262(a)(1)) - The width of a vehicle and combination vehicle and trailer, including its load, is limited to 8'-6", without a permit.
- Vehicle Length (Section 14-262(c)) - The length of the semi-trailer portion of a tractor-trailer unit, including its load, is limited to 48 feet, without a permit.
- Vehicle Height (Section 14-264) - The height of a vehicle, with its load, is limited to 13'-6", without a permit.
- Vehicle Weight (Section 14-267a(b)(7)) - The gross vehicle weight (weight of vehicle including its load) is limited to 80,000 pounds, on vehicles with a 51 feet wheelbase, without a permit.
- Axle Weights of Vehicles (Section 14-267a) - The axle weights of vehicles vary and are determined by vehicle type and axle spacing.

Section 14-270 of the *General Statutes* assigns authority to the Commissioner of Transportation to grant permits for vehicles exceeding the limits of the vehicular regulations.

To facilitate construction of the Department's projects, Policy Statement PT-14 was developed. It states that the Department will grant a permit for the transportation of "any structural beam (member or component) that measures 120 feet or less and weighs no greater than 120,000 pounds provided the individual axle weights on the vehicle and trailer transporting the beam (member or component) do not exceed 20,000 pounds." The phrase "structural beam" may be interpreted to mean any structural member or component.

1.3.2 Design Requirements

The vehicle regulations of the *General Statutes* and Policy Statement PT-14 establish design guidelines for the length, width, height and weight of prefabricated structural members and components.

To avoid problems associated with transporting materials during construction, prefabricated structural members or components that will require a permit to be transported should be identified early in the design phase.

The maximum member or component shipping length, width, height and weight shall be shown on the General Plan. For the Structure Layout for Design (SL/D) submission, the best available information should be shown on the plan. The actual, as designed, shipping lengths, widths, heights and weights should be shown on the Final Plans for Review. For additional information, see DIVISION II.

The shipping information will be reviewed by the Oversize and Overweight Permits Section, which will determine if the members are transportable.

If a member exceeds the length and weight limits of Policy Statement PT-14, the designer must submit adequate justification with the SL/D submission. If sufficient justification exists, the Office of Engineering will request a waiver of PT-14 and confirmation that a permit will be granted to transport the member in accordance with Section 14-270 of the *General Statutes* from the Oversize and Overweight Permits Section.

If a member when transported will exceed the height and width limits of the *General Statutes*, the designer must submit adequate justification with the SL/D submission. If sufficient justification exists, the Office of Engineering will request confirmation that a permit will be granted to transport the member in accordance with Section 14-270 of the *General Statutes* from the Oversize and Overweight Permits Section.

The special provision entitled “Section 1.06 - Control of Materials” should be included in all projects. This special provision addresses the shipping of materials in accordance with the *Connecticut General Statutes* and the Department’s Policy Statement PT-14.

If a member exceeds the height and width limits of the *General Statutes* or the length and weight limits of PT-14, and the Oversize and Overweight Permits Section confirms that a permit will be granted in accordance with Section 14-270 of the *General Statutes* to transport the member, the project’s contract documents should indicate that the Department will grant a permit to transport the oversized item.

1.4 BRIDGE INSPECTION AND EVALUATION REQUIREMENTS

1.4.1 Inspection Access

Per a recommendation in Administration Memorandum No. 80, all bridges shall include features, both off and on the structure, that will make them accessible to bridge inspectors and facilitate the future inspection of the structure. These features may include a shelf at the face of the abutment stem, ladder stops on slopes, catwalks, ladders, access doors (in bottom flanges and the ends of box girders), hand rails and cables, lighting and electrical outlets, and any other facility necessary for the inspection of the structure. The features may also include the design and placement of structural members and components (such as generous bridge seats for box girder structures, internal cross frames and bracing in box girders) that allow access for bridge inspectors.

For bridges that are excessively wide, where normal inspection equipment cannot access the interior members, the bridge may require permanent movable inspection platforms or permanent catwalks. The need for and type of permanent inspection platforms shall be determined by the Bridge Safety and Evaluation Unit.

1.4.2 Notice to Bridge Inspectors

As a result of a recommendation in Administration Memorandum No. 80, the Designer shall note on the General Plan any members and components needing special attention, such as fracture critical members, during the inspection of the structure. This information shall be contained in the “Notice To Bridge Inspectors” block.

The “Notice To Bridge Inspectors” block shall be shown on the Structure Layout for Design (SL/D) Plans and fully completed on the Final Plans for Review.

1.4.3 Inspection Manuals

For movable bridges, segmental bridges and other bridges as directed by the Department, the Designer shall provide an inspection manual. The manual should contain the instructions, procedures, check lists, diagrams and details necessary to

perform a complete in-depth inspection of the various members and components of the bridge.

Inspection manuals shall be submitted with the Final Plans for Review.

A note indicating that an inspection manual is available for a bridge should be placed in the "Notice to Bridge Inspectors" block on the General Plan.

1.4.4 Inventory and Operating Load Ratings

Inventory and operating load ratings shall be determined for all new and rehabilitated bridges carrying vehicular traffic. For the requirements noted below, rehabilitated structures that include a superstructure replacement shall be considered to be 'new' structures. These rating shall conform to the following:

- Load ratings shall be performed using the "Load Factor Method" as set forth in Chapter 7 of the Department's Bridge Inspection Manual, as revised.
- Load ratings shall be performed using the following approved "Load Rating Software."
 - PENNDOT's Bar7, PS3 and Box5
 - STAADPro
 - Mathcad
- Load ratings are required for the following load cases for all structures:
 - Inventory Rating for the AASHTO HS20 Design Vehicle.
 - Operating Rating for the AASHTO HS20 Design Vehicle.
 - Operating Rating for the Department's Operating Vehicles (P204 & P380).
 - The P204 truck weighs 204,000 pounds and is on eight axles. (see Plate 1.1.1) The rating factor for rehabilitated bridges may be less than 1.0, but must be provided regardless of its value.
 - The P380 truck weighs 380,000 pounds and is on nineteen axles. (see Plate 1.1.2) The rating factor for new structures must be equal to or greater than 1.0. The rating factor for rehabilitated bridges may be less than 1.0, but must be provided regardless of its value.

The following components shall be rated for load carrying capacity:

1. All types of main superstructure components, such as stringers, floor beams, box girders, adjacent box beams, etc.

2. Piers (caps and columns) that have only one or two columns and all steel and timber substructure components.
3. Timber and steel decks. Concrete decks shall not be rated.

When there are a large number of components that make up a structure, the components should be compared and the weaker or controlling components selected and analyzed. A minimum of two of each type of component should be analyzed, one of which represents the capacity of the low speed lanes.

The inventory and operating load rating analysis and a summary of the results shall be submitted with the final documents for review.

1.5 ANALYSIS AND DESIGN METHODS

1.5.1 General

The analysis and design of members and components for highway, pedestrian and railway structures shall conform to Articles 1.5.2 through 1.5.3. Designers may use analysis and design methods that differ from those described with the prior approval of the Department. The analysis and design of structure not described shall be as directed by the Department.

1.5.2 Highway and Pedestrian Structures

1.5.2.1 Structural Steel

Except as noted in Article 1.5.2.4 for load combinations containing seismic loads, all structural steel members and components shall be designed using one of the following methods as directed by the Department:

- Load and Resistance Factor Design Method (LRFD) as described in the AASHTO *LRFD Bridge Design Specifications*.
- Service Load Design Method (Allowable Stress Design) described in the AASHTO *Standard Specifications for Highway Bridges*.

1.5.2.2 Reinforced Concrete

Cast-in-place reinforced concrete decks shall be designed using one of the following methods as directed by the Department:

- The Empirical Design Method described in the AASHTO *LRFD Bridge Design Specifications*.

- Strength Design Method (Load Factor) described in the AASHTO *Standard Specifications for Highway Bridges*.

Precast concrete box culverts shall be designed using one of the following methods as directed by the Department:

- Load and Resistance Factor Design Method (LRFD) as described in the AASHTO *LRFD Bridge Design Specifications*.
- Strength Design Method (Load Factor) described in the AASHTO *Standard Specifications for Highway Bridges*.

Except as noted in Article 1.5.2.4 for load combinations containing seismic loads, all other reinforced concrete members and components shall be designed using one of the following methods as directed by the Department:

- Load and Resistance Factor Design Method (LRFD) as described in the AASHTO *LRFD Bridge Design Specifications*.
- Service Load Design Method (Allowable Stress Design) described in the AASHTO *Standard Specifications for Highway Bridges*.

1.5.2.3 Prestressed Concrete

All prestressed concrete members and components shall be designed using one of the following methods as directed by the Department:

- Load and Resistance Factor Design Method (LRFD) as described in the AASHTO *LRFD Bridge Design Specifications*.
- Based on strength using the Strength Design Method (Load Factor Design) and on behavior at service conditions using Service Load Design Method (Allowable Stress Design) critical during its life from the time prestressing is first applied as described in the AASHTO *Standard Specifications for Highway Bridges*.

1.5.2.4 Seismic Analysis

The analysis and design of all members and components for load combinations containing seismic loads shall be performed using one of the following methods as directed by the Department:

- The Load and Resistance Factor Design Method described in the AASHTO *LRFD Bridge Design Specifications*.
- Strength Design Method (Load Factor) described in the AASHTO *Standard Specifications for Highway Bridges*.

1.5.3 Railway Structures

The analysis and design of members and components for railway structure shall be in accordance with the AREMA Specifications.

1.6 COMPUTATIONS

1.6.1 General

All computations, either prepared by hand or performed by computer, shall be on letter size sheets. For hand computations, each sheet shall have a heading with the following information:

- designer's name or company,
- the subject (computation for),
- State project number,
- designer's (preparer's) initials and date prepared,
- checker's initials and date checked, and
- sheet number.

The headings of all computation sheets shall be filled in and complete.

The use of computers and computer software applications as a tool in the performance of design computations is acceptable. The designer is fully responsible for all his computations performed either by hand or by computer software applications.

For hand computations, the sources of all equations, values, constants, "magic" numbers, charts, graphs and other supporting data used in the design shall be referenced on each and every computation sheet that its use appears on.

When computer output is included in the design computations, it shall be self-explanatory. If the output is not self-explanatory, an explanation or documentation of the output must be included in the computations and be referenced on all output sheets.

All design, quantity and load rating computations shall be bound separately for individual bridges or structures and include a cover, title sheet, and an index.

All computations shall be submitted with the Final Plans for Review.

1.6.2 Quantity Computations

1.6.2.1 General

Once the plans are essentially complete, individual quantity computations shall be made for all items shown on the plans. The computations shall be complete and

accurate and arranged in an orderly fashion so that a person examining them will be able to follow the calculation sequence. All items shall be clearly labeled. Sketches may be used for clarity. All quantity computations shall be made entirely with US Customary units.

Quantity computations shall be prepared in accordance with the “Method of Measurement” and the “Basis of Payment” of the specification that describes the work. The result of a computation shall be a whole number value. The units of the value computed must agree with the “Basis of Payment.” Care shall be used in rounding values. Unassigned amounts shall not be added arbitrarily to any quantity computations.

Quantity computations shall be furnished to the District Construction Office having jurisdiction over the work for use during construction.

1.6.2.2 Lump Sum Items

If a lump sum item will be specified more than once in a project or contract (such as “Structural Steel” for two separate bridges), the item names should include “site numbers” in their description (such as “Structural Steel (Site No.)”). The use of site numbers with lump sum items accurately defines the limits of work for those items in a project or contract. The site numbers shall be clearly designated on the plans and in the specifications.

Unless otherwise directed by the Department, individual quantity computations shall be performed for the following lump sum items to obtain values with the listed units:

<u>Item</u>	<u>Units</u>
Structural Steel	Weight of Structural Steel (lb)
Shear Connectors	Estimated total number (each)
Abrasive Blast Cleaning and Field	Weight of Structural Steel & Surface
Painting of Structure	Area to be Painted (lb & ft ²)

Note: The quantities are used for cost estimating purposes.

1.6.2.3 Contingency Items and Token Quantities

Contingency items are items that are likely, but not certain, to be required for the construction work. Contingency items should not be included in the bid package. In the past, these items have been used to “establish a bid price” for an item which may or may not be required for the construction work. At times, the Department has received extremely high bid prices for these low quantity items, and when there is an increase in the quantity, it becomes very expensive for the Department. The

Office of Construction prefers to negotiate prices when it becomes necessary to add items to a contract. If the need for an item is definite, but the quantities are unsure, a quantity should be given that is large enough to attract a reasonable bid price. "Token quantities" should not be given.

Section 2
DESIGN SUBMISSIONS & CONTRACT DOCUMENTS

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Section 2
DESIGN SUBMISSIONS AND CONTRACT DOCUMENTS

2.1 DESIGN REVIEW SUBMISSIONS

2.1.1 General

The following list outlines the design process and describes the submissions required for the design of bridges, box culverts and retaining walls. It should not be regarded as fully complete. The following items, where applicable, should be submitted in the order listed to the Department for review and approval:

1. Environmental Review of the site,
2. Hydrologic Study,*
3. Preliminary Hydraulic Study (including any temporary facility as required),*
4. Scour Analysis (draft / final),*
5. Structure Type Studies or Rehabilitation Study Report,
6. Railroad Clearance Diagram,
7. Structure Layout for Design (SL/D) plans and Soils & Foundation Report,
8. Final Hydraulic Study,*
9. Final Plans for Review,
10. Incorporation of Review Comments, and
11. Final Submission.

* for structures crossing a waterway

2.1.2 Hydrologic Study

Prior to the start of the structure design and prior to the start of a Hydraulic Study to determine the waterway opening, the design discharge shall be calculated and submitted for approval. All pertinent "backup" data shall be submitted to facilitate the review process. This work shall conform to the latest edition of the Department's *Drainage Manual*.

2.1.3 Preliminary Hydraulic Study

A Hydraulic Study is required if the structure requires work within the floodplain of a watercourse or stream with a watershed area exceeding one square mile. All work within the floodplain must meet the requirements of Sections 13a-94, 22a-344 and 25-68b through 25-68h of the *Connecticut General Statutes* along with the Department's *Drainage Manual*. If a floodway is established, every effort should be made to avoid encroachment into it. Note, certain activities, such as the construction of bridge piers within the floodway may be acceptable provided there is no increase in the "with floodway" watersurface profile for the base flood or the ten year flood. Prior

to the preparation of a Structure Type Study, a preliminary Hydraulic Study must be prepared and submitted for review and approval. If Stream Channel Encroachment Lines are established, they should be shown on the plans.

2.1.4 Scour Analysis

The potential for scour at bridges over waterways must be evaluated and submitted to the Department for review and approval. For this purpose, the FHWA document entitled "Evaluating Scour at Bridges" (HEC-18) or successor documents shall be used. Substructures for bridges over waterways shall be designed to safely support the structure subjected to the design scour. Substructures, subjected to scour shall be designed with pile foundations, foundations on rock, foundations located below the maximum estimated scour depth, or any other means approved by the Department, provided adequate scour protection is maintained. The preferred foundation types are pile foundations and foundations on rock.

2.1.5 Structure Type Studies

Structure Type Studies shall be prepared for each new highway, pedestrian and railway crossing. The studies should consider the safety, serviceability, maintainability, constructibility, permit requirements, economics and aesthetics of the proposed structures. The studies shall be developed after careful appraisal of the site conditions, foundation conditions, hydraulic and drainage conditions, design discharge and scour potential, coordination with DEP fisheries, rights of way, utilities, and highway limitations (including maintenance and protection of traffic and environmental impacts) both present and future. Additional studies may be requested if the Department finds the original proposals unsuitable or inadequate.

Multiple studies done just for quantity are not desired but only those studies that show promise or feasibility within the parameters herein should be pursued. For a group of bridges in a contract, structure type should be similar so that similarity of construction details may result in economy of costs. Repetition of a structure type merely for ease of design is to be avoided. Attention to detail in the appearance of the structure is to be kept foremost in mind. New materials and developments may be incorporated into the design of the proposed structure with the prior approval of the Department.

Where the structure is required to have more than one span, the resulting multi-span structure shall be designed as continuous to eliminate the need for deck joints.

The structure type studies shall incorporate or otherwise resolve all requirements and constraints from applicable studies, reports and analysis developed by groups both within and outside the Department for the crossing location.

The structure studies are to be prepared in a pamphlet form on letter size sheets. US Customary units of measurement shall be used in all studies. The sheets are to be

numbered and each structure study is to be indexed. Construction costs shall be prepared for each structure type. One complete quantity and cost estimate sheet per study or structure shall be prepared. Additional costs for contingencies, such as minor items not normally computed, shall not exceed five percent of the total cost.

The structure studies shall be submitted for review. A meeting will be held to review the structure studies and select the type of structure to be designed. Upon approval of the structure type, the designer shall be authorized to proceed with the preparation of the Structure Layout for Design (SL/D) Plans.

2.1.6 Rehabilitation Study Reports

A condition survey and rehabilitation study shall be prepared for each existing highway, pedestrian and railway crossing. The report should consider the safety, historical significance, serviceability, constructibility, economics and aesthetics of the proposed structure repairs or improvements. For structures over waterways, the report should include the necessary requirements listed in Sections 2.1.2 through 2.1.5. The report shall be developed after careful appraisal of the existing condition of the structure, the intent of the project such as roadway widening or structure repairs, and highway limitations (including maintenance and protection of traffic and environmental impacts) both present and future. Additional studies may be requested if the original proposals are found to be unsuitable or inadequate.

The structure studies are to be prepared in a pamphlet form on letter size sheets. US Customary units of measurement shall be used in all studies. The sheets are to be numbered and each structure study is to be indexed. Construction costs shall be prepared for each alternate studied. One complete quantity and cost estimate sheet per study or structure shall be prepared. Additional costs for contingencies, such as minor items not normally computed, shall not exceed five percent of the total cost.

The structure studies shall be submitted for review. A meeting will be held to review the reports and select the desired rehabilitation plan for the structure to be designed. Upon approval of the rehabilitation plan, the designer shall be authorized to proceed with the preparation of the Structure Layout for Design (SL/D) Plans.

2.1.7 Railroad Clearance Diagram

The Designer shall develop a "Railroad Clearance Diagram" and an "Approval of Railroad Clearance" form for approval by the railroad and the Department. See DIVISION II for examples of the clearance diagram and approval form.

2.1.8 Structure Layout for Design Plans

Upon approval of the structure type studies or the Rehabilitation Study Report, and following notification authorizing the start of the final design phase, the designer shall

prepare Structure Layout for Design (SL/D) Plans for all bridges, box culverts and retaining walls.

The SL/D plans should be prepared on full size sheets. US Customary units of measurement shall be used in all plans. All details shall be drawn to scale. Extraneous information not relevant to the construction of the structure should not be shown on the plans. This includes miscellaneous topographic information such as trees, shrubs, signs, utility poles and other items that are detailed on the highway plans.

The SL/D plans shall contain the following:

- a. Site Plan - A plan showing the location of the structure and approaches, topographical data including original and final contours, adjacent ramp and intersecting roadways and channels, if any, etc.
- b. General Plan - A "Structure Plan" showing baseline stationing, controlling horizontal dimensions, span lengths, skew angle and clearances for the structure and approaches.

Projected below the "Structure Plan" should be an "Elevation" view showing the proposed structure with controlling dimensions and clearances, footing elevations, foundations, pertinent water and rock elevations, etc.

A typical cross section of the structure showing lane and shoulder arrangements, sidewalks if required, bridge railings, member spacing, slab thickness, and other pertinent details. For box culverts, this cross section shall show the number and size of the cells and type of construction, precast or cast-in-place.

The "General Plan" should also include a table of "Transportation Dimension and Weight" in accordance with Article 1.3 and the "Notice to Bridge Inspectors" block.

- c. Boring Plan(s) - Borings shall be plotted in accordance with Article 2.2.2.2.
- d. Stage Construction Plans, if applicable.
- e. Pier Plan(s) - A pier "Plan" and "Elevation," if applicable, showing the proposed pier with controlling dimensions, footing elevations, foundation, etc.
- f. Additionally, architectural aspects of the structure shall be noted, on the SL/D plans, such as bridge railing, pier and abutment configuration, surface treatment, etc.

The inspection access features, if required, should be shown on the Structure Layout for Design (SL/D) Plans. The SL/D plans will be submitted to the Bridge Safety and Evaluation Unit for review. The Bridge Safety and Evaluation Unit review should indicate one or more of the following:

- No special inspection access features required.
- The inspection access features shown are adequate.
- Certain inspection access features shown are not required.
- The following additional inspection access features are required.

The designer shall submit the SL/D plans, along with a copy of the Soils and Foundations Report for review and approval. Upon approval of the SL/D plans, the designer will be authorized to proceed with the development of the final contract documents.

2.1.9 Soils and Foundation Investigation

2.1.9.1 General

Subsurface exploration and testing programs shall be performed to provide pertinent and sufficient information for the design of substructures and retaining walls. The subsurface exploration and testing programs shall also provide pertinent and sufficient information for the design and construction of temporary support elements (sheet piling, cofferdams, soldier pile and lagging, etc.) The investigations shall conform to the Department's *Soils and Foundations Guide for Design by Consulting Engineers*.

2.1.9.2 Soils and Foundation Reports

A Soils and Foundation Report shall be prepared for each structure in accordance with the Department's *Soils and Foundations Guide for Design by Consulting Engineers*. The Report shall include any information necessary for the proper design of all structural elements and components that may be influenced by subsurface conditions. The Report should include, but not be limited to, boring logs, excavation requirements, foundation recommendations, soil and rock properties and capacities, axial and lateral pile capacities, design criteria, backfill and drainage requirements, and related special provisions.

The Report shall be made entirely with US Customary units of measurement. The Report shall be submitted for review and approval. A copy of the Report shall be submitted with the Structure Layout for Design (SL/D) Plans.

2.1.10 Final Hydraulic Study and Scour Reports

Final Hydraulic Study and Scour Reports based on the selected structural type must be prepared and submitted. The Final Hydraulic Study should address any concerns presented during the Preliminary Hydraulic Study and should contain a Hydrology Section as approved by the Department in addition to the detailed hydraulic analysis. The hydraulic and scour data should be tabulated on the plans.

2.1.11 Final Plans For Review

As part of the "Final Plans for Review Submission," the designer shall submit the following structure related items. The actual number of copies required varies and must be coordinated with the individual Project Engineer for the particular job:

- Final Plans for Review,
- Specifications,
- proposal estimates,
- Soils Report – Structure,
- Final Hydraulic Report (along with all data files on 3½" Diskettes),
- design computations,
- load rating computations (Load Factor Method),
- quantity computations,
- structure costs with estimated steel weights (if applicable), and
- Final Scour Report along with all data files on 3½" diskettes or CD-ROM.

The "Final Plans for Review" shall be complete. All bridge plans not prepared by the Department shall be signed by the responsible party from the Consultant Engineer or the Municipality. The requirements as noted in Section 108 (Responsibility for accuracy of the Work) of the Department's *Consulting Engineers Manual* shall be applicable to all material submitted at the Final Plans for Review Submission.

Incomplete submissions of plans, specifications or other data required for the Final Plans for Review Submission will not be accepted. The structural material submitted and the design of the same should be well coordinated with the roadway and utility plans and shall satisfy the needs of maintenance and protection of traffic.

The "Final Plans for Review" for structures incorporating special features to facilitate inspection and items requiring special attention will be submitted to the Bridge Safety & Evaluation Unit for review. They will indicate whether these features are adequate for future inspection and return the plans with comments or signify that the plans are satisfactory.

2.1.12 Incorporation of Review Comments

The various submissions will be reviewed and the review comments will be forwarded to the designer. All comments received shall be incorporated into the design prior to the next submission or mutually resolved. Written responses to all comments are desired.

2.1.13 Final Submission

Upon completion of the review of the "Final Plans for Review," all plans, specifications and cost estimates that require modifications will be returned to the designer for incorporation of the review comments.

For the "Final Submission," the designer shall submit the following structure related items:

- the final Mylars for all structure plans,
- two sets of white prints,
- one set of the final specifications,
- the final specifications in Microsoft Word format on 3½" diskettes or CD-ROM,
- two sets of any revisions to the design computations, and
- the Final Structure Plan files in MicroStation format on 3½" Diskettes.
- load ratings shall include the following:
 - a summary sheet of Load Ratings and back-up calculations (i.e., dead load, distribution factors, design parameters, etc.) for all load cases.
 - a computer disc containing the input data files.
 - one set of half-size (11" x 17") plans

2.2 REQUIREMENTS FOR FINAL CONTRACT DOCUMENTS

2.2.1 General

The contract documents include the Final Plans and Specifications necessary to complete the contemplated construction work for a project.

US Customary units of measurement shall be used in all plans and specifications. All layout dimensions and elevations shall be given as decimal dimensions in feet. The following note shall be placed in the General Notes:

When dimensions are given to less than three decimal places,
the omitted digits shall be assumed to be zeros

Detail dimensions (those not normally measured by the surveyors) should be given in feet and inches.

2.2.2 Final Plans

The final plans should be prepared on full size sheets. All details shall be drawn to scale. Plans for individual bridges shall be self-contained sets. On large projects with

multiple retaining walls or resurfacing projects with numerous bridges, these structures may be combined into one set of plans for efficiency of detailing.

The designer shall prepare final contract plans for all structures. The use of a “Limited Investigation Disclaimer” should be limited only to sheets pertaining to estimated quantities, borings, and substructure components.

Existing structures (houses, garages, storage tanks, etc.), which will be demolished before the project is constructed, shall not be indicated on the structure plans. The location of the existing foundation should be noted on the contract drawings. Any existing drainage facilities that are in conflict with footings, retaining walls, etc. should be shown on the plans.

The use of the word “by others” on the contract plans is considered unacceptable. Such reference, especially when it refers to utility companies should state the name of the company responsible for the completion of the work.

For bridges on a horizontal curve, basic layout information shall be shown as described in DIVISION III.

All final plans shall be submitted to the Department in “MicroStation” digital CADD format. Specific requirements and materials, such as level symbology and seed files, are available from the Department.

2.2.2.1 *Presentation of Drawings*

The following is the recommended order for the presentation of structure plans and generally follows the order of construction:

- General Plan (one or two sheets),
- Layout Plan (if required),
- Boring Logs,
- Stage Construction Plans,
- Foundation Plans,
- Abutment and Wingwall Plans,
- Pier Plans (if required),
- Framing Plans,
- Beam and Girder Details,
- Bearing Details,
- Slab Plans,
- Slab and Approach Slab Details,
- Joint Details,
- Metal Bridge Rail Detail Sheet (if required),
- Pedestrian Railing or Bicycle Railing Detail Sheet (if required),
- Protective Fence Detail Sheet (if required),
- Deck Drainage Details (Scuppers and Piping if required),

- Electrical Detail Sheet,
- Utility Sheets (if required), and
- Existing Structure Plans (if required).

2.2.2.2 Boring Logs

The boring logs shall be in US Customary units of measurement and shall be shown on the plans. The format of the boring logs plotted on the plans shall be identical to the format of the Department’s standard boring log forms. A list of boring log abbreviations used for describing the soil and rock, such as colors, textures, properties, and types, shall also be shown on the plans.

2.2.2.3 Quantities

Quantities shall be tabulated and shown on the “General Plan.” For dual bridges they shall be tabulated separately.

2.2.2.4 Transportation Dimensions and Weight

The maximum transportation lengths, widths and height of bridge members along with the maximum transportation weight must be shown on the “General Plan.” The following is a sample of the information required:

Member	Shipping Length	Shipping Height	Shipping Width	Shipping Weight
G-1	115 ft	9 ft	10 ft	118,000 lbs

2.2.2.5 High, Low & Flood Water Elevations

For structures over tidal waterways, the “General Plan” shall indicate the mean high water and mean low water elevations. For structures over non-tidal waterways, the plans shall indicate the watershed area, the magnitude, frequency and the water surface elevation for the design flood, as well as the normal water surface elevation.

2.2.2.6 Quantity Disclaimer Note

The following note must be placed on those Structure Sheets that contain estimated quantities, boring and substructure components:

The information, including estimated quantities of work, shown on these sheets is based on limited investigation by the State and is in no way warranted to indicate the true conditions of actual quantities or distribution of quantities of work which will be required.

2.2.2.7 Notice to Bridge Inspectors

The designer shall note on the General Plan any item that would require special attention, such as fracture critical members, during inspection of the structure. This information shall be contained in the "Notice to Bridge Inspectors" block as shown in DIVISION II.

2.2.2.8 Coordinate Tabulation

The designer shall tabulate coordinates on each set of bridge plans for structures on a horizontal curve. These coordinates shall be tied into the Connecticut Coordinate Grid System. Coordinates shall be tabulated for the following:

- locations of working points,
- ends of wingwalls,
- ends of slabs,
- ends of approach slabs, and
- intersections of the centerlines of bearings at the abutments and piers with:
 - ☒ construction centerlines,
 - ☒ baselines,
 - ☒ points of application of grade,
 - ☒ gutterlines, and
 - ☒ centerlines of stringers.

2.2.2.9 Beam or Girder Lengths

The horizontal lengths of beams or girders measured center to center of bearings along the centerline of the member shall be shown on the plans.

2.2.2.10 Erection Plans

In order to expedite railroad approvals and avoid delays during construction, design plans for bridges being erected over electrified rail lines must include full erection plans, including crane requirements and placement, pick points, erection sequence, etc.

2.2.2.11 Utility Locations

All existing underground utilities in the vicinity of the construction must be shown on the General Plan and on all foundation drawings. It is imperative that utilities adjacent to but not actually within the excavation limits also be shown since pile driving or other deep foundation work may impact them. The size, type, owner and location of the utility must be given.

2.2.3 Specifications

2.2.3.1 *Standard Specifications for Roads, Bridges and Incidental Construction*

This is the category of specifications that is commonly referred to as the “Standard Specs.” They are the basic construction specifications that describe and define the requirements of those items of construction most commonly used in highway construction. These specifications are in the charge of the “Standing Committee on Standard Specifications,” otherwise known as the “Specifications Committee.”

Amendments, additions to, or deletions from this book are accomplished through Committee action. The need for a particular action is usually brought to the attention of the Committee by those intimately concerned with the particular specification.

These specifications undergo constant change as new methods, materials and technology become available. The vehicle for accomplishing permanent change to a standard specification is the Supplemental Specification discussed in the following section.

2.2.3.2 *Supplemental Specifications*

As previously stated, the Supplemental Specifications permanently add to, delete, or otherwise revise the Standard Specifications. Prior to publishing and disseminating these specifications, they must have been approved by the Specifications Committee and the Federal Highway Administration.

The Supplemental Specifications are issued periodically in a “package” containing all the current supplements that have been issued since the acceptance of the last *Standard Specifications* book.

The Supplemental Specifications may be considered part of the *Standard Specifications*. When a new book is printed, these are automatically incorporated. For the present, however, they will be issued in package form.

2.2.3.3 *Special Provisions*

2.2.3.3.1 General

In those cases where neither the standard specification nor subsequent supplemental specifications are found to be adequate, or where no specification exists, a special provision must be prepared.

The Department has developed and maintains lists of standardized special provisions known as “Owned Special Provisions.” The purpose of these special provisions is to establish uniformity in the specification of materials and construction methods.

These "Owned Special Provisions" should be inserted into the contract documents unchanged. The designer is responsible for the correct application of the recurring special provisions to each project.

2.2.3.3.2 Contractor Designed Items

For all items requiring the Contractor to provide designs for permanent structural features, special provisions shall be included in the contract requiring the Contractor to provide Mylar copies of all design plans. These Mylars shall conform to the Department's standard format for structural design plans and shall be signed and sealed by a Connecticut Professional Engineer. The District Project Engineer shall be responsible for forwarding these Mylars to the Map File Room to be filed with the contract plans.

Section 3
LOADS

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Section 3 **LOADS**

3.1 SUPERSTRUCTURE DESIGN LOADS

3.1.1 Dead Load

Dead loads are permanent loads that are supported by the structure. For composite construction, dead load is defined as any permanent load that is applied to the structure before the composite concrete deck has cured. For non-composite construction, all permanent loads shall be considered dead loads.

3.1.2 Composite Dead Loads

Composite dead load is defined as any permanent load that is applied to a composite structure after the placement of the composite concrete deck.

3.1.3 Live Load

The HS20 Loading as defined in the *AASHTO Specifications* shall be used for all structures designed by the Service Load Design Method (Allowable Stress Design) or the Strength Design Method (Load Factor Design) except as noted below.

The HL-93 Loading as defined in the *AASHTO LRFD Bridge Design Specification* shall be used for all structures designed by the Load and Resistance Factor Design Method (LRFD) except as noted below.

The Alternate Military Loading of two axles four feet apart each weighing 24,000 pounds shall be used if it produces the greater stresses for:

- structures supporting the Interstate System excluding ramp structures except as noted below, and
- structures at locations where two Interstate System highways intersect, including ramp structures at interchanges.

In addition to the requirements listed above, all bridges shall also be analyzed for two Department operating vehicles. This is being done to ensure adequate strength for all legal weight vehicles and permit vehicles for all span lengths and most “superloads” permitted by the Department. See Section 1.4.4 for operating vehicle descriptions and specified load rating requirements.

3.1.4 Other Loads and Conditions

All bridges shall be designed for the following loads and conditions, as applicable.

3.1.4.1 *Future Paving Allowance*

Vehicular bridges without a bituminous overlay shall be designed for a future paving load of 30 pounds per square foot to account for a 2½" bituminous concrete overlay.

Structures with a bituminous overlay shall not be designed for any additional loads to account for future additional paving.

3.1.4.2 *Remain-in-place Forms*

Bridges where the use of remain-in-place forms is allowed shall be designed for the additional dead load of the form and the concrete in the valleys.

3.1.4.3 *Temperature Effects*

For bridges where the effects of temperature cause loads on members, the temperature range for cold climates shall be used as outlined in the AASHTO *Specifications*.

3.2 EARTH PRESSURES

3.2.1 General

For determination of lateral earth pressures, methods prescribed in the AASHTO *Specifications* may be used. For broken back slopes, walls supporting high fills, or other special loading conditions, proper design methods should be selected by the designer and submitted for approval during the preliminary stage of design.

In the design of substructure units such as abutments, wingwalls and retaining walls, the lateral earth pressure shall never be assumed to be less than 33 pounds per square foot per linear foot of wall.

3.2.2 Design Assumptions

3.2.2.1 *Unit Weight of Soil*

The unit weight of soil over the footing shall be assumed to be 125 pounds per cubic foot unless specific conditions require it to be otherwise.

3.2.2.2 *Coefficient of Friction*

The coefficient of friction between the bottom of footing and the soil beneath it shall be a maximum of six tenths (0.6) for all except special cases.

3.2.2.3 Footing Keys

Use of a key in the footing to develop passive pressure against sliding is not normally recommended; if proposed, the designer shall submit studies to the Department for approval during the preliminary stage of design.

3.2.3 Surcharge

Earth pressures due to surcharge loads shall be taken into consideration. A minimum surcharge loading equivalent to two feet of soil shall be used.

3.2.4 Unbalanced Loads

Concrete tunnels with skewed end sections, integral or semi-integral abutments, rigid frames, box culverts, etc., will require special consideration in the design and sequence of backfilling in order to prevent cracking due to unbalanced loading.

The designer shall specify backfilling requirements where the effects of unbalanced backfill loading will produce a detrimental effect.

3.2.5 Box Culverts

For the design of box culverts, the lateral pressure due to earth adjacent to and above the box shall be computed for earth at rest. It may be assumed to be 0.45 times the corresponding vertical earth pressure, unless specified by the designer to be otherwise.

3.3 DISTRIBUTION OF LOADS

3.3.1 Distribution of Loads to Superstructure Components

3.3.1.1 Dead Loads and Composite Dead Loads

All composite dead loads shall be distributed to all beams equally.

For precast adjacent box beam bridges, all dead loads shall be distributed to all beams equally. If multiple beam types are required in the same cross section, the distribution of loads must take into account the stiffness of each beam. The distribution of dead loads for this condition shall be as follows:

$$DL_k = DL_{Total} \times \frac{I_k}{(I_1 + I_2 + I_3 + \dots + I_n)} \text{ where:}$$

DL_k = Dead load on beam 'k'

DL_{Total} = Total dead loads applied to the superstructure parapet excluding beam weight (parapets, wearing surface, railings, sidewalks, etc.)

I_k = Moment of inertia of beam 'k'

$$(I_1 + I_2 + I_3 + \dots + I_n) = \text{Total moments of inertia of all beams}$$

3.3.1.2 Live Loads

The distribution of loads to superstructure components shall be in accordance with *AASHTO Specifications*.

For precast adjacent box beam bridges, all live loads shall be distributed to all beams equally. If multiple beam types are required in the same cross section, the distribution of loads must take into account the stiffness of each beam. The distribution of live loads for this condition shall be as follows:

1. A distribution factor should be calculated according to the *AASHTO Specifications* assuming the entire bridge cross section is made up of the predominant beam in the cross section.
2. The distribution factor for each beam should be calculated based on the relative stiffness of the two adjacent beams as follows:

$$DF_k = DF \times \frac{3 \times I_k}{(I_{k-1} + I_k + I_{k+1})} \quad \text{where:}$$

DF_k = Distribution factor for beam 'k'

DF = Distribution factor as described above in 1

I_k = Moment of inertia of beam 'k'

I_{k-1} = Moment of inertia of beam to the left of beam 'k'

I_{k+1} = Moment of inertia of beam to the right of beam 'k'

3. Since all beams of a common type should be designed and detailed in a similar fashion, the maximum distribution factor for each beam type should be used for the design of all common beams.

3.3.2 Distribution of Loads from Superstructure to Substructure Components

3.3.2.1 Dead Load Reactions

3.3.2.1.1 General

The dead load reactions from the design of the superstructure may be used for the design of substructure components.

3.3.2.1.2 Abutments and Solid Wall Piers

For the design of earth retaining abutments and solid wall piers, the dead load reactions may be distributed evenly over the entire length of the substructure stem.

This procedure is sufficiently exact for most design purposes. However, in the design of abutments where the height of the stem is less than the beam spacing measured along the abutment, considerable judgment should be exercised in the establishment of a reasonable width over which each reaction is distributed.

3.3.2.1.3 Other Piers

For the design of hammer head, bent type and single column piers supporting discrete longitudinal composite members on bearings, the dead load reactions should be applied as concentrated loads at the bearing locations.

For the design of hammer head and bent type piers supporting precast concrete adjacent box beams on bearings, the dead load reactions may be distributed evenly to the top of the pier.

3.3.2.2 Live Load Reactions

3.3.2.2.1 General

The vehicle live load reactions from the design of the superstructure shall not be used for the design of the substructure components. These reactions are based upon the maximum conditions for one member. The use of these loadings would result in a substructure design with an unrealistic loading condition.

The governing live load reactions for design should be determined from the vehicle loadings described in Article 3.1.3. When applying the truck load, only one truck per lane should be utilized. The concentrated load for shear should be included for the lane load. The live loads should be increased for the impact effect in accordance with the *AASHTO Specifications*. The live loads may be reduced due to multiple lanes being loaded simultaneously in accordance with the *AASHTO Specifications*.

3.3.2.2.2 Abutments and Solid Wall Piers

For the design of earth retaining abutments and solid wall piers, the live load reaction is calculated using a vehicle lane reaction. The vehicle lane reaction is determined by positioning the vehicle live load longitudinally on the structure to obtain the maximum reaction at the support location. The vehicle lane reaction should be increased for the number of design traffic lanes and distributed over the entire length of the substructure stem to obtain a load per unit length.

This procedure is sufficiently exact for most design purposes. However, in the design of abutments where the height of the stem is less than the beam spacing measured along the abutment, considerable judgment should be exercised in the establishment of a reasonable width over which each reaction is distributed.

3.3.2.2.3 Other Piers

For the design of hammer head, bent type and single column piers supporting discrete longitudinal composite members on bearings, the reactions at the bearings are calculated using the vehicle lane reaction. The vehicle lane reaction is determined by positioning the vehicle live load longitudinally on the structure to obtain the maximum reaction at the support location. To determine the live load reactions at the bearings, the vehicle lane reactions should be placed within the design traffic lanes and then distributed to the members assuming the slab between the members to be simply supported. The vehicle lane reactions should be positioned within the design traffic lanes in accordance with *AASHTO Specifications*. The design traffic lanes and the vehicle lane reactions within the lanes should be arranged to produce reactions that result in extreme force effects on the component under consideration.

For the design of hammer head and bent type piers supporting precast concrete adjacent box beams on bearings, the vehicle lane reactions may be distributed directly to the pier without any transverse distribution. The vehicle lane reactions should be positioned within the design traffic lanes in accordance with *AASHTO Specifications*. The design traffic lanes and the vehicle lane reactions within the lanes should be arranged to produce extreme force effects on the component under consideration.

Section 4
SEISMIC DESIGN AND RETROFIT

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Section 4 SEISMIC DESIGN AND RETROFIT

4.1 GENERAL REQUIREMENTS

4.1.1 Purpose

Designers in applying seismic design criteria should be aware that the purpose of the AASHTO seismic design requirements is to minimize damage and prevent collapse. They are not intended to eliminate all damage.

This Section is intended to supplement the AASHTO *Specifications* for seismic design.

4.1.2 Acceleration Coefficient

The acceleration coefficient (A) used for determining the seismic loading is based on the Peak Ground Acceleration Maps in the AASHTO *Specifications*. The acceleration coefficients for Connecticut generally vary on these maps from 0.14 to 0.16. To provide uniformity of design, a value of 0.16 shall be used for all designs.

4.2 ANALYSIS REQUIREMENTS

4.2.1 Single Span Bridges

Seat width and restraint forces for single span bridges shall be calculated according to the AASHTO *Specifications*.

4.2.2 Bridges with Two or More Spans

4.2.2.1 “Regular” Bridges

Bridges classified as “Regular” as defined by the AASHTO *Specifications* and not classified as “critical” bridges by the Department are to be analyzed by either the Uniform Load Method or the Single Mode Spectral Method. The Uniform Load Method is the preferred method of analysis. Bridges classified as “critical” by the Department shall be analyzed by the Multi-Mode Spectral Method.

4.2.2.2 “Irregular” Bridges

Bridges classified as “not regular” as defined by the AASHTO *Specifications* are to be analyzed by the Multi-Mode Spectral Method.

4.2.2.3 *Special Cases*

For bridges that are not conclusively “Irregular” as defined by the AASHTO *Specifications*, it is the option of the designer whether to use the Single Mode or Multi-Mode Spectral Method for analysis.

The Multi-Mode Spectral Method may also be used where it is anticipated that the increased accuracy of this method would be advantageous in reducing seismic demands or retrofit needs.

4.3 NEW BRIDGES

4.3.1 General

All new bridges are to be analyzed and designed for seismic forces in accordance with the AASHTO *Specifications* using the load factor method or the load and resistance factor method except as amended in this *Manual*. Special attention should be given to the pier type selection since the piers are the primary load carrying members for seismic loads.

4.3.2 Abutments and Wingwalls

New abutments and wingwalls (excluding single span bridges) shall be designed for seismic forces. Abutments shall be designed for seismic forces transmitted from the superstructure and all seismic design criteria for retaining walls.

4.3.3 Seismic Isolation Bearings

Seismic isolation bearings may be used at bridge piers and abutments, where it can be demonstrated that the performance characteristics of the bearings will provide a necessary benefit for the design of the bridge substructures. The design of seismic isolation bearings shall be in accordance with the AASHTO *Guide Specifications for Seismic Isolation Design*.

4.4 NEW RETAINING WALLS

Except for certain conditions stated below, the Department waives the AASHTO requirements that retaining walls be designed for seismic induced lateral earth pressures and inertia effects.

Only walls meeting at least one of the following conditions shall be designed for seismic forces:

- A wall that is greater than 25 feet high and is supporting a major highway.
- A wall that is greater than 25 feet high and is in front of a sidewalk.

- A wall located such that its collapse would endanger buildings or the lives of people.
- A wall supporting a multi-span structure (such as an abutment).

4.5 REHABILITATION OF EXISTING BRIDGES

4.5.1 General Requirements

In general, retrofit work on piers and abutments will not be required. Most retrofit work shall consist of providing lateral restraint at bridge bearings and providing adequate seat width.

The Department may require more extensive analysis and retrofit for major bridges, or if a unique situation exists such as a multi-level structure. The decision to include seismic retrofit of piers and abutments for these structures will be made on a case-by-case basis by the Department. For these cases, the designer shall use the load factor method for the analysis and design.

Actual implementation of corrective measures on bridge rehabilitations will be dependent on the cost, practicality of the modification, seriousness of the shortcoming, and the importance of the bridge.

4.5.2 Bridge Deck Patching Projects

All bridge rehabilitation projects that only include patching of the bridge deck need not be analyzed for seismic forces.

4.5.3 Bridge Widening Projects

4.5.3.1 *Widenings* ≤ 25%

All bridge rehabilitation projects where the widened portion of the cross section is less than 25% of the total width of the completed bridge will generally not require analysis for seismic forces.

4.5.3.2 *Widenings* > 25%

All bridge rehabilitation projects where the widened portion of the cross section is greater than or equal to 25% of the total width of the completed bridge shall be designed for seismic forces.

The preliminary design of the new portions of the substructure shall be based on all AASHTO loading conditions with the exception of seismic forces. Once the preliminary design is complete, the entire structure shall be analyzed for seismic forces. If deficiencies are found in the existing structure, the designer shall investigate the following alternatives:

- Retrofit of existing substructures and design of new foundations for seismic forces.
- Strengthen and stiffen the new foundations to carry a larger portion of the seismic forces.
- Reduce the seismic forces in the foundations through the use of seismic isolation bearings.
- If the costs of any of the preceding alternates are excessive, or if the deficiencies are not significant, the new substructures should be designed for non-seismic forces only.

The decision to implement needed retrofit work for the existing as well as new portion of the structure must be determined on an individual basis for each bridge based on factors such as retrofit cost and seriousness of the deficiencies.

If new columns are designed for non-seismic forces only, the detailing of the confinement reinforcement shall be according to seismic provisions in the AASHTO *Specifications* for Performance Category B.

4.5.4 Superstructure, Deck or Bearing Replacement Projects

All bridge rehabilitation projects that include replacement of the superstructure, bridge deck, or bridge bearings are to be analyzed for AASHTO seismic forces. The method of analysis should involve modeling the entire structure. For most cases, the piers can be assumed to be fixed at the top of the footings.

In general, seismic retrofit work shall be limited to correcting deficiencies in support length and providing adequate restraint for seismic forces at bearings. No retrofit will be required for the bridge substructures.

4.5.5 Superstructure Replacement Projects with Widening > 25%

On projects where the bridge superstructure is to be replaced along with being widened, the completed bridge shall be designed for seismic forces. On existing multi-span structures, the designer shall investigate eliminating deck joints by making spans continuous.

The preliminary design of the new portions of the substructure shall be based on all AASHTO loading conditions with the exception of seismic forces. Once the preliminary design is complete, the entire structure shall be analyzed for seismic forces. If deficiencies are found in the existing structure, the designer shall investigate and compare construction costs for the following alternatives:

- Retrofit of existing substructures and design of new foundations for seismic forces and any additional loads induced by the elimination of simple spans.
- Strengthen and stiffen the new foundations to carry a larger portion of the additional seismic and non-seismic forces.
- Reduce the additional forces in the foundations through the use of seismic isolation bearings.
- Replace the entire structure, including foundations taking advantage of longer, continuous spans.

The decision to implement needed retrofit work for the existing as well as new portion of the structure must be determined on an individual basis for each bridge based on factors such as retrofit cost and seriousness of the deficiencies. It may be more prudent and cost effective to replace the structure in its entirety.

If new columns are designed for non-seismic forces only, the detailing of the confinement reinforcement shall be in accordance with the seismic provisions in the AASHTO *Specifications for Performance Category B*.

4.5.6 Retrofit Guidelines

The following two FHWA reports should be used as a guide for seismic retrofit of bridges:

- Report No. FHWA-IP-87-6, "Seismic Design and Retrofit of Highway Bridges"
- Report No. FHWA-RD-94-052, "Seismic Retrofitting Manual for Highway Bridges"

4.5.7 Seismic Isolation Bearings

Seismic isolation bearings may be used for bridge rehabilitation projects at piers and abutments, where it can be demonstrated that the performance characteristics of the bearings will provide a necessary benefit for the design of the bridge substructures. The design of seismic isolation bearings shall be in accordance with the AASHTO *Guide Specifications for Seismic Isolation Design*.

Section 5
ABUTMENTS, PIERS AND WALLS

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Section 5
ABUTMENTS, PIERS AND WALLS

5.1 GENERAL

5.1.1 Abutments

An abutment is the portion of the bridge that supports the end of a bridge span, provides lateral support for approach roadway fill and supports the approach roadway and approach slab. Abutments may be described by their location relative to the approach embankments.

A stub (embankment) abutment is located at or near the top of the approach fill. A partial depth abutment is located approximately mid-depth of the front slope of the approach embankment. A full depth (shoulder) abutment is located at the approximate toe of the approach embankments.

Abutment types shall be selected considering structure aesthetics, foundation recommendations, structure location, and the loads it must transmit to the foundation. For structures over waterways, the abutment type and location should also be specified with consideration to hydraulic conditions at the site. Wherever possible, use stub (embankment) abutments for structures over waterways.

The acceptable abutments types include non-proprietary systems such as gravity walls, cantilever walls, counterfort walls and integral abutments. Abutments shall not be placed on fill supported by mechanically stabilized earth walls or prefabricated modular walls. Generally, for abutments and wingwalls founded on rock, where the footings are exposed, the abutment and wingwalls shall be designed without a toe.

5.1.2 Piers

A pier is that portion of the bridge between that provides intermediate support of the superstructure and the foundation. Pier types shall be selected considering structure aesthetics, foundation recommendations, structure location, and the loads it must transmit to the foundation. If possible, on large projects with many piers, the type of pier shall be consistent throughout the entire project for reasons of economy. The acceptable pier types include wall piers, open column bents, multiple column piers, and single column piers. The use of permanent steel pier bents is discouraged due to future maintenance.

5.1.3 Walls

Walls should be used where the construction of a roadway or facility cannot be accomplished with slopes. Walls can be classified as either retaining walls, or wingwalls. Wingwalls are used to provide lateral support for the bridge approach roadway embankment. For bridges with long wingwalls that are parallel to the roadway, the entire wingwall should be referred to as a retaining wall.

Wingwalls shall preferably be U-type (parallel to the roadway). Flared wingwalls are permitted where conditions warrant such as for hydraulic performance of waterway crossings. The acceptable wingwall types include non-proprietary systems such as gravity walls, cantilever walls and counterfort walls. Proprietary systems, such as mechanically stabilized earth and prefabricated modular walls, shall only be used for retaining walls.

Retaining walls may be non-proprietary systems such as gravity walls, cantilever walls, counterfort walls or tie backwalls, or may be proprietary systems such as mechanically stabilized earth walls or prefabricated modular walls.

The tops of retaining walls shall not be determined by the exact fill slope but shall follow a smooth unbroken line for a more pleasing appearance. This may require the use of vertical curves, in which case elevations shall be given at five foot intervals.

5.1.4 Foundations

The foundation is that part of the structure that serves to transmit the forces acting on the abutments, piers, or walls to the ground. Foundations are classified as either shallow or deep. A shallow foundation derives its support by transferring load directly to soil or rock at a shallow depth. Spread footings are shallow foundations. A deep foundation derives its support by transferring loads to soil or rock at some depth below the structure by end bearing, adhesion or friction or both. Driven piles and drilled shafts are deep foundations.

Foundation type is generally based on the anticipated (structure) loads, underlying soil conditions, scour potential, site constraints along with the ease and cost of construction.

5.2 IDENTIFICATION NUMBERS

All abutments and piers shall be identified by numbers which start with the number "one" and progress consecutively but separately in the direction of stationing of the roadway, such as, Abutment 1, Pier 1, Abutment 2, etc.

All wingwalls shall be identified by a combination of a number and a letter (alphanumeric), such as 3A or 3B. The number used must correspond to the substructure unit to which the wingwall is attached. Looking up station, the letter “A” indicates the wingwall is on the left and the letter “B” indicates the wingwall is on the right.

Retaining walls shall be identified by three numbers that start at 101 and progress consecutively in the direction of stationing of the roadway, such as Retaining Wall 101, Retaining Wall 102. These numbers may designate a proprietary wall, a proprietary embankment wall or a cast-in-place wall. A table shall be provided on the plans identifying the relationship between the wall number, type and site number of the wall, and location as in the following:

RETAINING WALL NUMBER	DESCRIPTION	LOCATION
101	Embankment Wall – Site 1	Station 10+00 to 12+50
102	Retaining Wall – Site 2	Station 25+50 to 32+50
103	Cast-in-place – Site 3	Station 70+00 to 72+50
104	Retaining Wall – Site 4	Station 80+00 to 82+50

5.3 EXCAVATION

5.3.1 General

Contract items for structure excavation, unless the work is included under other items, are required for the removal of all material of whatever nature necessary for the construction of foundations for bridges, box culverts, retaining walls and other structures. The contract items specified on the plans depends on the type of material removed, earth or rock, and whether or not separate payment will be made for the work related to cofferdams and dewatering.

On any project where only some of the structures and/or their components require cofferdams and some do not, a combination of structure excavation items shall be shown on the plans. The plans for the structures and components requiring “Cofferdam and Dewatering” shall clearly delineate the limits of the cofferdam.

5.3.2 Construction Requiring Cofferdam and Dewatering

At water crossings, where structures or their components are located partially or wholly in the water and the bottom of the footing is below water level, or where a considerable flow or concentration of water is present that cannot

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be diverted, partly or wholly, from the site, the plans shall include the following item:

ITEM NAME	PAY UNIT
Cofferdam and Dewatering	L.F.

The hydraulic design of the cofferdam should be done in accordance with Chapter 18 (Temporary Hydraulic Facilities) of the *Drainage Manual*.

The plans shall also include either one or both of the following items, as required for the type of material removed:

ITEM NAME	PAY UNIT
Structure Excavation – Earth (Excluding Cofferdam and Dewatering)	C.Y.
Structure Excavation – Rock (Excluding Cofferdam and Dewatering)	C.Y.

Where underwater (tremie) concrete may be used to seal the bottom of a cofferdam to allow dewatering, the weight of the tremie concrete, adjusted for buoyancy, shall be added to pile and foundation loads for design purposes.

5.3.3 Construction in the Dry

Where structures or their components are to be constructed in the dry or where water may be diverted from an excavation, eliminating the need for a cofferdam, the plans shall also include either one or both of the following items, as required for the type of material removed:

ITEM NAME	PAY UNIT
Structure Excavation – Earth (Complete)	C.Y.
Structure Excavation – Rock (Complete)	C.Y.

The diversion of water or water courses, either partially or wholly, from an excavation or site, must be coordinated with hydraulic studies and DEP, Federal and State permit submittals. At the sites where water is diverted from an excavation, the following item shall be included in the project.

ITEM NAME	PAY UNIT
Handling Water (Site No.)	L.S.

5.4 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS

Expansion and contraction joints in concrete abutment and wall stems shall be provided in accordance with AASHTO *Specifications*. Construction joints shall be placed as conditions warrant. Expansion or contraction joints should not be provided in footings. Footings for abutments and walls should be continuous including any steps provided.

No reinforcement shall pass through expansion and contraction joints. Reinforcement shall pass through construction joints.

5.5 DAMPPROOFING

The rear face of cast-in-place abutments and wall stems shall be damp-proofed.

5.6 BACKFILL REQUIREMENTS

5.6.1 General

Unless otherwise directed, all abutments, wingwalls and retaining walls shall be backfilled with Pervious Structure Backfill to the limits described below. Pervious Structure Backfill is a clean, granular soil. For design purposes, the effective angle of internal friction shall be taken as equal to 35°.

5.6.2 Backfill Limits

Place a wedge of Pervious Structure Backfill above a slope line starting at the top of the heel and extending upward at slope of 1:1½ (rise to run) to the bottom of the subbase. In cut situations, the following note, with a leader pointing to the slope line, shall be placed on the plans:

Slope line except where undisturbed material obtrudes within this area.

5.7 SUBSURFACE DRAINAGE

5.7.1 General

Subsurface drainage shall be accomplished with the use of weepholes extending through the wall stems or underdrains placed along the wall stems. Subsurface drainage for proprietary retaining walls shall conform to the Department's *Specifications* governing their design and construction.

5.7.2 Weepholes and Bagged Stone

Except for structures placed on embankments, four-inch diameter for dimension weepholes, sloped 1:8 (rise to run), shall be placed approximately twelve inches above the finished grade at the front face of the wall stem. For structures placed on embankments, the weepholes shall be extended through the slope with an outlet. Weepholes shall not drain onto adjacent sidewalks. Weepholes should be spaced at approximately eight to ten feet intervals unless conditions warrant a closer spacing. The spacing and invert elevations of the weepholes shall be shown in an elevation view.

The cost of furnishing and installing weepholes is included in the cost of the concrete. Bagged Stone is paid for as a separate item.

5.7.3 Underdrains

Underdrains shall be a six-inch nominal diameter, perforated and placed at the base of the stem and sloped a minimum of 1%. Underdrains shall be either connected to the roadway drainage or to a free outlet. The location and limits of the underdrain shall be shown in plan view. The invert elevations shall be shown in an elevation view.

Underdrains shall be paid for under the item "6 inch Structure Underdrain." When an underdrain is connected to the roadway drainage, the pipe beyond the face of the wall stem or the end of the wall shall be shown on the plans to be included in the roadway items, and should be coordinated with the roadway designer.

5.7.4 Subsurface Drainage Selection Criteria

5.7.4.1 *Shoulder Abutments*

At abutments in cut situations, either an underdrain or weepholes may be used with the latter being preferred. Weepholes should be used at abutments located on fills. When there is a sidewalk in front of any abutment, an underdrain should be used. Where this type of abutment is used at water crossings, drainage shall be provided by weepholes.

5.7.4.2 *Embankment Abutments*

At abutments in wet cuts, an underdrain should be used. At abutments in dry cuts and fills, extended weepholes should be used. If the total length of pipe for this system exceeds that required for underdrains, the latter is preferred.

5.7.4.3 *U-Type Wingwalls, Flared Wingwalls and Retaining Walls*

For walls with a fully exposed face adjacent to a sidewalk, an underdrain should be used. For walls with a fully exposed face not adjacent to a sidewalk, weepholes should be used. For walls with a partially exposed face, an underdrain should be used.

5.8 APPROACH SLABS

Approach slabs shall be provided on all bridges carrying State highways. Approach slabs shall be strongly considered on all bridges undergoing superstructure replacement and local road bridges.

Approach slabs should extend the full width of the roadway (including shoulders), have a standard length of 16 feet and be 1'-3" thick. Generally, approach slabs should follow the skew of the bridge for skew angles up to 35°. For skew angles greater than 35°, the ends of the approach slabs should be square to the roadway with a minimum length of 15 feet. Acute corners of approach slabs and approach pavement should be squared off for a distance of five feet from the gutter line. Approach slabs shall be anchored to the bridge abutment.

Approach slabs shall be constructed with Class "F" Concrete and have two mats of coated reinforcement. Approach slabs shall be covered with a waterproofing membrane and a bituminous concrete overlay. All the material items used in the construction of the approach slabs, including the overlay, shall be included in the structure items and quantities.

All elevations necessary for construction of the approach slabs shall be shown on the plans. These elevations shall include the elevations at the point of application of grade line, the gutter lines and at shoulder break lines at both ends of the approach slabs.

5.9 SLOPE PROTECTION

Provisions shall be made for protection of earth slopes in front of abutments on bridges over State highways, local roads, railroads and waterways. The slope of the embankment in front of the abutment shall be no steeper than 1:2 (rise to run).

5.9.1 Selection Criteria

The type of slope protection shall generally conform to the following criteria:

- Crushed Stone for Slope Protection shall be used under structures overpassing Interstate highways, railroads and waterways. Protection

between the edge of the shoulder and the toe of the slope should be founded on a six-inch granular fill base or geotextile. The limits of this base should be shown on the plans and shall be include in the estimated structure quantities.

- Concrete Block Slope Protection shall be used under structures overpassing State highways and local roads. The block shall be anchored or mortared into place to prevent vandalism. The use of granite block is not permitted due to its higher cost. Cast-in-place concrete is not permitted due to cracking and settlement of existing installations.
- Abutment slope protection for bridges over waterways should be designed in accordance with the procedures outlined in HEC-18 or successor documents as well as documents referenced therein.

5.9.2 Limits of Slope Protection

The limits of slope protection shall cover the complete area, exclusive of sidewalks, from the edge of the shoulder to the face of the abutment stem and transversely within lines parallel to and two feet outside of the bridge rails.

5.9.3 Inspection Shelf

Provisions for inspection access (for bridge inspectors) shall be provided on all slopes. On stems with exposed heights less than or equal to five feet, access shall be provided by a shelf at the top of the slopes. On stems with exposed heights greater than five feet, access may be by a shelf at the top of the slopes or ladder stops on the slope itself. The plans shall include details of the intersection of the shelf and the slope along the wingwalls.

5.10 SURFACE TREATMENTS

5.10.1 General

In general, abutments, piers and walls shall be faced with standard formed concrete. Surface treatments other than standard formed concrete should only be considered in the following situations:

- When the structure has been determined by the Department to be architecturally or historically significant.
- If there is a desire expressed for special surface treatments during the public involvement process of the project. The basis for surface treatments should involve the character of the area in which the wall is to be built. The use of special surface treatments should be coordinated with the town or city administration.

- Where the structure is to be built on a designated State scenic highway.
- The structure is part of the Merritt Parkway. For these structures, every attempt should be made to replicate the appearance and structure type that was originally built.
- The treatment of the structure is part of a right-of-way settlement with a property owner. For instance, if a property has an existing stone wall that is to be removed and relocated, the owner may request that the replacement wall also have a stone surface.

If special surface treatments are desired for a particular structure, every attempt should be made to achieve architectural aesthetics by means of shape and form, not through surface treatments alone. Surface treatments should generally be used in conjunction with the shape of the structure.

5.10.2 Form Liners

When the use of surface treatments has been determined to be appropriate, the preferred method is the use of concrete form liners. Form liners offer a lower cost alternative to stone veneer. There is a wide variety of form liners available for different architectural treatments. Linear corrugated form liners should be avoided since it is difficult to hide joint lines and form tie holes. Form liners that replicate stone are preferred since the random nature of the surface makes it easy to hide form tie holes.

5.10.3 Simulated Stone Masonry

In more sensitive areas, where the look of real stone is required, the use of simulated stone masonry may be considered. Simulated stone masonry utilizes a flexible form liner system and color stains to provide the aesthetic appeal of natural stone with the durability of reinforced concrete.

5.10.4 Stone Veneer

The use of stone veneer on concrete should only be considered in very sensitive areas where the increased cost can be justified. Stone veneer shall only be used with approval from the Department.

5.11 REQUIREMENTS FOR ABUTMENTS

5.11.1 General

The abutments shall be designed, unless otherwise noted, in accordance with the AASHTO *Specifications*.

Generally, abutments shall be constructed of reinforced concrete. Cast-in-place footings and stems shall be constructed with Class "A" Concrete.

Generally, reinforcement in footings and stems of abutment and wingwalls shall be uncoated. Coated reinforcement shall be used in abutments and wingwalls when they are subject to corrosive materials such as salt water, chemicals, etc. Provide a minimum of three-inch concrete cover over the reinforcement in the front face abutments. The concrete cover over the reinforcement in footings shall also be three inches.

5.11.2 Gravity Cantilever and Counterfort Abutments

5.11.2.1 *Steel Girder and Concrete Bulb Tee and Box Girder Bridges*

Gravity, cantilever, and counterfort walls, with bridge seats, may be used for abutments.

Bridge seats shall be sloped with a minimum two-inch draw from the front face of the backwall and closed at the ends. When determining bridge seat widths, consideration shall be given to superstructure jacking requirements as given in subarticle 7.2.13 and the clear distance requirements between the end bearing diaphragms and the front face of the backwall as given in subarticle 7.3.3.7. On bridges constructed with box girders, the clear distance from the end of the box girder to the face of the backwall should be no less than two feet.

At the elevation of the bridge seat, the minimum dimension from the front face of the abutment stem to the centerline of the bearings shall be 1'-3". The minimum backwall thickness shall be 1'-3". Stem thicknesses may be less than the combined dimensions of the bridge seat and backwall.

5.11.2.2 *Butted Deck Unit and Box Beam Bridges*

Gravity, cantilever and counterfort walls, with bridge seats, may be used for abutments.

Bridge seats shall be sloped to match the grade of beams.

At the elevation of the bridge seat, the minimum dimension from the front face of the abutment stem to the centerline of the bearings shall be nine inches. The minimum backwall thickness shall be 1'-3". Stem thickness may be less than the combined dimensions of the bridge seat and backwall.

5.11.3 Integral Abutments

Integral abutments are defined as abutments that are cast integrally with the superstructure. Integral abutments should be considered on all bridges, and especially where pile supported foundations are required, since the use of integral abutments will greatly reduce the number of piles and simplify the abutment details.

All integral abutment bridges shall be designed with full width approach slabs in order to minimize surcharge loads and hydrostatic pressures. Integral abutments shall be designed with U-Type wingwalls.

5.11.3.1 Fully Integral Abutments

Fully integral abutments are defined as abutments that are integral from the superstructure through to the piles. In order to control the effects of the soil mass on the abutment, the maximum height of the cast-in-place abutment shall be eight feet.

The piles shall be placed in a single line and typically are oriented such that the weak axis of the pile is parallel to the abutment face. For design purposes, the connection of the superstructure to the substructure shall be modeled as a pinned connection. The piles shall be designed for vertical forces only. The effects of thermal expansion, end rotation of the superstructure, and soil forces should be neglected.

5.11.3.2 Semi-Integral Abutments

Semi-integral abutments are defined as abutments that are integral from the superstructure through a portion of the abutment stem. Typically, a joint will be detailed in the abutment stem. In order to control the effects of the soil mass on the abutment, the maximum height of the integral portion of the cast-in-place abutment shall be eight feet.

For design purposes, the connection of the superstructure to the substructure shall be modeled as a pinned connection. The lower portion of a semi-integral abutment shall be designed as a standard cantilever abutment with all vertical forces from the superstructure transmitted to lower portion of the abutment.

5.12 REQUIREMENTS FOR PIERS

5.12.1 General

The piers shall be designed, unless otherwise noted, in accordance with the AASHTO *Specifications*. Generally, piers shall be constructed of reinforced concrete. While the design of steel pier caps is allowed, they are however

discouraged. For additional information, see Section 7. Piers may be made integral with the superstructure.

Footings shall be constructed with Class "A" Concrete. Generally, concrete pier stems, columns, and pier caps shall be constructed with Class "F" Concrete. Post-tensioned concrete pier caps may require concrete with greater compressive strengths.

All reinforcement in piers shall be uncoated. The concrete cover over the reinforcement in pier footings, stems, columns, and pier caps shall be three inches.

Circular concrete columns are preferred over rectangular concrete columns. With circular columns, spiral reinforcement is preferred over ties.

Cantilever concrete pier caps shall be post tensioned in order to eliminate cracking. The design shall be based on zero tension in the top of the cap after all losses have occurred under all loads.

The top surfaces of concrete piers and concrete pier caps shall have a transverse slope of 1:10 (rise to run). The slope shall be in both directions from the centerline to the face of the pier with a minimum draw of two inches.

Drilling holes for anchor bolts will not be permitted in concrete pier caps. Anchor bolts installed before the concrete is placed shall be set and held accurately by a template. Anchor bolts to be set after the concrete is poured shall be set in forms that shall be placed before the concrete is poured. The designer shall indicate on the plans which method of setting anchor bolts is to be used.

For structures over waterways, the following criteria applies:

- Pier foundations on floodplains should be designed to the same elevation as pier foundations in the stream channel if there is likelihood that the stream channel will shift its location over the life of the bridge.
- Align piers with the direction of flood flows. Assess the hydraulic advantages of round piers, particularly where there are complex flow patterns during flood events.
- Streamline piers to decrease scour and minimize the potential for the buildup of ice and debris. Use ice and debris deflectors where appropriate.

5.12.2 Wall Piers

A wall pier consists of a solid wall that extends up from its foundation. Generally, wall piers or wall piers combined with open bents should be considered at water crossings. Wall piers offer minimal resistance to water and ice flows.

5.12.3 Open Column Bents

An open column bent consists of a pier cap beam and supporting columns in a frame-type structure. Open column bents should be considered for wide overpasses at low skews.

Open column bents founded on rock shall generally be designed with isolated footings while open column bents founded on soil shall generally be designed with combined footings. When these piers are founded on piles, they may be designed with either isolated or combined footings.

5.12.4 Multiple Column Piers

A multiple column pier consists of an individual column supporting each beam or girder. Multiple column piers should be considered for wide overpasses at low skews.

5.12.5 Single Column Piers

Single column piers are simple, easy to construct, require minimum space, and provide open appearance to traffic. Single column piers may have a hammer head pier cap. Hammer head piers should be considered for overpasses at high skews with tight alignment constraints. This type of pier provides open appearance when supporting structures with long spans.

5.12.6 Protection from Adjacent Traffic

To limit damage to piers by vehicular traffic, crash walls shall be provided. The minimum height of the wall shall be 42 inches, and shall be placed a minimum of six inches from the face of the pier.

To limit damage to piers by railroad equipment, crash walls shall be provided in accordance with AREMA Specifications. Extensions to crash walls may be required to satisfy site conditions. The top surface of the crash wall shall have a transverse slope of 12:1.

5.13 REQUIREMENTS FOR WALLS

5.13.1 General

The following is a listing of appropriate retaining wall types that may be considered:

1. Non-Proprietary: Cast-In-Place Reinforced Concrete.
2. Proprietary: Prefabricated Modular Wall Systems.
Mechanically Stabilized Earth Walls (precast concrete).
Mechanically Stabilized Earth Embankment Walls (dry-cast block).

A design is required for the non-proprietary walls only. The Contractor shall be responsible for the structural/internal design of the proprietary walls. The design drawings shall be signed, sealed and dated by a qualified Professional Engineer, licensed to practice in the State of Connecticut. For projects where proprietary retaining walls are included, the walls will be bid as a lump sum for each site. The designer shall clearly define the horizontal, vertical, and transverse pay limits on the plans.

The Department maintains a list of approved proprietary retaining walls for each category listed above. No other proprietary retaining walls will be allowed.

5.13.2 Wall Selection Criteria

The designer shall select the appropriate retaining walls for each site. The designer may need to contact wall manufacturers to insure that each wall will be suitable at each site, and fit within the available right-of-way. The following general criteria should be followed for the selection of appropriate retaining walls:

5.13.2.1 *Walls Less Than Eight Feet (measured from front grade to back grade)*

5.13.2.1.1 Embankment Walls

Embankment walls are defined as mechanically stabilized earth structures faced with dry cast concrete block that are less than eight feet high and support an embankment. Embankment walls are typically used to support earth only, not roadways or where there is a potential for future underground utilities or drainage structures. The mechanical strength of the wall comes from soil reinforcements comprised of either geogrids or welded wire mesh.

Embankment walls are proprietary wall systems, and there are several approved manufacturers of these types of walls. It is not necessary to design a cast-in-place retaining wall as an alternate; however, the designer shall lay out the embankment wall on the plans with at least the following information:

- Retaining wall plan view with all required dimensions, contours, property lines, utilities, etc.
- Retaining wall elevation view showing top and bottom elevations, approximate step locations, existing and finished grade, etc. Where required, the designer shall also show the location of railings or fences required to be attached to the top of the wall.
- Typical sections (schematic) of the wall showing pay limits and minimum drainage requirements.
- Borings and soils information including the maximum allowable bearing pressure.
- Temporary Sheet piling required for excavation.

5.13.2.1.2 Cast-in-Place Walls

For locations where embankment walls are not appropriate (in accordance with the criteria listed above), a cast-in-place wall should be designed and detailed.

At the discretion of the Department, proprietary walls may also be allowed if the wall is very long resulting in a large overall area. The designer shall provide the same information for proprietary walls as required in Article 5.13.2.2.1.

If the appearance of stone is desired, architectural form liners should be used. These liners are significantly less costly than stone veneer. If there are multiple walls on a project, the surface treatment shall be similar for each wall.

5.13.2.2 *Walls Over Eight Feet (measured from front slope to back slope)*

5.13.2.2.1 Walls With Less Than 5000 ft² of Vertical Face Area (Measured to Bottom of Footing)

For this situation, a cast-in-place wall should be designed to be bid against the proprietary walls. The Contractor may be able to build the

cast-in-place wall with his own forces at a lower cost. For these situations, the designer shall completely design and detail the cast-in-place wall. For the proprietary retaining wall, schematic typical cross sections combined with the cast-in-place details should be enough for the proprietary wall manufacturers to design their walls.

The designer shall provide a list of the specific proprietary walls allowed for each site. For instance, the designer may limit the selection based on the available right of way at a site.

For mechanically stabilized earth walls with metallic soil reinforcements that are to be built in areas of potential stray currents within 200 feet of the structure (for example: an electrified railroad), a corrosion expert shall evaluate the potential need for corrosion control requirements.

If the wall is required to be designed for seismic loads, it shall be stated in the notes for the wall.

5.13.2.2.2 Walls With Over 5000 ft² of Vertical Face Area

For this situation, proprietary retaining walls will most likely be more economical; therefore, a cast-in-place wall design should generally not be done except where site conditions or soil constraints may require a cast-in-place wall. The designer shall determine which proprietary retaining walls are appropriate for each site. The designer shall also lay out the proprietary retaining walls on the plans with at least the following information:

- A list of the specific walls allowed for each site. For instance, the designer may limit the selections based on the available right of way at a site.
- Retaining wall plan view with all required dimensions, offsets, contours, property lines, utilities, etc.
- Retaining wall elevation view showing top and bottom elevations, approximate footing step locations, existing and finished grade, etc. Where required, the designer shall also show the location of railings or fences, light standard and/or sign support anchorage locations, rigid metal conduit and junction boxes.
- Typical Sections (schematic) of the wall showing pay limits and minimum drainage requirements. Specific details are not required for each wall manufacturer, only for each wall type.

- All soils information normally used for the design of a cast-in-place wall shall be shown on the plans including but not limited to borings and allowable soil bearing pressures.
- Temporary Sheet piling required for excavation.
- If the wall is required to be designed for seismic loads, it shall be stated in the notes for the wall.
- For mechanically stabilized earth walls with metallic soil reinforcements that are to be built in areas of potential stray currents within 200 feet of the structure (for example: an electrified railroad), a corrosion expert shall evaluate the potential need for corrosion control requirements.

5.13.2.3 *Architectural Treatments*

If the appearance of stone is desired, architectural form liners should be used. These liners are significantly less costly than stone veneer. Several of the proprietary retaining walls can be built with form liners resembling stone. The designer should contact the approved wall manufacturers for specifics about available form liners. Every effort should be made to keep the surface treatment similar for all the wall types specified.

5.13.2.4 *Large Anticipated Settlements and Liquefaction*

If large settlements or liquefaction are anticipated that require a wall supported on piles, in general, proprietary retaining walls should not be used. Even though these walls can accommodate some settlement, the opening and closing of the joints would produce an undesirable appearance. For these situations, a cast-in-place wall should be designed supported on piles, or the proprietary retaining walls shall be detailed with pile supported full width footings.

5.13.2.5 *Walls Supporting Roadways*

If the wall supports a roadway where there is a possibility of future underground utilities and drainage structures, mechanically stabilized earth walls should not be used. This would not be the case for walls supporting limited access highways. If the utilities are extensive or deep, it may not be possible to use the modular wall options either.

5.13.2.6 *Multiple Walls in Same Project*

If there are several retaining walls within the same project, the designer may wish to require that all walls selected by the Contractor for the project be manufactured by the same wall supplier. This is especially true for walls that are close together.

5.13.2.7 *Pre-Construction Procedures*

The designer should contact the wall companies for tall walls or walls with unusual geometry to be sure that the proprietary walls will function at each site. This should be done during the preliminary design phase of the project.

Prior to construction advertising, the designer should inform in writing each proprietary wall company that they are listed as acceptable alternates on the contract plans. This will allow them to obtain plans and specifications in order to accomplish preliminary design during advertising for the project. Part of this submission should include the anticipated advertising date.

5.13.3 Requirements for Cast-in-place Non-Proprietary Walls

5.13.3.1 *Flared Type Wingwalls and Retaining Walls*

The stems of flared type wingwalls shall be 1'-4" wide at the top, with the rear face battered. The minimum batter shall be 10:1.

5.13.3.2 *U-Type Wingwalls with Sidewalks*

The top of the wingwall section shall conform to the parapet width for the full length. If a batter is required, the rear face shall be vertical to approximately twelve inches below the sidewalk.

5.13.3.3 *U-Type Wingwalls with Sloped Curb*

The top of the wingwall section shall conform to the parapet width for the full length. If a batter is required, the rear face shall be vertical to approximately twelve inches below the bottom of subbase.

5.14 REQUIREMENTS FOR FOUNDATIONS

5.14.1 Structures over Waterways

Substructures for bridges over waterways shall be designed to safely support the structure subjected to the design scour. This policy is based upon the design guidelines contained within the FHWA document entitled "Evaluating Scour at Bridges" (HEC-18), wherein it states that "Bridges should be designed to withstand the effects of scour from a superflood with little risk of failing."

5.14.1.1 *Scour Evaluation Studies*

All bridge scour evaluations shall be conducted with the procedures contained in within the Department's Drainage Manual.

The following categories of reports are available:

Detailed (Level II) Bridge Scour Evaluations and Re-evaluation Reports – These are comprehensive studies accomplished in conformance with the requirements of HEC-18 and the Department's Drainage Manual.

Comparative Scour Reports – These studies were developed using data obtained from Level II evaluations as a basis for determining the scour vulnerability of bridges having similar characteristics. Comparative evaluations are not as detailed as Level II reports, however they do provide NBIS ratings and the associated general scour classifications.

UCGS Screening Reports - These studies, conducted by the U.S. Geological Survey, were undertaken to identify low risk bridges and to prioritize the remaining structures for further study. They are less detailed than either Level II Reports or Comparative Evaluations.

Based on the conclusions noted within these documents, all bridges over water have been classified into one of three general categories, Low Risk (NBIS Item 113 Rating of 8 or 9), Scour Susceptible (NBIS Item 113 Rating 4 or 5) or Scour Critical (NBIS Item 113 Rating of 3 or below). The NBIS Item 113 rating of 7 is reserved for bridge locations at which countermeasures have been installed to mitigate a previous scour problem. If the structure is a clear span bridge (no piers) and if the countermeasures have been designed in accordance with the procedures contained within HEC-23, the bridge may be considered "low risk." When countermeasures are placed adjacent to piers to correct a previous scour condition, the bridge is classified as "scour susceptible."

5.14.1.1.1 New Bridges over Waterways

Level II Scour Evaluations shall be performed for all new bridges over waterways unless one or more of the following conditions apply:

- The bridge has been designed to span the entire floodplain for the superflood (500 year recurrence interval) or the critical design event if less than the 500 year flood.
- The structure foundations will be set directly on sound bedrock.
- The abutment footings will be protected with riprap designed in accordance with the methods outlined in the latest version of

“Bridge Scour and Stream stability Countermeasures” (HEC-23) or successor documents. The use of riprap as the sole means of providing scour protection for new bridges is discouraged as noted below.

5.14.1.1.2 Reconstructed or Rehabilitated Bridges

Generally, scour evaluations shall be performed for all bridges which are to be reconstructed or rehabilitated where significant capital investment is involved and where the bridge has been classified as scour susceptible or scour critical. A significant capital investment correlates to the following improvement categories:

- o Deck replacement
- o Superstructure replacement or widening
- o Modification or major repairs to substructure units

Scour evaluations shall not be required where structures to be reconstructed or rehabilitated have been classified as low risk under the Department’s Bridge Scour Evaluation Program or for scour susceptible bridges which are not undergoing substructure modification and have had countermeasures installed following a Level II study.

Bridges which have been classified as scour susceptible or scour critical shall have hydrologic, hydraulic and scour evaluations performed which are sufficiently detailed to satisfy all applicable design and permitting requirements. If a detailed (Level II) scour evaluation has already been performed, the designer shall modify the results of this document as necessary to incorporate the “Modified Abutment Equations” contained within the Department’s Drainage Manual. All necessary scour countermeasures for scour susceptible or scour critical bridges shall be incorporated into the overall project plans, as appropriate.

5.14.1.2 *Scour Countermeasures*

With regard to abutment or pier foundations, two basic approaches are available to the designer, listed as follows in order of preference:

- a) Design the foundation to resist the effects of scour from a superflood.

Foundations subjected to scour shall be designed with footings supported on piles, footings founded on rock or deep footings (located below the maximum estimated scour). Structural tremies (concrete poured under water which directly supports the foundation loads) will be allowed in very limited situations, only where no other solution is feasible, and only with the approval of the Department. Preference for foundations adjacent to or within waterways will be for pile supported footings or direct foundations on rock. For pile foundations, the top of footing shall be set below the sum of the long-term degradation and contraction scour.

b) Protect the substructure units with riprap or similar armoring layers.

In general, the use of riprap to provide scour protection for new bridges is discouraged and should be used only where it has been demonstrated that alternate, preferred means of designing bridges to be safe from scour related failures are not feasible. On bridge rehabilitation projects where the substructure is being repaired and incorporated in the reconstruction of the bridge, riprap scour countermeasures may be an effective solution for protecting the bridge from scour.

The designer should explore and incorporate into the design all reasonable methods of minimizing local scour, such as the use of embankment or "stub" abutments placed at the top of a protected slope. These types of abutments are much less susceptible to scour than full height abutments. The use of stub abutments does not relieve the requirement for founding on piles or directly on rock. Piers that may experience local scour should be flow aligned and should have streamlined end sections.

5.14.2 Spread Footings on Soil

The top of all footings in soil should be a minimum of twelve inches below the finished grade. The bottom of all footings in soil shall not be less than four feet below, measured normal to the finished grade.

Generally, the use of footing keys to develop passive pressure against sliding is not allowed. The use of passive earth pressure along the sides of foundations to prevent sliding is also not allowed. Resistance from sliding shall be attained through friction between the foundation and the supporting material.

The plans shall show the following:

- The maximum design foundation pressure for the controlling Strength and Service Limit States.

$$\begin{array}{l} \text{Maximum Design Foundation Pressure} = \quad 3.2 \text{ TSF (Strength I)} \\ \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad 2.8 \text{ TSF (Service I)} \end{array}$$

- If applicable, also show the maximum design foundation pressure for the Extreme Event Limit State.

$$\text{Maximum Design Foundation Pressure} = \quad 3.6 \text{ TSF (Extreme Event II)}$$

5.14.3 Foundations on Rock

Generally, for cast-in-place construction, gravity-type or semi-gravity L-type sections shall be used for abutments, wingwalls and retaining walls founded on rock. There is no minimum embedment for footings placed on competent rock. Generally, structural underwater concrete is not permitted.

5.14.4 Driven Piles

Piles may be either end bearing or friction or a combination of the two. Piles end bearing on bedrock or dense hardpan typically are steel H-piles. Piles driven through a high compacted fill or into native soil containing numerous boulders and cobbles shall be steel H-piles. Generally, H-piles shall conform to the requirements of ASTM A709 Grade 50. Friction piles shall be used for most other cases. Generally, friction piles are precast concrete, cast-in-place concrete or prestressed concrete. Timber piles are not permitted.

Piles may be installed vertical or battered. The path of battered piles should be checked to insure the piles remain within the right of way and do not interfere with piles from adjacent and existing substructure units, nor conflict with temporary sheeting or cofferdams.

Pile foundations supporting abutments shall have a minimum of two rows of piles, unless the piles are incorporated into a fully integral abutment. Piles shall be anchored to and embedded in the footings a minimum of twelve inches.

Maximum pile spacing and maximum nominal resistance per pile should be utilized to minimize the number of piles. The lateral resistance of a pile pattern is the combination of the lateral component of the force acting on the battered piles and the lateral resistance of each pile, vertical and battered, in the pattern.

Test piles are typically required to establish pile order lengths and pile capacity for friction piles. If pile driving records and pile load test data are available for a site (e.g. a bridge widening where the same pile type is proposed), specifying the pile order length on the design plans may be

considered. Test piles with dynamic monitoring will still be required to establish the ultimate pile capacity. Static pile load tests may also be considered.

Pile order lengths for end bearing piles on bedrock should be provided on the design plans when there is confidence in the subsurface profile. If a test pile(s) is being considered to establish order lengths for end bearing piles on bedrock, the benefit of the refined pile order length shall be weighed against the time required to obtain the production piles. Test piles with dynamic monitoring and/or static load tests may still be required to establish the ultimate pile capacity. The need for test piles is evaluated by the geotechnical engineer and should be included in the Geotechnical Report.

Readily available pile types should be used whenever possible; especially if the order length can not be established until after test piles are driven. The location of test piles and load tests should be in areas that are readily accessible, and allow enough room for the Contractor to perform the work. A preconstruction test pile program may be considered on large projects where a benefit can be realized by establishing pile type(s) and pile capacity during the design phase.

If no test piles are specified for a given substructure, the estimated pile length shall be used as the pile order length. For these cases, the estimated pile length should be increased slightly to insure there is sufficient length.

The top of all footings should be a minimum of twelve inches below the finished grade. The bottom of all pile caps shall not be less than four feet below, measured normal to the finished grade.

For H-piles, pile point reinforcement and splices shall be prefabricated. The plans shall specify that the Contractor is required to submit pile point reinforcement and splice details to the Engineer for review and approval.

This following note shall be included on the contract drawings. :

Prior to driving the piles, the Contractor shall submit to the Engineer for review and approval his method and sequence of pile driving.
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The pile plan(s) included in the contract drawings shall show or note the following:

- A legend denoting vertical, battered and test piles.
- The number, location and length of test piles, if applicable.

Example:

ULTIMATE PILE CAPACITY	
Abutment 1	XX tons
Pier No. X	XX tons
Abutment 2	XX tons

The Scour and Downdrag resistance along with Φ will be determined by the geotechnical engineer and included in the geotechnical report. The Contractor will use the Ultimate Pile Capacity to properly size pile driving equipment and load testing apparatus. The Engineer will use the Ultimate Pile Capacity to establish the required driving resistance and validate load test results.

5.14.5 Drilled Shafts

VACANT

5.15 EARTH RETAINING SYSTEMS AND COFFERDAMS

5.15.1 Highway Applications

The location and limits, both horizontal and vertical, of all temporary and permanent earth retaining system contract items shall be shown at each location.

5.15.1.1 *Permanent Steel Sheet Piling*

Permanent Steel Sheet Piling is defined as a required and permanent structural element integral to the design of the structure. Permanent Steel Sheet Piling is designed and engineered by the Designer. To avoid unnecessary proprietary specificity, permanent steel sheet piling should be specified and designated by AASHTO or ASTM material classification and minimum required section modulus.

5.15.1.2 *Temporary Earth Retaining Systems*

Temporary earth retaining system shall be any type of adequately braced temporary retaining wall such as temporary sheet piling which the Contractor elects to build to satisfy, and which does satisfy, the condition that existing facilities be properly retained during excavation or fill for the placement of substructure or other facilities. A Temporary Earth Retaining System shall be designated on the plans to be left in place only if its removal may be detrimental to the structure. The item "Earth Retaining System Left in Place" shall be used only for a Temporary Earth Retaining System designated by the Designer to be left in place. A Temporary Earth Retaining System requested by the Contractor to be left in place for his own convenience is not compensable for additional payment.

5.15.2 Railroad Applications

The location and limits, both horizontal and vertical, of all temporary and permanent earth support systems necessary for the construction of railroad structures must be shown on the plans. All plans for temporary and/or permanent earth support systems for railroad structures must be submitted to the affected railroad for review during the standard project design submission phases. Contract plan details for temporary earth support in railroad applications must be specific in name and include a railroad parenthetical in the contract item name. Typical items for such use are "Temporary Sheet Piling (Railroad)" and "Soldier Pile and Lagging (Railroad)". The Designer should select the most appropriate temporary retaining system type in consideration of existing soil conditions and construction access limitations.

5.15.2.1 *Permanent Steel Sheet Piling*

Permanent Steel Sheet Piling adjacent to railroad tracks shall be designed for each specific location and shown on the plans. It should be specified and designated as noted in Section 5.15.2 above.

5.15.2.2 *Temporary Earth Support Systems*

Through communication with the affected railroad company during a project's scope development, a determination will be made whether or not a complete design for a temporary earth support system is required. When the temporary earth support system is fully designed by the Designer, the contract special provision for the subject item should allow for the Contractor to submit an alternate design.

The Designer shall evaluate the global stability of the railroad embankment for the temporary (and permanent) condition. In cases where the stability of the embankment may be compromised, the Designer shall either provide a complete design or include the necessary constraints for a Contractor to properly design the earth support system.

Working drawings and design calculations prepared by the Contractor shall be submitted to the Department and affected railroad company for review.

Items, such as "Sheet Piling left in Place (Railroad)" and "Soldier Pile and Lagging Left in Place (Railroad)" shall be designated on the plans only if their removal may be detrimental to the structure, as determined by the Designer in concert with the affected railroad company. Any system requested to be left in place by the Contractor for his convenience is not compensable.

5.15.3 *Cofferdams and Temporary Water Diversions*

Cofferdams and various methods to temporarily divert water from the site are used so that construction can take place in the dry. Various methods and items may be used to achieve this end depending on the nature of the site, the nature of the construction, and the amount of water encountered. Because of the need to secure environmental permits, considerable detail of the dewatering plan intended may be required on the plans.

The following items may be used:

5.15.3.1 *Structure Excavation (Complete)*

The items "Structure Excavation-Earth (Complete)" or "Structure Excavation-Rock (Complete)" are generally used where water intrusion into the excavation results from groundwater seepage or very minor stream or drainage flow. There is no additional payment for dewatering or temporarily diverting water since the work required to construct in the dry is considered to be of such a minor nature that it can be considered to be incidental to the excavation items. Any cofferdams, temporary diversion, pumping, or any other dewatering methodology is included in the cost of the work. Generally, since the impact on water resources is so small, very little detailing is required on the plans.

5.15.3.2 *Handling Water*

The item "Handling Water" is generally used where a temporary diversion of a watercourse is required and is generally used for construction of culverts or retaining walls adjacent to the watercourse. This lump sum item includes any temporary water diversion structures such as barriers, temporary pipes, or drainage channels, necessary to complete the work. Also included is any excavation required to accomplish the temporary diversion of water.

Any required excavation for the permanent construction will be paid for under the items "Structure Excavation-Earth (Complete)," "Structure Excavation-Rock (Complete)" or appropriate trench excavation items. A conceptual scheme showing all temporary water diversion structures such as barriers, temporary pipes, and drainage channels, and a conceptual scheme for staging of construction for water handling must be shown on the plans and will usually be included in permit applications. The hydraulic design of the aforementioned temporary facilities is based on the watercourse hydrology and information contained in Section 6.15 of the Department's Drainage Manual. A temporary design water surface elevation associated with the proposed temporary hydraulic facility should be shown on the plans and the permit plates.

The contractor will be required to submit working drawings to detail the proposal shown on the contract plans. If the contractor's working drawings differ from the proposal shown on the contract plans to the extent that a revision to the permit is required, the contractor will be required to prepare and apply for any revisions required to the permit.

5.15.3.3 *Cofferdam and Dewatering*

The item "Cofferdam and Dewatering" is generally used where substructure elements are located partly or wholly in the streambed and where the

bottom of footing is below water level, or on foundation work where considerable flow or concentration of water is present that cannot be conveniently diverted from the site. The extent of work involved in placing and dewatering the cofferdam is such that it is more than a minor part of the excavation items and is not considered incidental to those items. This item should be used in conjunction with the items "Structure Excavation-Earth (Excluding Cofferdam and Dewatering)" and "Structure Excavation-Rock (Excluding Cofferdam and Dewatering)".

A cofferdam forms an enclosure that may be completely dewatered to allow work in the dry. It may consist of steel sheet piling or any other material the contractor elects to use to satisfy this requirement. Some sides of the cofferdam may be formed by the existing stream bank or by existing structures such as abutments or retaining walls. However, any existing structures intended to be used must extend below the anticipated bottom of excavation and must be resistant to intrusion of significant amounts of water from below the footing.

Cofferdams that encroach into water channels must be hydraulically analyzed based on the watercourse hydrology and information contained in Section 6.15 of the Department's Drainage Manual. A temporary design water surface elevation associated with the proposed temporary hydraulic facility should be shown on the plans and the permit plates.

The horizontal and vertical limits of the cofferdam must be shown on the plans. Cofferdams are designed and detailed by the Contractor and submitted to the Engineer for review.

Section 6
CONCRETE STRUCTURES

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Section 6

CONCRETE STRUCTURES

6.1 MATERIALS

6.1.1 Concrete

6.1.1.1 *Cast-In-Place Concrete*

Concrete for cast-in-place concrete members or components shall conform to the requirements for classes of concrete in the *Standard Specifications* and Special Provisions.

The concrete classes, densities and compressive strengths are:

Class or Type of Concrete	Density (lb/ft ³)	f'c (psi)	Comments
"A"	150	3000	use <i>Standard Specifications</i>
"F"	150	4000	use <i>Standard Specifications</i>
"S"	150	3000	Special Provision Required
Lightweight	115	4000	Special Provision Required
Underwater	150	-	use <i>Standard Specifications</i>

If required (such as for cast-in-place post-tensioned concrete pier caps), concrete with greater compressive strength may be used.

6.1.1.2 *Precast, Non-Prestressed Concrete*

Concrete for precast, non-prestressed members or components shall conform to the requirements in the *Standard Specifications* and Article 6.3.3.1.

6.1.1.3 *Precast, Prestressed Concrete*

Concrete for prestressed concrete members or components shall conform to the requirements in the *Standard Specifications* and Article 6.3.4.5.

6.1.2 Reinforcement

6.1.2.1 *Non-Prestressed Steel*

Non-prestressed steel shall conform to the following:

- Uncoated bar reinforcement shall conform to the requirements of ASTM A615, Grade 60.

- Epoxy coated bar reinforcement shall conform to the requirements of ASTM A615, Grade 60 and be epoxy coated to the requirements of ASTM D3963.
- Galvanized bar reinforcement shall conform to the requirements of ASTM A615, Grade 60 and be galvanized, after fabrication, to the requirements of ASTM A767, Class 1, including supplemental requirements.
- Weldable bar reinforcement shall conform to the requirements of ASTM A706.
- Welded wire fabric shall conform to the requirements in the *Standard Specifications*.

6.1.2.2 Prestressed Steel

Prestressing steel shall be ½" diameter, uncoated, low relaxation strands conforming to the requirements of AASHTO M203, Grade 270.

6.1.3 Protective Coatings on Concrete Surfaces

The use of clear, penetrating, protective coatings and sealers on concrete is not permitted due to the long term maintenance requirements.

The use of colored protective coatings and sealers is permitted only with the written approval of the Department.

For dampproofing requirements, see Section 5.

6.2 FABRICATION REQUIREMENTS

6.2.1 General

The prestressed concrete fabricator's plant shall be certified by the Precast Prestressed Concrete Institute Plant Certification Program. The certification shall be as a minimum in the B3 Category, except for draped strand members, in which case a B4 Category certification is required. The certification requirements shall be shown on the plans.

6.2.2 Tolerances

Tolerances for prestressed members shall conform to the limits specified in the *Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products* (MNL-116).

6.3 DESIGN AND DETAILING REQUIREMENTS

6.3.1 Cast-In-Place, Non-Reinforced Concrete Members

Cast-in-place non-reinforced concrete members and components are not permitted, except for the use of underwater concrete for cofferdam seals. A cofferdam seal shall not be considered a structural member or component.

6.3.2 Cast-In-Place Reinforced Concrete Members

6.3.2.1 *General*

The use of cast-in-place reinforced concrete is acceptable for all types of members and components. Generally, cast-in-place concrete is used for substructure components, bridge decks and parapets. However, cast-in-place concrete may be used for superstructures when it is found to be economical and feasible.

6.3.2.2 *Concrete*

Generally, "Class "A" Concrete" shall be specified for more massive structure components such as footings and abutment or retaining wall stems.

Generally "Class "F" Concrete" shall be specified for components or elements requiring greater strength, increased durability or smaller coarse aggregate size such as pier columns and caps, bridge decks and parapets.

"Class "S" Concrete" is normally used for the repair of concrete substructures units and retaining walls. For additional information, see Section 16.

The concrete pay item for each component shall be clearly noted on the plans.

The concrete classes/types used in reinforced concrete members and components shall be as follows:

Component	Concrete Class/Type	Pay Item
Superstructure		
Deck	"F"	Class "F" Concrete
Deck (Lightweight)	Lightweight	Lightweight Concrete
Deck Parapet	"F"	Class "F" Concrete
Bridge Sidewalk	"F"	Class "F" Concrete
Median Barrier	"F"	Class "F" Concrete
Approach Slab	"F"	Class "F" Concrete
Slab Bridges	'F'	Class "F" Concrete
Foundation		
Piles	"A"	Class "A" Concrete
Substructure		
Footing	"A"	Class "A" Concrete
Abutment Stem	"A"	Class "A" Concrete
Bearing Pads	"F"	Class "F" Concrete
Wingwall Stem	"A"	Class "A" Concrete
Pier Column & Caps	"F"	Class "F" Concrete
Pier Walls & Shafts	"F"	Class "F" Concrete
Retaining Wall Stem	"A"	Class "A" Concrete
Retaining Wall Parapet	"A"	Class "A" Concrete
Substructure Repairs	"S"	Class "S" Concrete
Box Culverts		
Culvert (Cast-In-Place)	"F"	Class "F" Concrete
Cutoff & Return Walls	"A"	Class "A" Concrete
Nosing and Sills	"A"	Class "A" Concrete
Headwalls & Parapets	"A"	Class "A" Concrete

6.3.2.3 Reinforcement

Reinforcement shall generally be bar reinforcement conforming to the requirements of ASTM A615, Grade 60 and shall be specified as follows:

- Uncoated bar reinforcement - generally used for all components except as noted below.
- Epoxy coated bar reinforcement shall be used in superstructures, decks, deck parapets, median barriers; stems of concrete barrier curbs; and approach slabs.

The minimum size bar shall be #4, unless otherwise noted. In general, the spacing of bar reinforcement shall be limited to six-inch increments.

The minimum cross sectional area of load carrying reinforcement provided shall be that supplied by #5 @ twelve inches.

Bar lengths shall be specified in one-inch increments. The maximum length of bar reinforcement detailed shall be 40 feet. Where longer bars are required, splices shall be detailed. The use of mechanical connections to splice reinforcement is permitted provided the connectors meet the *AASHTO Specifications*. Mechanical connectors used to splice coated reinforcement shall be coated with the same coating as the coated reinforcement. Mechanical connectors shall be measured for payment by the number of connectors installed and accepted.

The designer is responsible for providing all of the details necessary to ensure the reinforcement is embedded, developed and spliced in accordance with the *AASHTO Specifications*.

The concrete cover over reinforcement shall conform to the requirements in the *AASHTO Specifications*, unless otherwise noted. The concrete cover over the reinforcement shall be shown on the plans.

The reinforcement pay items shall be clearly noted on the plans.

6.3.3 Precast, Non-Prestressed Concrete Members

6.3.3.1 General

Precast, non-prestressed superstructure members supporting vehicular traffic are not permitted.

For permanent and temporary precast concrete barrier requirements, see Section 12. For precast concrete box culvert requirements, see Section 13.

6.3.3.2 Concrete

The design of precast, non-prestressed members shall be based on a minimum concrete compressive strength (f'_c) of not less than 5000 pounds per square inch.

6.3.3.3 Reinforcement

Reinforcement shall conform to the requirements of Article 6.3.2.3.

6.3.4 Precast, Pretensioned Concrete Members

6.3.4.1 *Structure/Member Types*

6.3.4.1.1 Standard Members

In order to reduce fabrication costs, precast, pretensioned concrete superstructures shall be limited to the following standard member types: prestressed deck units and New England bulb tee girders. These standard member sections were developed by the PCI New England Technical Committee, of which the Department is a member, and meet the fabrication and tolerance practices of area precast concrete fabricators.

Prestressed deck units are precast, pretensioned rectangular sections with or without voids. Sections with circular voids are referred to as voided slabs and sections with rectangular voids are referred to as box beams. Sections without voids are referred to as solid slabs.

The New England bulb tee girders were developed by the technical committee to replace AASHTO/PCI I-girders. The use of AASHTO/PCI I-girders is not permitted.

The use of other precast members is permitted only with the written approval of the Department.

6.3.4.1.2 Modifications to Standard Members

The shape and dimensions of the New England bulb tee girders shall not be altered or modified, except as follows:

- The top flange at the girder ends may be clipped to minimize the bridge seat widths at abutments.
- Prestressed deck units may be modified to facilitate the placement of reinforcement that extends out of the members for components such as parapets and sidewalks or to accommodate drilled-in anchors for temporary precast barrier curb. The circular and rectangular voids in the deck units may be reduced in size or removed for placement of the reinforcement. Generally, the voids shall be placed symmetrical about the vertical axis of the member. The designer shall calculate the section properties for the modified sections.
- Spread deck units may be detailed without shear keys and holes for post-tensioned transverse strands.

- The fascia member of structures composed of butted deck units shall be detailed without a shear key.

6.3.4.2 Layout and Framing

6.3.4.2.1 Approximate Span Lengths

The following are the approximate simple span lengths for structures composed of butted deck units:

Deck Unit Type	Approximate Maximum Span Length (ft)
Solid Slabs	25
Voided Slabs	45
Box Beams - Straight strands	90
- Deflected strands	105

The following are approximate maximum simple span lengths for structures composed of New England Bulb Tee girders:

Girder Type	Girder Spacing (ft)		
	6	8	10
NEBT 40	90	80	75
NEBT 48	105	90	85
NEBT 56	120	105	95
NEBT 64	130	120	105
NEBT 72	140	125	115

Note: Longer spans may be obtained by using field-spliced post-tensioned bulb tees. For continuous spans utilizing field-spliced post-tensioned bulb tees, these span lengths can be assumed to be measured from dead load inflection points. See Article 6.3.4.4.3.

6.3.4.2.2 Oversized Members

Precast members over 120 feet in length or over 120,000 pounds will not be allowed due to shipping limitations. For members in excess of 120 feet, the use of field spliced post-tensioned bulb tees should be considered. For additional information, see Section 1.

6.3.4.2.3 Skew Angle

On structures composed of butted deck units, the maximum allowable skew angle is 45°.

6.3.4.2.4 Member Dimensions

Preferably, all members in a span shall have the same dimensions to facilitate fabrication and minimize costs. Generally, on multi-span structures, the individual span lengths may vary but the member depth should be constant.

Preferably, structures composed of butted deck units shall be designed with 3'-11½" wide members. Typically, the cost per square foot of deck surface is less for 3'-11½" wide members than it is for 2'-11½" wide members due to high fabrication costs.

If members with varying section properties are used in the same cross section, the distribution of loads must take into account the stiffness of each member. For more information, see Section 3.

6.3.4.2.5 Member Spacing

In structures composed of bulb tee girders or spread deck units, the member spacing should be maximized in order to reduce the number of members required and to develop the full potential of each member, thereby reducing the costs for fabrication, shipping and erection. However, in order to provide redundancy, a minimum of four stringer lines should be used in a cross section.

In structures composed of butted deck units, the members shall be placed at a nominal spacing to provide a gap between the adjacent members that accommodates the sweep of the members. The 2'-11½" wide members should be nominally spaced at three feet. The 3'-11½" wide members should be nominally spaced at four feet. The nominal spacings were determined by increasing the actual member width to a convenient value. The spacings have not been set at the maximum allowable sweep, since it varies with the span length. If the actual sweep of the members will not allow the members to be placed at the nominal spacing shown, the members should be butted up to and placed parallel with the adjacent member.

6.3.4.2.6 Framing Geometry

Members should be placed parallel to traffic and each other, and shall be uniformly spaced as much as practical. If this is unavoidable, the live load distribution factors as outlined in the *AASHTO Specifications* shall not be used. The designer should carefully investigate these situations to account for the variation in live load and member stiffness.

6.3.4.2.7 Cross Section

Structures composed of bulb tee girders or spread deck units require a composite concrete deck. The deck shall be detailed to match the roadway cross section. The members shall be placed plumb.

On structures composed of butted deck units, the members may be placed on either a straight (level or sloped) or broken cross section alignment. The alignment of the members need not match the roadway cross section. The bituminous concrete overlay shall be placed to match the roadway cross section.

6.3.4.2.8 Deck Overhang

The concrete deck overhang, measured from the centerline of the fascia member to the outside edge of the deck, should be limited to four feet or the depth of the member, whichever is less.

6.3.4.3 *Composite Construction*

6.3.4.3.1 General

All structural members in contact with and supporting a concrete deck shall be designed for composite action. The members shall be designed assuming construction without shoring (unshored construction).

6.3.4.3.2 Design Requirements

The composite section used for computing live load stresses shall also be used for computing stresses induced by composite dead loads.

The elasticity ratio for composite design shall be computed based on the modulus of elasticity of the concrete deck and the modulus of elasticity of the prestressed concrete member.

The shear reinforcement used in the design of the members should be used to achieve composite action with the deck. Additional reinforcement may be added if the area of shear reinforcement is not sufficient to produce composite action. There is no need to extend all shear reinforcement into the deck if it is not required for composite action.

6.3.4.3.3 Detailing Requirements

Shear reinforcement used for composite action shall be extended into the concrete deck. In deck unit members, the reinforcement shall be fabricated from one bar and have two loops that extend into the deck. In bulb tee members, the reinforcement shall be terminated with a 90° hook.

The top surface of the members shall be roughened with a raked finish to assist in composite action. The following note, with a leader pointing to the top surface of the member, shall be shown on the plans:

Raked Finish

6.3.4.4 Continuity on Multi-Span Structures

6.3.4.4.1 General

Deck joints should be eliminated wherever possible. The number of deck joints over piers shall be minimized on multiple span structures by using continuous decks.

6.3.4.4.2 Continuous Decks Supported by Simple Spans

On multi-span structures composed of simple spans, the decks shall be made continuous over the piers with no positive moment connection, wherever practical. The supporting members shall be designed as simple spans.

National Cooperative Highway Research Program (NCHRP) Report Number 322 "Design of Precast Prestressed Bridge Girders Made Continuous" suggests that consideration should be given to the design of jointless bridges (that is, members with a continuous slab with no moment connection), since there is little or no structural advantage to designing for live load continuity.

On structures composed of bulb tee girders or spread deck units, the deck shall be placed continuous over a full height diaphragm. The diaphragm shall be placed at the piers between the ends of the members in adjacent spans and extend transversely between the parallel members.

On structures composed of butted deck units, the ends of the members shall be connected with a "T - shaped" closure pour.

6.3.4.4.3 Continuous Decks supported by Continuous Members

Multi-span structures composed of continuous spans shall be designed with field spliced post-tensioned bulb tee girders. The bulb tee girders shall be pretensioned to control cracking during shipping and handling. The pretensioning of the girders shall be accounted for in the final design. Field splices in the members should be made near points of low dead load moment.

6.3.4.5 Concrete

The concrete design strength for prestressed members shall be as follows:

- The design of prestressed members shall be based on a minimum concrete compressive strength (f'_c) of not less than 5000 pounds per square inch. The recommended concrete compressive strength is 6500 pounds per square inch. Concrete compressive strengths greater than 6500 pounds per square inch may be used subject to approval by the Department.
- The compressive strength of the concrete at the time of transfer (f'_{ci}) shall not be less than 4000 pounds per square inch.

The allowable concrete stresses in the prestressed members shall conform to the AASHTO *Specifications* except as follows:

- The maximum allowable tension stress in tension areas (such as member ends at top) shall be $0.0948 \times (f'_{ci})^{1/2}$ at release before losses due to creep and shrinkage.
- The maximum allowable tension stress in the pre-compressed tensile zone (such as mid-span bottom) shall be $0.0948 \times (f'_c)^{1/2}$ at service load after losses have occurred.

The required compressive strength at the time of transfer f'_{ci} and the required 28-day compressive strength of concrete f'_c shall be clearly noted on the plans.

6.3.4.6 Reinforcement

6.3.4.6.1 Non-Prestressed Steel

In prestressed deck units, the non-prestressed steel, including the reinforcement extending out of the units, shall be epoxy coated bar reinforcement.

In bulb tee girders, the non-prestressed steel, except for the stirrups, shall be epoxy coated bar reinforcement. The stirrups may be either epoxy coated bar reinforcement or epoxy coated welded wire fabric.

The minimum size bar shall be #3. In general, the spacing of bar reinforcement shall be limited to four-inch increments.

Bar lengths, if specified, shall be in one-inch increments. The maximum length of bar reinforcement detailed shall be 40 feet. Where longer bars are required, splices must be detailed.

The designer is responsible for providing all of the details necessary to ensure the reinforcement is embedded, developed and spliced in accordance with the AASHTO *Specifications*.

The concrete cover over reinforcement shall conform to the requirements in the *AASHTO Specifications*, unless otherwise noted. The concrete cover over the reinforcement shall be shown on the plans.

The reinforcement pay items shall be clearly noted on the plans.

6.3.4.6.2 Prestressed Steel

The prestressing strands shall be tensioned to the allowable stresses listed in the *AASHTO Specifications*.

Typical strand patterns and the maximum number of strands for the various prestressed members are shown in Division III. Generally, the strands are spaced two inches apart, both horizontally and vertically. The strand patterns are for design purposes only and shall not be shown on the plans.

Preferably, all members in a span shall have the same number of strands, prestressing force and distance to the center of gravity of the strands to facilitate fabrication and minimize costs.

Strands may be either draped or de-bonded to reduce the tensile stresses at the member ends. Mixing draped and de-bonded strands in a member is permitted.

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

If de-bonded strands are used, no more than 25% of the total number of strands may be de-bonded. All de-bonding shall be located within a distance of 15% of the span length from the end of the member. The de-bonded strands shall be well distributed across the member cross section. No two adjacent strands (either horizontally or vertically) shall be de-bonded, although diagonally adjacent strands may be de-bonded. The outermost strands of each layer shall not be de-bonded.

The following information shall be shown on the plans:

- the ultimate tensile strength of the strands,
- the jacking force per strand,
- the number of strands,
- the center of gravity of strands,
- the strand diameter,
- de-bonding locations (if required), and
- the approximate location of drape points (if required).

6.3.4.7 *Camber*

6.3.4.7.1 General

Camber induced by prestressing shall be computed in such a manner as to include the effects of creep and growth in the modulus of elasticity. Sufficient camber should be induced in each member such that a net positive camber will remain under all dead loads.

6.3.4.7.2 Simple Spans

Dead load deflection and camber diagrams are not required for simple span bridges. Dead load deflections and cambers shall be calculated at the mid-span of the structure for the following listed items for each member and tabulated on the plans:

- Prestressed Beam Deflections. Deflections due to the weight of the beams calculated using the moment of inertia of the prestressed beam.
- Additional Dead Load Deflections. Deflections due to the uncured concrete slab, haunches, diaphragms, utilities and any other loads supported by the prestressed beam section alone.
- Composite Dead Load Deflections. Deflections due to the parapets, curbs, sidewalks, railings, bituminous concrete overlay and any other loads that are placed after the slab has cured and are supported by the composite section. (Structures composed of bulb tees girders or spread box beams with a composite deck only).
- Member Cambers (calculated at the following stages):
 - At Transfer. Camber due to pretensioning force at transfer minus the deflection due to the dead load of the member.
 - At Erection. Camber (due to pretensioning force minus the deflection due to the dead load of the member) that is present at approximately 30 days after transfer.
 - Final. Camber after all dead loads are applied to the structure, and after long term creep and relaxation have taken place.

An acceptable method for estimating cambers and deflections in simple span members using multipliers can be found in the "PCI Design Handbook - Precast and Prestressed Concrete."

6.3.4.7.3 Continuous Spans

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6.3.4.8 Diaphragms

Structures composed of bulb tee girders or spread deck units with a composite concrete deck shall have intermediate and end diaphragms.

On bridges with spans less than or equal to 80 feet, one intermediate diaphragm shall be placed between the members at mid-span. On bridges with spans greater than 80 feet, intermediate diaphragms shall be placed between the members at third points along the span.

On bridges skewed less than or equal to 30°, the intermediate diaphragms shall be placed in line along the skew. On bridges skewed more than 30°, intermediate diaphragms shall be placed normal to the main members and staggered, not placed in a line, across the width of the bridge.

End diaphragms shall be placed between members at all abutments and piers. End diaphragms shall be placed over and aligned with the centerline of each bearing line.

Intermediate and end diaphragms shall be comprised of cast-in-place concrete and be monolithic with the concrete deck. The use of steel diaphragms will not be permitted. The intermediate and end diaphragms shall be detailed to accommodate utilities as required. Diaphragms shall be completely cured prior to placement of the deck concrete in order to provide stability to the superstructure members.

6.3.4.9 Post-Tensioned Transverse Strands

Structures composed of deck units placed butted to each other shall be post-tensioned transversely with prestressing strands.

The number and location of these transverse ties is dependent upon the following: the length of the member, the depth of the member, the skew angle of the structure, and stage construction. Based on the skew angle of the structure, the ties may be placed parallel to the skew of the structure or normal to the sides of the member. See Division III for additional details.

The appropriate post-tensioning procedure along with the following note shall be shown on the plans:

No additional dead loads or live loads shall be applied to the butted deck units until the transverse ties have been fully tensioned and the
--

grout in the longitudinal shear keys has reached a seven-day compressive strength of 4500 psi.

The transverse strands shall be post-tensioned in accordance with one of the following procedures:

For structures with skew angles less than or equal to 30°:

TRANSVERSE STRAND POST-TENSIONING PROCEDURE

1. After erecting the prestressed deck units for the construction stage, install the transverse ties.
2. Tension each transverse tie to 5 kips.
3. Seal the bottom of the longitudinal shear keys with closed cell polyethylene foam backer rod and place non-shrink grout in the longitudinal shear keys and internal diaphragms. The grout shall be rodded or vibrated to ensure that all the voids in the shear keys are filled.

4. On shallow members with one row of ties, include the following note:

When the grout has attained a compressive strength of 1500 psi, tension each transverse tie to 30 kips.

On deep members with two rows of ties, include the following note:

When the grout has attained a compressive strength of 1500 psi, at each transverse tie location tension the bottom tie to 15 kips, then the top tie to 15 kips. Repeat this tensioning sequence once more so that each tie is tensioned to 30 kips.

NOTE: Where the total initial post-tensioning force of all the transverse ties is sufficient to displace the exterior members, the designer shall modify the post-tensioning procedures to require placement of hardwood shims between the members. The designer shall specify the number and location of these shims. The shims shall be placed between as many members as is required such that the total initial post-tensioning force does not displace any members.

For structures with skew angles greater than 30°:

TRANSVERSE STRAND POST-TENSIONING PROCEDURE

1. As each member is being erected, install the transverse ties and place hardwood shims between the adjacent deck units at each transverse tie hole location on the top and bottom.
2. On shallow members with one row of ties, include the following note:

Secure each member to the preceding member by tensioning each transverse tie to 30 kips before erecting the next member.

On deep members with two rows of ties, include the following note:

Secure each member to the preceding member by first tensioning the bottom tie at each transverse tie location to 15 kips, then the top tie to 15 kips. Repeat this tensioning sequence once more so that each tie is tensioned to 30 kips.
3. After all the members have been erected, seal the bottom of the longitudinal shear keys with closed cell polyethylene foam backer rod and place non-shrink grout in the longitudinal shear keys and internal diaphragms. The grout shall be rodded or vibrated to ensure that all the voids in the shear keys are filled.
4. When the grout has attained a compressive strength of 1500 psi, remove the hardwood shims. The voids left in the grout from the top shims shall be filled with grout. The voids in the grout from the bottom shims may be left unfilled.

6.3.4.10 *Drilling Holes*

The drilling of holes in (or the use of power actuated tools on) prestressed members shall not be permitted. However, inserts for attachments may be placed in the members during fabrication.

The following note shall be shown on the plans:

The drilling of holes in (or the use of power actuated tools on) prestressed members will not be permitted.

6.3.4.11 Seismic Restraint

6.3.4.11.1 General

All structures shall include restraint devices or connections, such as keeper blocks, bearings or dowels, designed to transfer seismic forces from the superstructure to the substructure.

The design and detailing of the restraint devices or connections shall account for thermal movement of the structure.

6.3.4.11.2 Transverse Seismic Restraint

On structures composed of bulb tee girders or spread deck units, supported by seat type abutments, the superstructure shall be restrained transversely by a keeper block placed between the center members at abutments. If necessary, multiple keeper blocks may be used at each abutment to resist the forces. At piers supporting members with a continuous deck, the superstructure shall be restrained with dowels projecting from the pier into the full height diaphragm. At piers supporting members with a discontinuous deck, the superstructure shall be restrained transversely by a keeper block placed between the center members at abutments.

On structures composed of butted deck units, the superstructure shall be restrained transversely by cheekwalls located at each end of the abutments and piers.

6.3.4.11.3 Longitudinal Seismic Restraint

On structures composed of bulb tee girders or spread deck units, the superstructure shall be restrained longitudinally by keeper blocks placed behind the end of each member at abutments after their erection.

On structures composed of butted deck units, the superstructure shall be restrained longitudinally by a backwall placed behind the ends of the members at the abutments after their erection.

6.3.4.12 Bearings

In general, elastomeric bearings shall be used to support prestressed deck units and bulb tee girders. The bearings may be either plain or steel-laminated.

On structures composed of butted deck units, the use of a single sheet of elastomer, placed continuous between the fascia units, is not permitted. Each deck unit shall rest on two individual bearings.

For additional bearing requirements, see Section 9.

6.3.4.13 Superstructure Jacking Requirements

6.3.4.13.1 General

Since future maintenance of the elastomeric bearings is not anticipated, provisions for jacking the superstructure of prestressed concrete bridges supported by elastomeric bearings are not required. For other prestressed concrete bridges that incorporate sliding bearings, the following provisions shall apply.

6.3.4.13.2 Design Requirements

Provisions for jacking of the superstructure shall be provided at all locations that have bearings that will require future maintenance. These bearings include all types that have sliding or rolling surfaces such as pot, disc, spherical, etc. Supports designed with non-sliding type bearings such as elastomeric and fixed steel bearings do not need to have jacking provisions specifically designed.

Lift points shall be located adjacent to the bearings and may be on main or secondary members. Preferably, lift points shall be over the bridge seats of abutments and the tops of piers so that jacks may be founded on these components minimizing the need for extensive temporary structures.

The jacking lift points shall be designed for the total dead load and the live load plus impact. If there are more than five lines of girders, the jacking lift points shall be designed for 150% of these values in order to jack individual girders in the future.

Superstructure and substructure members and components shall be strengthened as required to support the jacking loads.

6.3.4.14 Utilities

On structures composed of bulb tee girders or spread deck units, the utilities may be placed between adjacent members. The intermediate and end diaphragms shall be detailed to accommodate utilities as required.

On structures composed of butted deck units, the utilities may be placed between two members in a utility bay located under a sidewalk. Under no circumstances will utilities be permitted to be located inside deck units.

For additional information, see Section 15.

6.3.5 Cast-In-Place Concrete Beams

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6.3.6 Precast, Post-Tensioned Concrete Members

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Section 7
STEEL STRUCTURES

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Section 7
STEEL STRUCTURES

7.1 MATERIALS AND FABRICATION

7.1.1 Structural Steel Designations

AASHTO M270, Grade 50 shall generally be used for all structural steel. If the structure is to remain uncoated and allowed to weather, AASHTO M270, Grade 50W should be used.

The structural steel designations shall be shown on the plans. The designations shall reference AASHTO material specifications and include the applicable suffix codes. The suffix "T" indicates a Non-Fracture Critical material whereas an "F" indicates a Fracture Critical material. The "T" or "F" is followed by the appropriate AASHTO temperature zone for Connecticut, which is "2."

Examples:

Non-Fracture Critical Bridge Members	AASHTO M270 Grade 50 T2 AASHTO M270 Grade 50 WT2
Fracture Critical Bridge Members	AASHTO M270 Grade 50 F2 AASHTO M270 Grade 50 WF2

7.1.2 Coated and Uncoated Structural Steel

Structural steel bridges may be either coated or uncoated. Coated steel shall be either shop painted, galvanized or metallized. Uncoated steel shall be weathering steel.

7.1.2.1 Coated Structural Steel

In general, structural steel bridges shall be painted. Shop painted structural steel shall be prepared and coated in accordance with the special provision, entitled "Structural Steel (Site No.)."

With the exception of major structures or architecturally or historically significant structures, the choice of color on new painted steel, and for field painting of existing steel, shall be limited to the following:

- a. Green - Federal Standard 595, Color No. 24172
- b. Green - Federal Standard 595, Color No. 24277
- c. Blue - Federal Standard 595, Color No. 26329

The use of galvanized steel or metallizing should be considered in order to reduce future maintenance obligations.

7.1.2.2 *Uncoated Weathering Steel*

Where weathering steel has been found to be appropriate in accordance with Department guidelines, its use should conform to the FHWA Technical Advisory T5140.22, "Uncoated Weathering Steel in Structures," dated Oct. 3, 1989, and amended as follows:

- a. The design of weathering steel for bridges subject to vehicular salt spray, near a salt water environment, or a heavy industrial area should incorporate modest increases in flange plate thicknesses to allow for some minor section loss in the future.
- b. 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 in accordance with the special provision, entitled "Structural Steel (Site No.)." The intermediate coat shall be white (Federal Standard 595 Color No. 27925) in order to facilitate bridge inspection.
- c. Whenever possible, unpainted weathering steel bridges must be designed to eliminate deck joints. If deck joints cannot be eliminated, the areas adjacent to the joints shall be protected from leakage. Generally, the ends of the beams directly under joints can be painted for protection. The topcoat shall be Brown, Federal Standard 595 Color No. 20062. The steel should be painted for a distance approximately equal to one and one half times the depth of the girder on either side of the joint. All structural steel components within this distance (such as diaphragms, cross-frames, connection plates, stiffeners, etc.) shall also be painted.

The limits of the structural steel requiring painting shall be delineated on the plans.

- d. Proper precautions should also be taken to minimize substructure staining for construction conditions and the service life of the bridge. In general, this will include providing catchments and diversion bars at all bearings and ensuring that the Contractor adequately protects the substructure during construction.
- e. Provisions should also be included to control vegetation growth under the structure to reduce the moisture in the air that could have a detrimental effect on the structure.

7.1.3 Fasteners

Fasteners shall be high-strength bolts conforming to the requirements of ASTM A325 or A490.

On coated structures, the high-strength bolts shall conform to ASTM A325, Type 1 and be mechanically galvanized in accordance with ASTM B695, Class 50. On uncoated, weathering steel structures, the high-strength bolts shall conform to ASTM A325, Type 3 or ASTM A490, Type 3, although ASTM A325 is preferred.

The high-strength bolts may be installed and tightened using compressible washer type direct tension indicators conforming to ASTM F959.

The high-strength bolt, nut and washer designations shall be shown on the plans. These designations shall reference ASTM *Specifications*, and include types and grades where applicable.

Generally, standard-sized holes shall be specified in the component parts of bolted connections. Where design considerations permit, however, connections should be designed to accommodate oversized holes to allow for potential enlargement of holes in the field where necessary to facilitate field erection.

7.1.4 Welding

Welding of fracture critical and non-fracture critical structural steel members or components for highway bridges shall conform to the ANSI/AASHTO/AWS D1.5 - *Bridge Welding Code*.

Welding of structural steel members or components, such as sign supports and inspection platforms, shall conform to the ANSI/AASHTO/AWS D1.1 - *Structural Welding Code*.

Welding symbols shall conform to the latest edition of AWS A2.4 - Standard Symbols for Welding, Brazing and Nondestructive Examination.

Fillet weld sizes shall be shown on the plans and shall conform to the sizes shown in DIVISION III. Generally, the minimum size fillet weld shall be 5/16". Smaller welds may be required for thin plates. Connections made with fillet welds placed on opposite sides of a common plane of contact shall not be detailed with the weld-all-around symbol. Per the *Bridge Welding Code*, "fillet welds deposited on opposite sides of a common plane of contact between two parts shall be interrupted at a corner common to both welds."

Weld symbol for complete penetration groove welds shall be specified, without dimensions, by three capital letters, CJP. This allows the weld joint configuration and details to be determined by the fabricator.

Non-destructive testing (NDT) of welds shall be specified with symbols, combined with the welding symbols, for the welds requiring testing. The quantities of non-destructive testing methods required for field welds shall be shown in the "Inspection of Field Welds" block on the General Plan.

Multiple pass welds, inspected by the magnetic particle method, shall have each pass or layer inspected and accepted before proceeding to the next pass or layer.

The welding specifications shall be shown on the plans.

7.1.5 Fabrication

7.1.5.1 General Requirements

Fabrication of structural steel members or components for highway bridges shall conform to the AASHTO *Standard Specifications for Highway Bridges*, Division II, Section 11 and interim specifications.

The structural steel fabricator's plant shall be certified by the AISC Quality Certification Program. The certification requirements depend on the category of structure being fabricated as follows:

1. Category SBr - Simple Steel Bridge Structures. Typical work includes highway sign structures, inspection platforms, bridge components such as cross frames and unspliced rolled beam bridges.
2. Category MBr - Major Steel Bridges. All bridge structures other than unspliced rolled beam bridges.

If the structure has fracture critical members or components, the fabricator's plant shall also be certified to produce fracture critical members in accordance with a fracture control plan as defined by the *Bridge Welding Code*. A fabricator with this endorsement will have a suffix "F" added to the above categories (Category SBrF or Category MBrF).

The certification requirements for specific components shall be shown on the plans.

7.1.5.2 Special Fabrication Requirements for Box Girders

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7.2 GENERAL DESIGN REQUIREMENTS

7.2.1 Structure Types

7.2.1.1 *Cost Effective Span Lengths*

The following are appropriate ranges of cost effective span lengths for various steel bridges types:

TYPE OF BRIDGE	COST EFFECTIVE SPAN LENGTH (ft)
Rolled Beams	50 to 90
Plate Girders	80 to 250
Box Girders	150 to 250

The span lengths shown are for simple span bridges. For continuous bridges, these span lengths can be assumed to be measured from dead load inflection points.

For spans over 250 feet, special design studies must be done. Plate and box girders may still be the structure of choice since they provide redundancy. Other options are arches, trusses or cable stayed bridges, although these structure types should be limited to very long spans.

7.2.1.2 *Non-Redundant Systems*

Non-redundant systems such as girder and floor beam bridges should be avoided even though they may have an initial lower cost. The reason for this is the lack of redundancy, fatigue problems, and difficulties involved with future widening associated with these types of structures.

The only situations where non-redundant bridges should be considered are in the case of through-girder or through-truss spans where the minimum depth of the superstructure is critical.

7.2.1.3 *Box Girders*

Generally, box girders should be considered only for very long spans. They should also be investigated for use on curved roadways where torsional rigidity is required. Box girder cross sections shall be a trapezoidal shape with webs sloped equally out from the bottom flange. The webs shall be the same depth. The minimum web depth shall be 6½' to allow for inspection and maintenance inside the box girders. In general, box girders shall be rotated so that the top and bottom flanges are parallel with the deck cross slope.

7.2.1.4 Short Spans

Rolled beam and girder type bridges may also be used for shorter spans at locations where utilities must be supported between stringer lines.

7.2.2 Span Layout

7.2.2.1 Member Spacing

Member spacing should be maximized in order to reduce the number of members required thereby reducing the costs for fabrication, shipping, erection and future maintenance. However, in order to provide redundancy, a minimum of four stringer lines should be used in a bridge cross section.

Generally, the most economical spacing for rolled beams is between eight feet and 9'-6". It is recommended that the minimum spacing for I-shaped plate girders and top flanges of box girders be kept to nine feet.

7.2.2.2 Deck Overhang

The concrete deck overhangs, measured from the centerline of the fascia member, should be limited to four feet or to the depth of the member whichever is less. For deck overhangs greater than four feet, the designer shall include requirements in the contract documents for special forming requirements needed to prevent torsional rotation of the fascia member during concrete placement. This rotation is caused by the effect of the typical forming brackets used in construction.

7.2.2.3 Framing Geometry

Members should be laid out parallel and uniformly spaced as much as practical. If this is unavoidable, the live load distribution factors as outlined in the AASHTO *Specifications* shall not be used. The designer should carefully investigate these situations to account for the variation in live load and member stiffness.

7.2.3 Continuity

Continuous spans shall be used for all multiple span bridges. Provisions for thermal movement of the bridge shall generally be made at or behind the abutments. For bridges on a grade, provisions for thermal movement of the bridge shall generally be made at the high end of the bridge.

7.2.4 Fatigue

7.2.4.1 *General Requirements*

The provisions in the *AASHTO Specifications* shall be followed for the design of bridges. Fatigue requirements shall apply to elements of steel members where the summation of the calculated maximum live load tension stress and the dead load stresses results in net tension.

7.2.4.2 *Rolled Beams*

7.2.4.2.1 Simple Spans with Cover Plates

For simple span rolled beams with cover plates, the cover plates shall be extended approximately full length. The cover plates shall be fillet welded across the ends.

7.2.4.2.2 Continuous Spans with Cover Plates

For continuous span rolled beams with cover plates, the cover plates shall be terminated with end welds in non-fatigue regions. For the bottom flange, the regions are near the interior supports and, for the top flange, the regions are near the middle of the spans.

7.2.4.3 *Diaphragm Connection Plates*

For all types of steel bridges, the design of the flanges should be based on Category C in order to allow the welding of diaphragm connection plates to the flanges. If a preliminary design does not satisfy the requirements of Category C, then one of the following options should be followed:

- a. The flange can be increased in size to reduce the live load stress range.
- b. The location of flange splices can be changed to reduce the live load stress range.
- c. The connection can be bolted to reduce it to a Category B detail.

Note: For option c, the weld of the connection plate to the web adjacent to the flange is also a Category C detail, which is subjected to virtually the same stress range, and may also need to be bolted. For this reason, this option should be avoided.

7.2.5 Fracture Critical Bridge Members

7.2.5.1 Definitions

Fracture Control Plan (FCP) - The Fracture Control Plan is the materials testing and fabrication provisions for Fracture Critical Members as outlined in the ANSI/AASHTO/AWS D1.5 *Bridge Welding Code*.

Fracture Critical Member (FCM) - Fracture Critical members or member components are tension members or tension components of bending members (including those subject to reversal of stress), the failure of which would be expected to result in collapse of the bridge. The designation "FCM" shall mean fracture critical member or member component. Members and components that are not subject to tensile stress under any condition of live load are not fracture critical.

Attachments - Any attachments welded to a tensile zone of a FCM member shall be considered a FCM when any dimension of the attachment exceeds four inches in the direction parallel to the calculated tensile stress in the FCM. Attachments shall meet all requirements of the Fracture Control Plan.

Welds - All welds to FCM's shall be considered fracture critical and shall conform to the requirements of the Fracture Control Plan. Welds in compression members or compression areas of bending members are not fracture critical.

7.2.5.2 General Provisions

All fracture critical members shall be identified on the plans. Each FCM shall be individually designated on the plans by three capital letters, FCM, enclosed in a diamond. Each portion of a bending member that is fracture critical including welds shall be clearly described giving the limits of the FCM.

Based on the definitions above, the following guidelines shall be followed for designation of FCM's on plans:

I-Shaped Girder Bridges - For longitudinal girder bridges, FCM components of the beams shall be considered fracture critical if there are three or less girders in the bridge cross section. This requirement does not apply to temporary stages in construction.

Box Girder Bridges - For longitudinal box girder bridges, FCM components of the beams shall be considered fracture critical if there are two or less box girders in the bridge cross section. For the case of a two-box girder cross section, the top flanges and the welds of the webs to the top flanges shall not be considered fracture critical. This requirement does not apply to temporary stages in construction.

7.2.6 Diaphragms and Cross-Frames

7.2.6.1 General Provisions

Intermediate and end bearing diaphragms and cross frames (cross members) shall be provided for rolled beams, plate girders and box girders. They shall be designed and located, unless otherwise noted, in accordance with the AASHTO *Specifications*.

Intermediate cross members for rolled beams and plate girders shall preferably be placed at the 0.4 point of end spans of continuous bridges and at the center of interior spans. If practical, they should also be placed adjacent to a field splice. Cross members shall be spaced as far apart as possible to limit the overall number but still satisfying the AASHTO criteria. The need for cross members shall be investigated for all stages of construction.

7.2.6.2 Skewed Bridges

On bridges skewed less than 20°, the intermediate diaphragms shall be placed in line along the skew. On bridges skewed more than 20°, intermediate cross members shall be placed normal to the main members and staggered, not placed in a line, across the width of the bridge.

7.2.6.3 I-Shaped Beams and Girders with Web Depth ≤ Four Feet

7.2.6.3.1 Intermediate Diaphragms

Channel members shall be typically used for end and intermediate diaphragms. For intermediate diaphragms, the channel size shall be dependent upon the main member's depth. See the following table:

Member DEPTH (in)*	CHANNEL SIZE
21 - 24	C 12 × 20.7
27 - 30	C 15 × 33.9
33 - 36	MC 18 × 42.7

* Member depth is normal beam depth for rolled beams, actual web depth for plate girders.

7.2.6.3.2 End Bearing Diaphragms

End bearing diaphragms are required at all abutments and at intermediate locations where slab continuity is broken. These diaphragms shall preferably be channel sections and should be designed as simple span members with vertical dead loads, and live loads plus impact applied. The preferred channel size shall

be C 15 × 33.9 and MC 18 × 42.7. For bridges with severe skew angles or wide girder spacings, wide flange sections or K-frames may be used in lieu of channels.

End diaphragms typically shall be placed along the centerline of bearings and be set on a sloped line. A minimum clear distance of twelve inches shall be provided between end diaphragms and front face of backwall.

The bridge skew angle shall be considered in determining the length of the end diaphragm. Consideration shall be given to composite action in the design of all end diaphragms. For both non-composite and composite end diaphragms, shear connectors, 7/8" diameter, with a maximum spacing of twelve inches, shall be welded to the top flange of the end diaphragms.

7.2.6.4 I-Shaped Beams and Girders with Web Depths > Four Feet

7.2.6.4.1 Intermediate Diaphragms

Cross frames shall be used for intermediate diaphragms. Intermediate cross frames shall be designed to satisfy the lateral wind load stresses and slenderness ratio, KL/r , requirements outlined in the AASHTO *Specifications*. When computing the AASHTO allowable compressive stress, a value of 0.75 shall be used for the effective length factor, K .

The most economical intermediate cross frame considered for use shall be the X-type. When additional bracing is required, K-type frames should also be considered. All members shall be fabricated from equal leg angles or WT sections. Cross frames shall be as deep as practical. The cross frame depth shall be constant to facilitate fabrication.

7.2.6.4.2 End Bearing Diaphragms

End bearing cross frames shall have a K-type configuration with a channel member typically used at the top. All other members shall be equal leg angles or WT sections. The design of the top member shall follow that outlined for the end bearing diaphragms in Section 7.6.3.2. The size of the end diaphragm's bottom chord may be increased to provide for future jacking of the girder ends. For both non-composite and composite end bearing diaphragms, shear connectors, 7/8" diameter with a maximum spacing at twelve inches shall be welded to top flange of top chord member.

7.2.6.5 **Box-Girders**

7.2.6.5.1 Intermediate Diaphragms

Intermediate cross frames, not required for the completed bridge, may be required for construction purposes and shall be located and spaced as a matter of engineering judgment. They may be installed as temporary members or left-in-place as permanent members. Consideration shall be given to locate, at a minimum, intermediate cross frames at the lifting points of each shipping piece, on each side of a field splice, and at maximum positive moment sections. These cross frames shall be designed to satisfy the construction load stresses and slenderness ratio requirements. Typical cross frame configurations shall be the X and K types. All members shall be fabricated from the equal leg angles.

7.2.6.5.2 End Bearing Diaphragms

For the design of simple and continuous bridges of moderate length supported by two or more single cell boxes, *AASHTO Specifications* require internal diaphragms at each support to resist transverse rotation, displacement and distortion. Intermediate cross members for these types of bridges are not required. If plate diaphragms are used, they shall be connected to the webs and flanges of the section. Access holes shall be provided.

7.2.7 **Lateral Bracing**

7.2.7.1 **Requirements for I-Shaped Members**

7.2.7.1.1 Design Requirements

For I-Shaped members, the need to laterally brace the bottom flanges shall be investigated as per *AASHTO Specifications*. Lateral bracing should be avoided whenever possible. Reducing the cross frame spacing or modifying flange plate dimensions shall be considered when attempting to eliminate the bracing.

Bracing members, if required, shall be designed to satisfy lateral wind load stresses and slenderness ratio, KL/r , requirements. The allowable fatigue stress ranges shall not be exceeded at the connections. Warren type patterns with single members is recommended.

7.2.7.1.2 Detailing Requirements

Bracing members shall typically consist of equal leg angles or WT sections attached to the flange or web via gusset plates, clip angles or WT sections. Gusset plates shall be bent to accommodate the difference in elevation between girders. If it is not practical to make connections to the flange, then connections

shall be made to the web. Flange connections shall not interfere with the web to flange welds.

The minimum thickness of gusset plates shall be 9/16". The minimum size angle used as a connecting or bracing member shall be L 4 × 4 × 5/16". Angles with unequal legs should not be used.

The need to temporarily brace the compression flange for stability during erection shall be investigated. This can be accomplished with intermediate diaphragms.

7.2.7.2 Requirements for Box Girders

7.2.7.2.1 Design Requirements

For box girders, generally no external lateral bracing should be required between the box sections. To increase the torsional stiffness of an individual box section during fabrication, erection and placement of the slab, permanent, internal lateral bracing either full or partial length shall be placed at or near the plane of the top flanges.

Bracing members and their connections shall be similar to those for I-Shaped members. The bracing shall be designed to resist the shear flow across the top of the section, satisfying stress and slenderness ratio requirement. Warren type bracing without transverse members 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 or web.

7.2.8 Stiffeners

7.2.8.1 Bearing Stiffeners

7.2.8.1.1 Design Requirements

Rolled Beams - Bearing stiffeners are generally not required, but shall be provided when the web shear stress at the reaction exceeds that permitted by AASHTO. The full beam depth times the web thickness shall be used to compute the shear stress. When bearing stiffeners are required, their design shall follow the provisions for plate girders.

Plate Girders - Bearing stiffeners shall be placed at all bearing locations and other locations supporting concentrated loads.

When computing the AASHTO allowable compressive stress for the stiffener plates, a value of 0.75 shall be used for the effective length factor, K.

The stiffener plate to web fillet welds shall be designed to satisfy the total reaction and the *Bridge Welding Code*. The weld size shall not be less than 5/16". For skewed plates, the *Bridge Welding Code* design requirements for skewed joints should be considered when sizing the welds.

7.2.8.1.2 Detailing Requirements

To simplify fabrication, the stiffener plates on any one structure should have the same width and thickness. The minimum thickness of a stiffener plate shall be 9/16".

Stiffener plates which act as connection plates shall be fillet welded to the top flange and milled to bear and fillet welded to the bottom flange. To avoid possible warping of the bottom flange, complete penetration groove welds should not be used to attach the plate to the flange. When the plates are welded to the tension flange at interior supports of continuous bridges, the allowable fatigue stress range shall not be exceeded (see Section 7.2.4 "FATIGUE").

When the bearing stiffeners consist of two pairs of plates, they shall be offset sufficiently to permit proper welding.

The stiffener plates shall be placed symmetrically over the bearings and be vertical after the application of full dead loads.

7.2.8.2 Intermediate Transverse Stiffeners

7.2.8.2.1 Design Requirements

The design of intermediate transverse stiffeners shall be according to the *AASHTO Specifications*.

If intermediate stiffeners are used, they shall be designed for one side of the web only, for reasons of economy.

7.2.8.2.2 Detailing Requirements

To simplify fabrication, the stiffener plates on any one structure should have the same width and thickness. The minimum thickness of a stiffener plate shall be 9/16".

Intermediate stiffeners not supporting concentrated loads shall be detailed with a tight fit against the compression flange and cut short at the tension flange. This

will greatly reduce the amount of labor for the installation of the stiffener. For stiffeners that are also used as diaphragm connection plates, the requirements for diaphragm connection plates shall be followed.

The intermediate stiffeners shall be detailed on one side of the web. The use of intermediate stiffeners on the outside face of exterior girders is not acceptable.

For details, see DIVISION III.

7.2.8.3 Longitudinal Stiffeners

7.2.8.3.1 Design Requirements

The design of longitudinal stiffeners shall be according to the AASHTO *Specifications*. Generally, the use of longitudinal stiffeners is discouraged. Longitudinal stiffeners are generally not economical for spans less than 300 feet. If longitudinal stiffeners are used, for reasons of economy, they shall be designed for one side of the web only. Butt splices in longitudinal stiffeners shall be made before attachment to the web, and tested by the ultrasonic method.

7.2.8.3.2 Detailing Requirements

Longitudinal stiffeners shall be welded to the web plates and cut back $\frac{3}{4}$ " when interrupted by connection plates and bolted splices. The longitudinal stiffener need not be made continuous across bolted splices.

7.2.9 Connections and Splices

7.2.9.1 General

Shop connections may be made by either bolting or welding. Generally, all field connections should be made with high strength bolts. The use of field welding is discouraged due to difficulties with achieving proper coatings in the field. Welded field splices are not allowed.

7.2.9.1.1 Design Requirements

All bolted connections shall be designed as slip critical connections in accordance with AASHTO *Specifications*. Connections on uncoated bridges and painted bridges shall be designed with Class B surface conditions. Connections on galvanized bridges shall be designed with Class C surface conditions.

In general, connections shall be designed with $\frac{7}{8}$ " diameter ASTM A325 high strength bolts.

7.2.9.1.2 Detailing Requirements

The bolt diameter, hole size, bolt spacing and edge distances shall be shown on the plans. The type of connection (slip critical) and the class of faying surfaces (Class B or C) shall be specified on the plans.

To facilitate steel erection, only one type and diameter of bolt should be specified on any one bridge. Splices should be designed as though oversized holes were to be used to allow reaming in the field to facilitate fit-up. However, standard sized holes shall be specified on the plans.

7.2.9.2 ***Bolted Splices***

7.2.9.2.1 Detailing Requirements

The bolt diameter, hole size, bolt spacing and edge distances shall be shown on the plans. The minimum thickness of web and flange splice plate shall be 9/16" Splice plates shall be detailed with a minimum edge distance of two inches. The maximum distance between the ends of the members being spliced shall be one inch.

Location of shop and field splices is dependent upon such factors as design criteria, available length of plates and members, transportation of members, erection and site limitations, etc. Refer to the section on the transportation of members for additional information and guidance.

7.2.9.3 ***Cross Member Connections***

7.2.9.3.1 Design Requirements

The design of the connection of cross members shall be consistent with the design of the members being attached. The connections for the end bearing cross members shall be designed for the shear due to dead and live loads plus impact.

For intermediate diaphragm connections, the number of bolts should be kept to four on each side of the diaphragm. In all cases, the number of bolts should be kept to a minimum.

7.2.9.3.2 Detailing Requirements

In general, when detailing bolted connections, the size, number and general layout of the bolts should be shown. Bolt hole spacing and edge distances should be left to the fabricator.

Holes for end diaphragm connections shall be located parallel to the main member's web. Standard sized holes shall be used in the cross members while oversized holes, unless otherwise noted, shall be used in the stiffener or connection plates. At one side of a cross member, standard sized holes field drilled through the stiffener or connection plate may be used as an alternate method for erection.

Long slotted holes in the stiffener or connection plates shall be considered for erection of intermediate cross members for girders adjacent to a stage construction line.

For bridges with skews more than 20°, when the differential dead load deflection of adjacent girders at any intermediate cross member connection is $\frac{3}{4}$ " or more, long slotted holes shall be detailed in the stiffener or connection plates attached to the girder with the larger deflection. The following note should appear on the plans when long slotted holes are used:

Bolts in long slotted holes shall only be finger-tightened prior to pouring the deck slab and then fully-tightened immediately after completing the pour.

Gusset plates shall be made rectangular to simplify fabrication.

Shop welds shall be made on one side, as much as practical, to avoid having to turn over the cross member assemblies in the fabricating shop.

7.2.10 Composite Construction

7.2.10.1 Design Requirements

All structural members in contact with and supporting a concrete deck shall be designed for composite action.

In general, 7/8" diameter stud type shear connectors shall be used for composite construction. Spirals, angles or channel shear connectors are not permitted.

7.2.10.2 Detailing Requirements

The minimum height shear connector is four inches. The maximum height of unstacked shear connectors is eight inches. Stacked shear connectors shall be used at the locations where the haunch depth exceeds six inches.

Shear connectors are typically welded to the members in the field. Field welding through a mist coat of up to 2 mils of zinc primer is permissible.

Only the diameter of the shear connectors shall be shown on the plans. Shear connector heights shall not be shown on the plans. The heights shall be determined after the erected members have been surveyed and the haunch depths calculated. Shear connectors are paid for on a lump sum basis for each site. Shear connector quantities shall be computed for the designer's own information but shall not be shown on the plans.

On flange splice plates, one row of shear connectors shall be placed along the centerline of the splice plates.

7.2.11 Dead Load Deflection and Cambers

7.2.11.1 *Simple Span Bridges*

Dead load deflection and camber diagrams are not required for simple span bridges. Dead load deflections and cambers shall be calculated at the mid-span of the structure for the following listed items for each member and tabulated on the plans:

1. Structural Steel Deflections. Deflections due to the weight of the beams or girders, including the diaphragms and bracing and calculated using the moment of inertia of the steel section.
2. Additional Dead Load Deflections. Deflections due to the uncured concrete slab and haunches, utilities, and any other loads supported by the steel section alone. These deflections shall be calculated using the moment of inertia of the steel section.
3. Composite Dead Load Deflections. Deflections due to the parapets, curbs, sidewalks, railings, bituminous concrete overlay and any other loads that are placed after the slab has cured. This deflection shall be calculated using the moment of inertia of the composite section with a modular ratio equal to 3 times that of the final section as outlined in the *AASHTO Specifications*.
4. Total Dead Load Camber. Camber required to compensate for the summation of the structural steel, slab dead load and the composite dead load deflections listed above.
5. Vertical Curve Ordinate Camber. Camber required when the member falls within the limits of a summit vertical curve. When the member falls within the limits of a sag vertical curve, provisions for sag ordinates must be made within the concrete haunch and shall not be specified in the camber table.
6. Extra Camber. Extra camber shall be provided when the grade of the roadway is on a tangent grade or on a sag vertical curve and is computed as follows:
 - Extra Camber (inch) = $L / 100$, where: L = Span Length (feet)

When the roadway is on a crest vertical curve, the extra camber is to be specified only when it exceeds the vertical curve ordinate. In this case, the amount of extra camber to be tabulated shall be only that portion in excess of the vertical curve ordinate.

7. Total Camber. The Total Camber is equal to the summation of all calculated cambers and is that dimension to which the member is to be fabricated.

For a table for the dead load deflections and cambers, see Division III.

7.2.11.2 Continuous Span Bridges

Dead load deflections and cambers shall be tabulated for the following listed items for each member and shown on the plans. The locations tabulated shall be the member bearing points and points at equal spaces along the member at approximately ten feet on center:

- Structural Steel Deflections: Same as for simple span bridges.
- Additional Dead Load Deflections: Same as for simple span bridges.
- Composite Dead Load Deflections: Same as for simple span bridges except that composite section properties should be used for both positive and negative moment regions.
- Total Dead Load Camber: Same as for simple span bridges but measured to a reference line, which is a theoretical straight line in each span connecting the points located at the top of the web at the centerlines of bearing.
- Vertical Curve Ordinate Camber: Same as for simple span bridges.
- Extra Camber: Extra camber shall not be provided for continuous bridges.
- Total Camber: The Total Camber is equal to the summation of all calculated cambers and is that dimension to which the member is to be fabricated.

For a table for the dead load deflections and cambers, see DIVISION III. A diagram for dead load deflection shall not be shown. A total camber diagram shall be shown on the plans. For details of a total camber diagram, see DIVISION III.

7.2.12 Bearings

For bearing requirements, see Section 9.

7.2.13 Superstructure Jacking Requirements

7.2.13.1 *Design Requirements*

Provisions for jacking of the superstructure shall be provided at all locations that have bearings that will require future maintenance. These bearings include all types other than fixed bearings.

7.2.13.1.1 New Construction

At abutments, preference shall be given to widening of the bridge seat and providing auxiliary jacking stiffeners so that jacks may be placed in front of the bearing to jack under the beam. Provision for massive diaphragms, which restrict access to the ends of the beam and backwalls should be avoided.

At piers with continuous caps, preference shall be given to designing diaphragms for jacking forces and providing auxiliary pads on pier caps.

Other unusual situations (i.e., piers consisting of individual columns under each girder) will require special study and may require provisions for jacking from ground level.

7.2.13.1.2 Rehabilitation Projects

For superstructure replacements, jacking provisions shall be provided only if economically viable. Jacking requirements should not be allowed to justify major substructure modifications where the substructures are otherwise adequate.

Lift points shall be located adjacent to the bearings and may be on main or secondary members. Preferably, lift points shall be over the bridge seats of abutments and the tops of piers so that jacks may be founded on these components minimizing the need for extensive temporary structures.

The jacking lift points shall be designed for the total dead load and the live load plus impact. If there are more than 5 lines of girders, the jacking lift points shall be designed for 150% of these values in order to jack individual girders in the future.

Superstructure and substructure members and components shall be strengthened as required to support the jacking loads.

7.2.13.2 *Detailing Requirements*

Lift points shall be clearly identified on the plans. The dead and live loads required to jack the bearing shall also be shown on the plans. If there are more than five

lines of girders, two sets of loads shall be shown. The loads shall be for simultaneous jacking of all girders, and for jacking of individual girders. Additional stiffeners or brackets, if required, shall be shown on the plans.

7.2.14 Inspection Hand Rails

When girders are five feet or more in depth, a safety hand bar shall be provided 3½' above the bottom flange for inspection access on both sides of all girders except the outside face of fascia girders. The bar shall have a minimum diameter of one inch and shall be designed for a minimum point load of 270 pounds.

7.3 STRUCTURE TYPE SPECIFIC REQUIREMENTS

7.3.1 Rolled Beams

The use of rolled beams should be investigated for appropriate span lengths since the cost of fabrication is significantly lower than equivalent I-shaped plate girders.

If cover plates are used on rolled beams, the width of the cover plate shall be narrower than the flange. The minimum thickness of a cover plate shall be 9/16". The ends of the cover plates shall be rectangular in shape with rounded corners. Tapered end cover plates are not permitted. The attachment of cover plates to rolled beams shall be made with fillet welds. Rolled beams with cover plates, if used, shall be designed for fatigue. See Section 7.2.4 "FATIGUE."

All fillet welds connecting the cover plate to the beam shall be non-destructively tested by the magnetic particle method.

The plans shall clearly state that, if the cover plate is fabricated by butt welding two or more plates together, the butt welds shall be non-destructively tested by the ultrasonic tested prior to attaching the cover plate to the beam.

7.3.2 I-Shaped Plate Girders

7.3.2.1 Hybrid Girders

The design of hybrid I-shaped plate girders should be avoided.

7.3.2.2 Web Plates

The minimum thickness of web plates shall be 3/8". Web plate depths shall be specified in two-inch increments.

In general, for plate girders with web depths less than 50 inches, unstiffened webs are more economical. For web depths greater than 50 inches, the following

alternates shall be investigated for the web design to determine which is the most cost effective:

- a. Fully stiffened web with minimum web plate thickness.
- b. Unstiffened web.
- c. Partially stiffened web with only a few stiffeners near supports.

In order to determine which of these alternates is most cost effective, the 1 to 4 rule should be used. That is, if the web and flange material costs \$1 per pound, then the connection plate material costs \$4 per pound.

7.3.2.3 Flange Plates

The minimum thickness of flange plates shall be $\frac{3}{4}$ " to eliminate warping of the plates when they are welded to the web. The flange plate widths shall be specified in two-inch increments.

To minimize potential stability problems during various phases of construction, the minimum width of flange plates shall be determined based on the maximum of the following:

- a. the length of the unsupported field piece divided by 85, or
- b. twelve inches.

Flange width transitions shall generally be avoided. Flange plate thickness should be varied instead. At flange plate transitions, the thickness of the thinner plate shall not be less than $\frac{1}{2}$ the thickness of the thicker flange.

The number and spacing of flange plate thickness transitions should be based on the total cost of the finished girder. While numerous flange transitions will produce the lightest girder, the fabrication costs for the splices may result in a higher total cost. The designer should investigate eliminating flange transitions, especially where they are closely spaced. As a rule, the approximate weight of flange material that should be saved in order to justify the introduction of a flange transition is as follows:

$$M = 255 + 21A$$

M = Weight of steel, pounds

A = Cross sectional area of thinner flange plate, square inches

In order to eliminate shop welded butt splices, field splices should be located at flange plate transitions.

7.3.2.4 Shop Splices

Shop web splices shall be located within the middle third of the span.

Shop flange splices shall be located a minimum of six inches from web splices.

Both web and flange splices shall be located a minimum of six inches from stiffeners and connection plates.

This information on web and flange plate shop splices shall be shown on the plans.

7.3.3 Box Girders

7.3.3.1 Hybrid Girders

The design of hybrid box girders should be avoided.

7.3.3.2 Web Plates

The minimum thickness of web plates shall be 3/8". Web plate depths shall be specified six-inch increments.

7.3.3.3 Flange Plates

The minimum thickness of flange plates shall be 3/4" to eliminate warping of the plates when they are welded to the web. A maximum flange plate thickness of three inches shall be used for box girders.

The minimum is two-inch increments.

Flange width transitions shall generally be avoided. Flange plate thickness may be varied instead. At flange plate transitions, the thickness of the thinner plate shall not be less than 1/2 the thickness of the thicker flange.

The number and spacing of flange plate thickness transitions should be based on the total cost of the finished girder. While numerous flange transitions will produce the lightest girder, the fabrication costs for the splices may result in a higher total cost. The designer should investigate eliminating flange transitions, especially where they are closely spaced. As a rule, the approximate weight of flange material that should be saved in order to justify the introduction of a flange transitions is as follows:

$$M = 255 + 21A$$

M = Weight of steel, pound

A = Cross sectional area of thinner flange plate, square inches

In order to eliminate a shop welded butt splice, field splices should be located at flange plate transitions.

7.3.3.4 Shop Splices

Shop web splices shall be located within the middle third of the span.

Shop flange splices shall be located a minimum of six inches from web splices.

Both web and flange splices shall be located a minimum of six inches from stiffeners and connection plates.

This information on web and flange plate shop splices shall be shown on the plans.

7.3.3.5 Bolted Field Splices

Where bolted field splices are called for, the splice shall be detailed to provide adequate clearance for bolting the connections at the acute corners between the top flange and the web for both bolts and splice plates.

7.3.3.6 Fabrication Requirements

A minimum distance of one inch shall be provided between the outside face of the web and the edge of the bottom flange as a holding shelf for the flux deposited by the welding machine. At web stiffeners, provide a ½" clearance above a line 60° from the bottom flange to accommodate a traveling welding machine.

7.3.3.7 Access Manholes

Access manholes shall be provided in the end or bottom flange of box girders. These manholes shall be located and detailed such that bridge inspectors can gain access without the need for special equipment. The distance between the end diaphragm and the backwall should be increased to a minimum of two feet when access is provided in the end diaphragms of box girders. For access through the bottom flange, ladder supports shall be incorporated. The preferred location for access is through the ends of the boxes.

The manholes shall have rounded corners fitted with a hinged cover and provided with an appropriate locking system and all access doors shall open inward. When access is provided through the end diaphragms, the access door should be covered with a steel wire mesh to allow ventilation. If access manholes are provided through the bottom flange, the access doors should be designed to be lightweight. 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 all allowable limits.

7.3.3.8 *Remain-In-Place Forms*

Box girders shall be designed for the additional weight of remain-in-place forms placed within the boxes to form the deck slab.

7.3.3.9 *Drainage*

In order to provide drainage of the inside of the box girder, two-inch minimum diameter drains shall be provided at the low end of the girder. The corners of all plates should be clipped so as not to trap moisture inside the girder. Bridge deck drainage may extend vertically through the girder but shall not be carried longitudinally within it.

7.3.3.10 *Utilities*

Gas, water and sewer lines are prohibited from being located within box girders. Electric, telephone and cable companies should be discouraged from locating their lines within the boxes. All utilities can generally be accommodated outside of and between the girders.

7.3.4 *Curved Girders (includes rolled beams, plate girders and box girders)*

When designing curved girder structures, designers must investigate all temporary and permanent loading conditions, including loading from wet concrete in the deck pour, for all stages of construction. Future re-decking must also be considered as a separate loading condition. Diaphragms must be designed as full load carrying members. A three-dimensional analysis representing the structure as a whole and as it will exist during all intermediate stages and under all construction loading conditions is essential to accurately predict stresses and deflections in all girders and diaphragms and must be performed by the designer.

The designer is responsible for assuring that the structure is constructable and that it will be stable during all stages and under all loading conditions. To achieve this end, the designer must supply basic erection data on the contract plans. This information must include, but is not limited to, the following:

- Pick points and reactions at pick points for all girder sections.
- Temporary support points to be used during all stages and loading conditions, and reactions for which support towers should be designed at all of these points.
- Deflections to be expected in all girders under all conditions of temporary support and under all anticipated loading conditions.

- Direction pertaining to the connection of diaphragms to assure stability during all temporary conditions.

Specifications prepared for this work must require the Contractor to submit full erection plans, prepared and stamped by a Professional Engineer registered in the State of Connecticut, for review by the Department. These plans will be reviewed by the designer as a working drawing and comments forwarded from the Office of Engineering to the District Engineering Manager having jurisdiction over the project for transmittal to the Contractor. The designer's review must ensure that all information given on the Contract plans has been accurately accounted for in the Contractor's erection plans.

The designer shall provide any such additional information, up to and including full erection plans in the Contract documents as directed by the Department.

Further design information for curved structures is contained in the *Guide Specifications for Horizontally Curved Steel Girder Highway Bridges*, published by the American Association of State Highway and Transportation Officials.

7.3.5 Through-Girders

Vacant

7.3.6 Trusses

Vacant

7.3.7 Rigid Frames

Vacant

7.3.8 Pin and Hanger Structures

The design of pin and hanger structures is not allowed.

7.3.9 Steel Piers and Pier Caps

Vacant

7.3.10 Railway Bridges

Vacant

Section 8
DECKS and DECK PROTECTIVE SYSTEMS

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Section 8
DECKS and DECK PROTECTIVE SYSTEMS

8.1 DECK TYPES

8.1.1 General

A deck is defined as a component, with or without a wearing surface, which supports wheel loads directly and is supported by other components.

8.1.2 Cast-In-Place Concrete Decks

8.1.2.1 *Materials*

8.1.2.1.1 Concrete

Generally, cast-in-place concrete decks, including the parapets, shall be constructed with Class "F" Concrete. Lightweight concrete may be considered for deck replacements where a reduced dead load is necessary to achieve the required load carrying capacity of the superstructure, substructure and/or foundation.

8.1.2.1.2 Reinforcement

Reinforcement for cast-in-place concrete decks, including the parapets, shall be bar reinforcement and conform to the requirements of Section 6. All the reinforcement shall be coated.

8.1.2.2 *Design*

Cast-in-place reinforced concrete decks shall be designed using the Strength Design Method (Load Factor Design) described in the AASHTO *Specifications* or the Empirical Design Method described in the AASHTO *LRFD Specifications*.

For slab design, the main reinforcement, perpendicular to traffic, may be determined using the design aid in Division III.

Cantilever deck overhangs shall be designed in accordance with AASHTO *Specifications* for truck and railing loads. For deck overhang limits, see Sections 6 and 7.

8.1.2.3 *Minimum Slab Thickness*

The minimum thickness of a cast-in-place concrete deck slab shall be eight and one half inches. The cover to the top mat of reinforcement shall be 2½". The top ½"

shall be included in calculations as dead load only. It should be assumed to be sacrificial and not included as a permanent part of the deck for design purposes.

8.1.2.4 Haunches

The minimum haunch depth shall be one inch (two inches for prestressed bulb tees) measured from the top of the top flange of the member to the bottom of the slab. For members with splices, the top of the member shall be the top of the splice plate. A deeper haunch may be required when the width of the top flange of a member exceeds 1'-4" in due to the cross slope of the slab. Changes in flange plate thicknesses and allowable camber tolerances shall be taken into consideration when determining the haunch depth to use in calculations.

Haunches with thicknesses less than four inches do not require reinforcement. Haunches with thicknesses from four inches to six inches shall be reinforced as shown in Division III. Reinforcement for haunches with thicknesses greater than six inches shall be detailed by the designer.

8.1.2.5 Reinforcement Details

8.1.2.5.1 Main Reinforcement Placed Perpendicular to Traffic

For decks with a skew angle less than or equal to 20°, the main reinforcement shall be placed on the skew. For decks with skew angles greater than 20°, in general, the main reinforcement shall be placed perpendicular to the centerline of the structure.

At acute corners of the deck, when the skew angle exceeds 20°, additional reinforcement shall be placed parallel to the end of the slab with appropriate increase in slab thickness.

Additional distribution reinforcement shall be placed midway between the top and bottom longitudinal bars at the end of decks. The bar size and length shall be as follows:

- for spans up to 50 feetUse #5 x 5 feet
- for spans over 50 feet and up to 80 feetUse #5 x 8 feet
- for spans over 80 feet.....Use #5 x 10 feet

8.1.2.5.2 Main Reinforcement Placed Parallel to Traffic

Main reinforcement parallel to traffic shall be designed in accordance with AASHTO *Specifications*.

8.1.2.5.3 Cover Requirements

The minimum concrete cover over top reinforcement shall be two and one half inches. The minimum concrete cover over bottom reinforcement shall be one inch.

8.1.2.5.4 Splices

Splices for all deck reinforcement, both longitudinal and transverse, shall be shown on the plans. A minimum of one splice shall be detailed for the transverse reinforcement. The use of mechanical connectors to splice reinforcement is permitted when lap splices cannot be accommodated. For additional information, see Section 6.

8.1.2.5.5 Tie Down Bars

Tie down bars aid in supporting and anchoring the mats of deck reinforcement. Tie down bars shall be shown on the plans.

8.1.2.6 **Construction Joints**

Construction joints to facilitate deck construction are permitted. Transverse construction joints are typically required when a sequence of pours is necessary. Longitudinal construction joints may be required for stage construction. Decks adjacent to construction joints shall be properly designed and supported for all loading conditions. The members supporting the deck adjacent to the construction joints shall also be investigated to ensure that they are adequate for all loading conditions. Closure pours may be detailed for stage construction conditions where large differential deflection is anticipated.

8.1.2.7 **Forming**

Generally, removable forms shall be used for the construction of cast-in-place decks. The use of remain-in-place metal forms for cast-in-place decks may only be considered by the Department for use in the following locations:

- in all bays of bridges over electrified railroads,
- inside post-tensioned concrete or steel box girders, and
- in bays of bridges requiring utility installations prior to placing the concrete deck.

The designer shall include provisions in his design calculations for remain-in-place forms in these situations where they may be considered for use.

Remain-in-place forms shall not be used at the following locations:

- under cantilever slabs such as the overhang outside fascia members, and
- under longitudinal deck joints between members.

All affected members shall be designed to carry the extra dead load of the forms and the concrete in the valleys. The extra depth of the concrete in the valleys of the form shall be neglected in the design of the deck. The cover for the bottom reinforcement shall be measured from the top of the remain-in-place forms.

The design, fabrication and installation of remain-in-place forms, the placing of concrete and inspection shall conform to the Special Provision "Concrete for Structures."

Prestressed concrete remain-in-place forms for cast-in-place decks may only be used with the approval of the Department.

8.1.2.8 Deck Pouring Sequence

For bridges with continuous members, cast-in-place concrete decks shall be placed in sequence. The sequence of pouring concrete shall be shown on the plans and include the following:

- sections in which the deck is to be poured,
- sequence in which the sections are to be poured,
- direction of pouring each section, and
- minimum compressive strength the concrete in each section must obtain prior to placing concrete in other sections.

Additionally, the following note shall be shown on the plans:

A deck pouring sequence different from that shown may not be used without the prior approval of the Engineer.

8.1.3 Adjacent, Transversely Postensioned, Prestressed Box Members

Generally, bridge superstructures constructed with adjacent, transversely postensioned, prestressed box members do not require a cast-in-place concrete deck. The tops of the members serve as the deck and are designed to support live loads. The proper deck profile and cross-slope should be obtained with a bituminous concrete overlay by varying its thickness. Placing a cast-in-place concrete deck on top of adjacent box

members to obtain the proper deck profile and cross-slope is discouraged and may only be used with the written approval of the Department.

8.1.4 Precast Concrete Deck Panels

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8.1.5 Bridge Grid Decking

Vacant

8.1.6 Aluminum Bridge Decks

Vacant

8.2 DECK PROTECTIVE SYSTEMS

8.2.1 Highway Bridges

8.2.1.1 General

The decks of all bridges, both new and rehabilitated, shall be protected from damage, deterioration and corrosion due to deicing salts.

8.2.1.2 Concrete Decks

The preferred method to protect cast-in-place and precast concrete decks consists of using coated reinforcement and a membrane waterproofing protected with a 2½" minimum thickness bituminous concrete overlay.

The standard membrane waterproofing shall be "Membrane Waterproofing (Woven Glass Fabric)." This membrane shall be protected by a bituminous concrete overlay with a minimum thickness of 2½". The bottom course of overlay shall be 1" of Bituminous Concrete-Class 2. The top course shall be a minimum of 1½" of Bituminous Concrete-Class 1. Bituminous Concrete-Class 2 may be used as a temporary wearing surface during stage construction. The actual length of time it may be used as a wearing surface depends on the amount and type of traffic.

Generally, "Membrane Waterproofing (Sheet)" shall not be specified, unless its use is specifically requested by the Office of Construction to accommodate unusually restrictive construction schedules. Where "Membrane Waterproofing (Sheet)" is used, it shall be protected by a bituminous concrete overlay with a minimum thickness of 2½". The bottom course of overlay shall be 1" of Bituminous Concrete-Class 12. The top course shall be a minimum of 1½" of Bituminous Concrete-Class 1. Bituminous Concrete-Class 12 is not designed for direct wheel traffic and should be protected with Bituminous Concrete-Class 1 as soon as possible.

On decks where it is necessary to increase the overlay thickness to obtain the proper profile and cross-slope, such as bridges composed of adjacent box members, the bottom course of bituminous concrete shall be a uniform 1" thick. The thickness of the top layer shall be varied as required. The finish course of the top layer shall be a uniform 1½" thick.

Weepholes shall be provided in cast-in-place concrete decks to drain the membrane and overlay interface. Weepholes shall be placed along gutterlines adjacent to deck joints at the low end of spans on the low side of cross slopes. Weepholes shall outlet on the inside of fascia members. The outlet pipe of the weephole shall be extended as required so as not to drain onto the superstructure members and components. Weepholes shall not be located over travel lanes, shoulders, sidewalks, parking areas, or in spans over railroad tracks. Where easily achieved during rehabilitation projects, existing weepholes should be plugged and paved over when not in accordance with these requirements.

Other methods to protect concrete decks such as using a cathodic protection system or latex modified concrete may only be used with the written approval of the Department.

8.2.1.3 Other Deck Types

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8.3 FINISHED DECK AND GRADE ELEVATIONS

8.3.1 General

All elevations necessary for construction of the deck and placement of the bituminous concrete overlay shall be shown on the plans.

Bridges located at merging and diverging roadways shall be carefully detailed with the dimensions and elevations necessary for construction.

8.3.2 Finished Deck Elevations

For cast-in-place concrete decks, finished deck elevations and member deflections shall be tabulated at member bearing points and at points equally spaced along the members at approximately ten feet on center. The finished deck elevations are those elevations on the top of the concrete deck. The tabulated member deflections are those deflections due to all dead loads except the selfweight of the members and cross members.

For precast concrete deck panels, deck elevations shall be tabulated at edges of the panels at the panel joints. The deck elevations are those elevations on the top of the concrete panel.

8.3.3 Finished Grade Elevations

Finished grade elevations are those elevations on top of the final riding surface (such as the bituminous concrete overlay). On all bridges, the finished grade elevations shall be shown at the following points:

- the intersection of the point of application of grade line with the deck joints and ends of slabs,
- the intersection of the gutter lines with the deck joints and ends of slabs, and
- the intersection of the cross slope breaks at the shoulders with the deck joints and ends of slabs.

Section 9
BEARINGS

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Section 9 **BEARINGS**

9.1 GENERAL

Bearings are structural devices that transmit loads from the superstructure to the substructure. Bearings may also be required to allow for horizontal movement due to temperature and time dependent causes, allow rotation due to loads on the superstructure, and transmit seismic forces from the superstructure to the substructure. The selection and layout of bearings shall be consistent with the proper functioning of the bridge.

Bearings may be fixed or movable as required for the bridge design. Movable bearings may include guides to control the direction of translation. Fixed and guided bearings shall be designed to resist all loads and restrain unwanted translation. Keeper blocks may also be used to restrain some of these loads.

Combinations of bearing types should not be used at the same line of bearing. Differing deflection and rotational characteristics may result in damage to the bearings or structure.

Several bearing types are recommended below for different situations. Other bearing devices may be used, provided that they have been approved by the Department.

9.1.1 Skew Effects

Provisions shall be made in the bearing design for both lateral and longitudinal movement based on the geometry of the deck, the layout of the deck expansion joints and keeper assemblies. For bridges with complicated deck configurations, a thermal expansion analysis of the deck should be done in order to determine the thermal movements relative to the bridge bearings. The geometry of the deck, not the structural framing, should be the basis for the expansion analysis. For narrow bridges where the effects are minimal, transverse expansion may be neglected.

9.1.2 Curvature Effects

For curved superstructures, provisions shall be made in the alignment of bearing guides and keeper blocks for both lateral and longitudinal movement based on the geometry of the deck and the layout of the deck expansion joints. Generally, the direction of movement of the superstructure may be assumed to be parallel to the chord of the deck centerline taken from the joint to the neutral point of the superstructure. The neutral point is defined as the point where no thermal movement occurs.

9.1.3 Temperature Range

The temperature range used for the calculation of thermal movement at bearings shall be 120°F. This temperature range is based on a mean low temperature of -10°F and a

mean high temperature of +110°F. The median temperature for design of bearings shall be +50°F.

9.1.4 Coefficient of Thermal Expansion

For the design of bearings, a coefficient of thermal expansion shall be taken as 6.4×10^{-6} per °F. This equates to approximately 2¾" total movement for a 300 foot long bridge.

9.1.5 Seismic

If the bridge is designed for seismic events, the bearings may be designed to transmit seismic forces from the superstructure to the substructure. The movement due to seismic forces shall be accommodated in the design of the bearings. It is important that the bearing remain stable under the maximum anticipated bridge displacement during the seismic event. For requirements for the design of seismic isolation bearings, see Section 4.

Rocker type bearings should not be used due to the high susceptibility of overturning during seismic events.

9.1.6 Single Span Bridges

The design of single span bridges may be based on providing elastomeric expansion bearings at both ends of the superstructure if the grade of the roadway is less than 5%. The designer should incorporate keeper assemblies in order to maintain alignment of the superstructure. Designs of this nature will reduce the amount of expansion at the bearings and deck joints. For simple span bridges, with a fixed and an expansion bearing, the fixed bearing should be located at the low end of the structure.

9.1.7 Multi-Span Bridges

The design and layout of bearings in multi-span bridges should be based on the design of the deck expansion joints, the capacity of the bearings to accommodate the anticipated loads and movement, and the seismic design of the substructure where applicable.

9.2 BEARING SPECIFIC DESIGN REQUIREMENTS

9.2.1 Steel Reinforced Elastomeric Bearings

Steel reinforced elastomeric bearings should be the first bearing of choice for any bridge bearing due to the low initial cost and the low future maintenance costs. These bearings should be considered for low to moderate load situations.

Steel reinforced elastomeric bearings may be designed as either rectangular or round. Round elastomeric bearings should be considered where significant movement occurs in both the longitudinal and transverse direction.

If the shearing force in the bearing is less than 20% of the minimum vertical load on the bearing, the interface of the bearing and the concrete bearing seat should not be attached or bonded. For cases where the shearing force is greater, the following possibilities should be investigated:

- a. The bearing should be redesigned to attempt to reduce the shearing force.
- b. The bearing should be shop vulcanized under heat and pressure to a bottom steel plate that is anchored to the substructure.
- c. A PTFE slider type bearing can be considered.

Steel reinforced elastomeric bridge bearings should only be designed with virgin neoprene not natural rubber.

Holes for anchor bolts shall not pass through the elastomeric bearing. If anchor bolts are required, then the bolts shall be located outside the limits of the bearing.

9.2.1.1 Steel Bridge Beams

For the design of steel bridge beams, the top of the bearing should be vulcanized under heat and pressure to a steel top plate to facilitate installation. The top plate should be bolted to a beveled sole plate. Field welding should be avoided due to the possibility of damage to the elastomer during welding.

9.2.1.2 Prestressed Concrete Bridge Beams

For prestressed concrete bridge beams without steel sole plates, if the grade of the roadway is less than 5% the bearings may be manufactured with a sloping top surface provided that the internal steel reinforcement plates are parallel and level.

9.2.2 Cotton Duck Reinforced Bearings with PTFE Slider

Cotton Duck fabric reinforced elastomeric bearings should be considered for locations with low to moderate loads combined with moderate to high movement.

The movement due to expansion is accommodated between the PTFE and the slider plate. The PTFE material should be bonded to the top surface of the bearing. The slider plate shall be welded to a top plate or the beveled sole plate.

9.2.3 High Load Multi-Rotation Bearings

High Load Multi-Rotational bearings should be considered for locations with moderate to high loads combined to moderate to high movement. The designer should not completely design high load multi-rotational bearings for each location; however, a preliminary design should be done to determine the rough overall dimensions of the bearing. The specifications for high load multi-rotational bearings require that the Contractor or his Fabricator design the specific bearings based on the type of bearing that is supplied.

The sealing rings used to secure the elastomer disc within the pot shall be round in cross section. Flat rings will not be allowed due to problems with leakage of the elastomer.

9.2.4 Steel Fixed Bearings

Steel bearings may be used where no movement is necessary and where the only rotation is in the transverse axis of the bridge. A 1/8" thick, 90 durometer random fabric pad should be used to seat the steel masonry plate on the concrete substructure bearing pad. For steel bridge beams, the anchor bolts for the bearing should not pass through the flange of the beam.

Section 10
DECK JOINTS

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Section 10 **DECK JOINTS**

10.1 GENERAL

The selection and layout of deck joints shall allow for deformations due to temperature and time dependent causes, be consistent with the proper functioning of the bridge, be able to stand up to vehicular live load, and provide a water tight seal to prevent roadway runoff from falling on the structural members below.

The number of movable deck joints in a structure should be minimized. Continuous deck/superstructure systems should be used and, where appropriate, integral bridges.

Several joint types are recommended below for different situations. Other joints may be used, provided that the Department has approved them.

10.1.1 Location of Joints

Deck joints should be avoided at or near points of sag vertical curves.

Deck joints at abutments shall be located behind the abutment backwall so that any leakage of the joint would not damage the structural elements below. An exception to this may be for modular joints where future maintenance is required. In this case, the joint may have to be placed in front of the backwall.

Generally, open finger joints shall only be used behind the abutment backwall where the water and debris can be intercepted by a concrete drainage structure. (See Division III.)

10.1.2 Skew Effects

Provisions shall be made in the joint design for both lateral and longitudinal movement based on the geometry of the deck and the design of bearings and keeper assemblies. For bridges with complicated deck configurations, a thermal expansion analysis of the deck should be done in order to determine the thermal movements relative to the bridge joints.

10.1.3 Curvature Effects

For curved superstructures, provisions shall be made in the joint design for both lateral and longitudinal movement based on the geometry of the deck and the design of bearings. Generally, the direction of movement of the superstructure may be assumed to be parallel to the chord of the deck centerline taken from the joint to the neutral point of the superstructure.

10.1.4 Temperature Range

The temperature range used for the calculation of thermal movement of deck joints shall be 120°F. This temperature range is based on a mean low temperature of -10°F and a mean high temperature of +110°F. The median temperature for design of joints shall be +50°F.

10.1.5 Coefficient of Thermal Expansion

For the design of deck joints, a coefficient of thermal expansion shall be taken as $6.4 \times 10^{-6}/^{\circ}\text{F}$. This equates to approximately 2¾" total movement for a 300-foot long bridge.

10.1.6 Movement Due to Seismic Events

If the bridge is designed for seismic events where significant movement is important to the proper function of bridge elements (such as seismic isolation bearings), the movement due to seismic forces shall be accommodated in the design of the joints. For other bridges, the joint need not be designed for seismic movement, and should not be designed to survive the seismic event undamaged.

10.2 TRANSVERSE JOINTS

10.2.1 Fixed Joints

10.2.1.1 *Abutment Joints*

For fixed joints at abutments, the first preference for joint type should be the Asphaltic Plug Expansion Joint System.

10.2.1.2 *Pier Joints*

For fixed joints at piers, the first preference for joint type should be the Asphaltic Plug Expansion Joint System.

10.2.2 Expansion Joints with Movement Up to 5/8"

10.2.2.1 *Abutments Joints*

For joints at abutments where the total movement is less than 5/8", the first preference for joint type should be the Asphaltic Plug Expansion Joint System.

10.2.2.2 *Pier Joints*

For joints at piers where the total movement is less than 5/8", the first preference for joint type should be the Asphaltic Plug Expansion Joint System.

10.2.2.3 Box Culverts

For joints along the side edges of reinforced concrete box culverts, the first preference for joint type should be a sawed joint in the Bituminous Concrete (Class 1) Overlay filled with Silicone Joint Filler.

10.2.3 Expansion Joints with Movement Between 5/8" to 1½"

10.2.3.1 Normal Bridges

The first preference for joint type should be the Asphaltic Plug Expansion Joint System.

10.2.3.2 Skews

For joints with skews greater than 45°, where the effects of skew cause significant racking (transverse movement) of the joint, and where the length of travel of the truck wheels can cause severe rutting, the first preference for joints should be Elastomeric Concrete Headers with a Silicone Sealant ("Silicone Expansion Joint System").

10.2.3.3 Pin and Hanger Joints

For existing joints that have pin and hanger expansion devices connecting the beams where there is potential for differential vertical movement across the joints, the first preference for joints should be Elastomeric Concrete Headers with a Silicone Sealant ("Silicone Expansion Joint System").

10.2.4 Expansion Joints with Movement Between 1 ½" and 3"

For joints where the total movement is between 1½" and 3", the first preference for joints should be Elastomeric Concrete Headers with a Silicone Sealant ("Silicone Expansion Joint System").

10.2.5 Expansion Joints with Movement Between 3" and 4"

For joints where the total movement is between 3" and 4", the first preference for joints should be Elastomeric Concrete Headers with a Neoprene Strip Seal ("Elastomeric Concrete Expansion Joint System").

10.2.6 Expansion Joints with Movement Greater Than 4"

10.2.6.1 Joints at Abutments

10.2.6.1.1 Modular Joints

Modular expansion joints may be used at abutments, provided that the distance between the abutment backwall and the ends of the beams and diaphragms is kept to two feet minimum in order to facilitate inspection and future maintenance.

10.2.6.1.2 Finger Joints

Where a proper drainage structure can be constructed behind the abutment backwall, an open finger joint can be considered. The drainage structure should be provided with an access door or manhole for cleaning. The structure should also be connected to a storm drainage system or a standard outlet. Where the bottom of the drainage structure is not the top of the abutment footing, a two feet deep sump should be detailed to catch sedimentation.

10.2.6.2 Joints at Piers

10.2.6.2.1 Modular Joints

The first preference for joint type at piers should be Modular expansion joints. The distance between adjacent diaphragms shall be kept to two feet minimum in order to facilitate inspection and future maintenance. The beam-ends may be kept closer if proper maintenance can be accomplished. Joint manufacturers should be contacted for specific requirements for each joint.

10.2.6.2.2 Finger Joints

Where the location of the joint is at the crest of a vertical curve, an open finger joint can be considered. A drainage trough shall be provided that is connected to a proper piping system (see Section 11).

10.3 LONGITUDINAL JOINTS

10.3.1 Deck Joints

Longitudinal deck joints should be avoided wherever possible due to problems with motorcycle safety and difficulties associated with the intersection of the transverse deck joints. If longitudinal joints are unavoidable, they shall be located out of the traveled way. Since differential vertical movement is common in longitudinal joints, the only joints that should be considered are Elastomeric Concrete Headers with a Silicone Sealant or a Neoprene Strip Seal. A Silicone Sealant is preferred.

10.3.2 Concrete Median Barrier

Where split concrete median barrier is used, the longitudinal joint between the barriers should not be sealed. A one-inch open joint should be detailed for this situation.

10.4 JOINT SPECIFIC DESIGN REQUIREMENTS

10.4.1 Asphaltic Plug Expansion Joint System

The asphaltic plug expansion joint system shall always be placed after the final pavement has been placed on the bridge and the pavement in the area of the header has been saw cut and removed. This applies for rehabilitation and new construction.

The asphaltic plug joint should be detailed from curb to curb. The joint in the parapet should be sealed to the top of the curb portion of the parapet only with a non-sagging silicone joint material held in place with a backing rod. The portion of the parapet that is above the curb portion should be left open.

10.4.2 Elastomeric Concrete Headers with a Silicone Sealant

The Elastomeric Concrete Header Expansion Joint System with a Silicone Sealant shall always be placed after the final pavement has been placed on the bridge and the pavement in the area of the header has been saw cut and removed. This applies for rehabilitation and new construction.

The Silicone Sealant should be detailed from curb-to-curb and up to the top of the curb portion of the parapet.

The elastomeric header material should be recessed 1/8" below the bituminous overlay to account for long-term compaction of the bituminous overlay under traffic.

10.4.3 Elastomeric Concrete Headers with a Neoprene Strip Seal

The Elastomeric Concrete Expansion Joint System with a neoprene strip seal shall always be placed after the final pavement has been placed on the bridge and the pavement in the area of the header has been saw cut and removed. This applies for rehabilitation and new construction.

The neoprene seal should be detailed from curb to curb and up to the top of the curb portion of the parapet. The steel extrusion can be attached in the parapet with the elastomeric concrete material. For bridges with minor skews, the extrusion may be run into the parapet along the skew.

The elastomeric header material should be recessed 1/8" below the bituminous overlay to account for long-term compaction of the bituminous overlay under traffic.

The minimum gap between the bottom of the steel extrusion and the deck should always be 1/2". For this reason, the 1 1/2" deep extrusion should be used for standard 2 1/2" bituminous overlays.

10.4.4 Modular Expansion Joints

The design and detailing of modular expansion joints is the responsibility of the manufacturer of the joint; however, the designer should provide the proper room in the slab for the installation of the joint. The designer may have to contact each approved manufacturer to ensure that each joint can fit within the bridge slab.

The modular joints shall be detailed from curb to curb and up to the top of the curb portion of the parapet. For bridges with skews, the joint system should be run into the parapet on the skew and covered with curb plates. The curb plates shall be designed to accommodate all movements, and the free edge should overlap the parapet on the trailing edge of the parapet.

Only joints that are approved by the Department that have successfully tested for fatigue may be used (see recurring specifications for details on approved companies and fatigue requirements).

Section 11
SURFACE DRAINAGE

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Section 11 **SURFACE DRAINAGE**

11.1 GENERAL

Generally, wherever possible surface drainage should be handled with roadway catch basins located before and after the bridge. When it is not possible to handle all the surface drainage off the bridge, the entire deck drainage system shall be designed to be as maintenance free as possible. Wherever possible, drainage routes shall be short and direct, and abrupt changes in direction shall be avoided. Pipes and troughs shall be sized to handle design flows, and slopes shall be maximized. Clean-outs shall be provided at strategic locations to simplify maintenance of the system.

Where pollution of streams, ponds and water supply areas may be a factor, further consideration is required.

11.2 DESIGN GUIDELINES

Adequate facilities shall be provided to collect and dispose of the surface water on the structure by means of suitable scuppers, troughs and leaders where required by drainage requirements. Direct discharge from scuppers, etc., is preferable over waterways, and all other areas where the discharge will not be detrimental to the area below. This discharge shall not be allowed to fall on any components of the structure. The FHWA document entitled "Design of Bridge Deck Drainage" (HEC-21) or its successor shall be used.

11.2.1 Scuppers

Scuppers are to be located to avoid long runs of pipe/trough and shall be designed to satisfy the structural and drainage requirements. Scuppers shall be designed in accordance with the provisions of the latest edition of the Department's *Drainage Manual*.

11.2.2 Drainage Piping

Drainage piping shall have a minimum diameter of 8". For aesthetic reasons, leaders shall be located on the inside face of the fascia girders, on the rear face of piers, and recessed into the front face of abutments. Piping shall not be located within concrete pier columns. Piping should not be used where runs are required with an angle of less than 30° to the horizontal.

11.2.3 Open Troughs

Where piping is not appropriate, open troughs shall be used. Troughs shall be of adequate depth and shall have a self-cleaning pitch of 3% or greater to carry the

discharge and minimize the possibility of spilling or clogging. Provisions must be made to contain the splashing where scuppers spill into the troughs.

11.2.4 Underground Pipe

The underground drainage beyond the bridge piping must conform to the requirements of the Department's *Drainage Manual* and shall be included in the roadway items.

Section 12
BRIDGE RAILS & BARRIERS

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Section 12
BRIDGE RAILS & BARRIERS

12.1 BRIDGE RAILS

12.1.1 General

Bridge rails are required for all structures carrying vehicular traffic. Bridge rails may be a solid concrete parapet or an open rail system whichever is appropriate for the service level and traffic volumes of the roadway in question as defined below. Only bridge rail systems crash tested under the testing procedures specified in NCHRP Report 350 and approved by the Department may be used on bridges carrying vehicular traffic.

For continuous construction, the pouring sequence for the parapets shall be identical to that of the slab.

12.1.2 Limited Access Highways

Bridge rails shall be solid concrete parapets, 42 inches high. Vertical transitions shall be provided at the ends to reduce the height to match the approach railing system.

12.1.3 Other Highways

Bridge rails should be solid concrete parapets, 32 inches high and topped with an appropriate railing or protective fence system. If sidewalks are required on the bridge they shall be topped with an appropriate railing or protective fence system. When the sidewalk parapet is to be topped with a railing, the height above the top of the sidewalk should be 32 inches. When the sidewalk parapet is to be topped with a protective fence, the height above the top of the sidewalk may be raised to 36 inches if advantageous in achieving minimum protective fence heights specified in Section 12.2.2 and if acceptable to local authorities.

The use of parapet end blocks above the top of the parapet shall be at the discretion of the designer. In areas involving sight distance problems, the parapet end blocks should not be used.

The end height of these blocks shall match the approach railing height. Where parapet end blocks are not provided, exposed rail ends and sharp changes in rail geometry should be avoided.

12.1.4 Scenic Overpasses

For bridges on non-limited access highways where there is a strong need to provide a scenic view, an open bridge rail system approved by the Department should be used in

place of a concrete parapet. The use of this system should be limited to very sensitive areas.

12.1.5 Box Culverts and Short Bridges

On box culverts and very short span bridges, short runs of concrete parapet (less than 30 feet long) are visually disruptive and difficult to provide with an appropriate approach rail anchorage system.

Whenever possible, the first choice should be the use of one of the three nested W-beam rail systems developed to span over short bridges and culverts. These systems span over the structure by leaving out one, two or three of the rail posts. The structure should be extended far enough behind the rail to provide the required deflection distance. A drawing detailing these rail systems is available from the Department.

If the structure is beyond the limits of these rail systems, the next choice should be to use a crash tested bridge rail system that utilizes a W-beam element and provides continuity of the approach railing. The structure should be extended far enough behind the rail to provide the appropriate deflection distance.

Where one of these three rail systems is not possible due to structure type or rights-of-way restrictions, a concrete parapet should be used with a continuous approach rail element attached to it.

On very short structures with low drop-off heights, the Department on a case-by-case basis may waive the pedestrian and/or bicycle railing requirements. Where pedestrian or bicycle requirements are not waived, the Department's Pedestrian Railing may be used.

12.1.6 Retaining Walls

On retaining walls adjacent to traffic, bridge rails should be solid concrete parapets, 32 inches high and topped with an appropriate railing or protective fence system. If the retaining wall is adjacent to a sidewalk, they shall be topped with an appropriate railing or protective fence system. When the sidewalk parapet is to be topped with a pedestrian railing, the height above the top of the sidewalk should be 28 inches. When the sidewalk parapet is to be topped with a protective fence, the height above the top of the sidewalk may be raised to 36 inches if advantageous in achieving minimum protective fence heights specified in Section 12.2.2 and if acceptable to local authorities. An open bridge rail system should be used in place of a concrete parapet where the resulting concrete parapet would be less than 30 feet long.

12.2 PEDESTRIAN RAILINGS, BICYCLE RAILINGS & PROTECTIVE FENCES

12.2.1 General

A railing is required on all parapets less than 42 inches in height. The railing shall be a pedestrian railing, bicycle railing, or protective fence.

12.2.1.1 *Pedestrian Railing*

A drawing is available for the Department's standard pedestrian railing. Pedestrian railings shall be designed in accordance with the AASHTO *Specifications*. The top of rail members shall be at least 42 inches above the top of the sidewalk.

12.2.1.2 *Bicycle Railing*

For bridges on designated bicycle routes, a bicycle railing shall be designed in accordance with the AASHTO *Specifications*. A map depicting designated bicycle routes in the State of Connecticut is available from the Department.

12.2.1.3 *Protective Fence*

Protective fencing should satisfy the aesthetic considerations of the structure and be designed in conformance with the AASHTO *Specifications* for pedestrian railings. Where protective fencing is provided, it shall consist of black PVC coated fabric with galvanized steel posts and rails. Exceptions will only be allowed for showcase bridges or bridges with historical significance. Fences over electrified railroads shall be solid. A protective fence, if used, satisfies the requirements for either a pedestrian or bicycle railing.

12.2.2 Railing / Protective Fence Selection Procedures

12.2.2.1 *Highway Overpasses*

12.2.2.1.1 Protective Fence

Protective fencing is required on both parapets of all highway overpass structures carrying local or secondary roads. The height of the fencing above the top of the sidewalk or roadway surface shall be a minimum of eight feet. The maximum size of the opening in the fence shall be two inches. The need for a curved top fence should be investigated. The face of the fence shall be flush with the parapet face on sidewalk parapets and shall be set back as far as practical from the face of safety shape parapets as detailed in Division III.

Protective fencing is not required on overpass structures carrying limited access highways or ramps.

Under certain circumstances protective fences are required by law as specified in *Public Act No. 00-184*. No waivers to these requirements that conflict with *Public Act No. 00-184* will be granted under any circumstances.

12.2.2.1.2 Pedestrian Railing

Pedestrian railings are not required. Protective fencing will provide pedestrian protection on local or secondary roads.

12.2.2.1.3 Bicycle Railing

Bicycle railings are not required. Protective fencing will provide bicycle protection on local or secondary roads.

12.2.2.2 *Stream or Wetland Overpasses - Structure with one or more sidewalks*

12.2.2.2.1 Protective Fence

Protective fencing is generally not required except where unusual conditions exist affecting the public safety below.

12.2.2.2.2 Pedestrian Railing

A pedestrian railing is required on both parapets for parapets under 42 inches high, except where a protective fence is provided.

12.2.2.2.3 Bicycle Railing

A bicycle rail is required on designated bicycle routes except where a protective fence is provided.

12.2.2.3 *Stream or Wetland Overpasses - Structure without sidewalks*

12.2.2.3.1 Protective Fence

Protective fencing is generally not required except where unusual conditions exist affecting the public safety below.

12.2.2.3.2 Pedestrian Railing

A pedestrian railing is required on both parapets for parapets under 42 inches high.

12.2.2.3.3 Bicycle Railing

A bicycle railing is required on designated bicycle routes.

12.2.2.4 Railroad Overpasses

12.2.2.4.1 Protective Fence

Protective fencing is required on all structures. It shall be placed on both parapets on the span over the railroad tracks. On long structures, protective fencing is required only over the tracks plus a minimum of 25 feet beyond the outside track and measured perpendicular to it.

The height of the fencing above the top of the parapet and the maximum size of the openings shall be in accordance with the following criteria:

LOCATION	HEIGHT* (ft)	MAXIMUM SIZE OPENING
Non-Electrified Zone	8 (min.)	2 inches or as approved by the Department
Electrified Zone	8 (min.)**	Solid Barrier required

* The height of the fencing above the top of the sidewalk or roadway surface.

** Use nine feet with a curved top at all sidewalks.

12.2.2.4.2 Pedestrian Railing

A pedestrian railing is not required where protective fence is provided. On long structures, where protective fencing is required only over the tracks plus a minimum 25 feet from the outside track, a pedestrian railing is required on both parapets outside these limits.

12.2.2.4.3 Bicycle Railing

A bicycle rail is not required where protective fence is provided. On long structures, where protective fencing is required only over the tracks plus a minimum 25 feet from the outside track, a bicycle railing is required outside these limits on designated bicycle routes.

12.2.2.5 Pedestrian Overpasses

Complete enclosure of pedestrian structures passing over highways and railroads is required. The need for protective fencing on pedestrian overpass structures at stream or woodland crossings shall be determined by the Department. The maximum size of the opening in the fence shall be two inches.

12.2.2.6 Walls

12.2.2.6.1 U-Type Wingwalls

Pedestrian railing, bicycle railing or protective fence is to be provided as required for the bridge.

12.2.2.6.2 Retaining Walls Adjacent to Traffic

A pedestrian railing is generally required for walls with parapets less than 42 inches high and adjacent to traffic. Retaining walls along a sidewalk generally follow the requirements of Section 12.2.2.2.

12.2.2.6.3 Retaining Walls not Adjacent to Traffic

A pedestrian railing or protective fence is generally required for walls that are not adjacent to traffic or a sidewalk where the vertical drop off is greater than four feet.

12.2.2.6.4 Concrete Barrier Walls

Pedestrian railing, bicycle railing and protective fences are not required.

12.2.3 Drawings for Railings & Fences

The following drawings are available from the Department:

1. Pedestrian Railing (Bridge), (horizontal end for use with end blocks)
2. Pedestrian Railing (Bridge), (angular end for use without end blocks)
3. Pedestrian Railing (Two Rail)
4. Metal Bridge Rail - Three Rail Traffic

These drawings are available from the Department in a MicroStation format and will be made available upon request.

12.2.4 Railings and Fences at Lighting & Signing Standards

When lighting or signing standards are located on structures, the railing or fence shall be continuous at these locations. The lighting or signing shall be located outside of the continuous railing or fence (between the railing or fence and the outside face of parapet). Protective fencing shall be designed with removable panels or other means to provide access to the handhole locations. The parapet details shall accommodate the lighting and signing standard anchorages outside of the railing or fence. The lighting or signing shall not generally be located on a span over a railroad-electrified zone. For details, see DIVISION III.

12.3 CONCRETE BARRIERS

12.3.1 Permanent Median Barriers on Bridges

Permanent median barriers on bridges shall be concrete and shall match the height and width on the roadway approaches. They may be either cast-in-place or precast concrete. For details, see DIVISION III.

12.3.2 Temporary Precast Concrete Barriers on Bridges

Temporary barriers used to protect the traveling public during the construction of bridges shall be precast concrete and shall conform to the Department's standardized details. In all cases, if the distance from the backside of the barrier to the edge of the deck drop off is less than six feet, the barrier shall be rigidly attached to the deck. In cases where this distance is greater than six feet, factors such as the type of road; speed, volume and composition of traffic; and the need to protect work areas with limited escape routes shall be taken into account and the barrier rigidly attached if appropriate. Lines of barrier used strictly to separate opposing traffic need not be rigidly attached to the deck and shall be paid for as a roadway item. A drawing is available detailing the Department's standardized temporary bridge barrier.

12.3.3 Concrete Barrier Wall

When required by geometric or roadway design requirements, a concrete barrier wall should be detailed as shown in DIVISION III.

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BURIED STRUCTURES

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Section 13
BURIED STRUCTURES

13.1 REINFORCED CONCRETE BOX CULVERTS

13.1.1 General

Reinforced concrete box culverts may be made of either precast or cast-in-place concrete. Generally, when conditions warrant a box culvert, for reasons of economy, it shall be made of precast concrete. Full-length cast-in-place concrete box culverts shall only be used with the approval of the Department. Sections of box culverts may be cast in-place when required by site conditions such as transitions between different size culverts, transitions between new and existing box culverts, adjacent utilities that cannot be relocated, or highly skewed culvert ends.

The culvert dimensions shall be consistent with the hydraulic characteristics of the waterway. Preferably, the height of the box culvert (the dimension from the top of the floor (invert) to the bottom of the roof) should be a minimum of six feet to facilitate its maintenance and inspection. For culverts that are designed to "silt in" with soil, the height should be measured from the invert of the channel.

For precast culverts, the size selection should be coordinated with the manufacturers to be consistent with standard sizes that are readily available. On projects requiring more than one culvert, of different size openings, an economic study should be conducted to determine if it is possible to use the same size opening for more than one structure.

Box culverts do not need to be analyzed for scour. However, erosion countermeasures may be required if recommended by the Hydraulics Report.

13.1.2 Excavation

For excavation requirements, refer to Section 5.

13.1.3 Foundation

For foundation requirements, refer to Section 5.

13.1.3.1 Culvert Bedding

Generally, box culverts shall be founded on twelve inches of granular fill to provide slightly yielding uniformly distributed support over the bottom width of the box section. The fill shall extend two feet beyond the sidewalls of the box culvert.

Box culverts founded on unyielding foundations, such as rock or piles, are not permitted.

13.1.3.2 Cutoff and Return Walls

The inlet and outlet ends of box culverts shall rest on cutoff walls. The cutoff walls shall have return walls below the outside walls that extend a minimum of four feet from the rear face of the cutoff wall. These walls shall be embedded a minimum of four feet below the finished elevation of the bottom of the channel. The walls shall have a minimum thickness of twelve inches. Cutoff and return walls shall be constructed of "Class "A" Concrete". The floor of the box culverts shall be connected to the cutoff walls with dowels.

13.1.3.3 Nosings Between Adjacent Parallel Multicell Box Culverts

The inlet and outlet ends of the walls between adjacent parallel multicell box culverts shall be protected with nosings. The nosings may be either cast-in-place or precast. Cast-in-place concrete nosing shall be constructed of "Class "A" Concrete." The nosings shall be founded on the cutoff wall and connected to the walls.

The maximum allowable joint width between adjacent parallel units shall be one inch. In order to provide a positive means of lateral bearing between parallel units, after placing the nosing, the joint shall be filled with sand made flowable by mixing it with water.

13.1.3.4 Sills

Sills shall be provided at the inlet and outlet ends of box culverts when warranted by hydraulic or environmental conditions. The dimensions shall be as recommended by the Hydraulic Report. The sills shall have a minimum thickness of twelve inches and shall be connected to the floor of the box culverts with dowels. Sills shall be constructed of "Class "A" Concrete."

13.1.3.5 Headwalls

Headwalls at the inlet and outlet shall be provided to satisfy the site grading conditions. Headwalls shall be constructed of "Class "A" Concrete." The headwalls shall have a minimum thickness of 1'-3" at the top. On precast concrete box culvert, dowel bar mechanical connectors shall be used to connect headwall stems to the roof of box culverts. The rear face of headwalls shall be dampproofed. Railings or fences shall be placed on all headwalls in accordance with the requirements of Section 12.

13.1.3.6 *Wingwalls*

Generally, cast-in-place concrete wingwalls shall be provided at the inlet and outlet of all box culverts. The designer should coordinate with the hydraulic engineer as to the appropriate angles for the flared wingwalls. The wingwalls should abut the ends of the outside walls of the box culvert. Wingwall stems and footings shall be made independent of the culvert walls, cutoff and return walls. The elevation of the bottom of the wingwall footings shall match the cutoff and return walls. Wingwalls shall be constructed of "Class "A" Concrete." The minimum thickness at the top of wingwall stems shall be 1'-3". Railings or fences shall be placed on all wingwalls in accordance with the requirements of Section 12.

13.1.3.7 *Dampproofing*

Dampproofing is not required on precast concrete box culverts.

13.1.3.8 *Subsurface Drainage*

Provisions for subsurface drainage are not required for the culvert backfill.

13.1.3.9 *Backfill Requirements*

13.1.3.9.1 General

Unless otherwise directed, all box culverts and their associated wingwalls shall be backfilled with "Pervious Structure Backfill" in accordance with the requirements of Section 5.

13.1.3.9.2 Backfill Limits

Place a wedge of Pervious Structure Backfill above a slope line starting at the top of the heel and extending upward at slope of 1:1½ (rise to run) to the bottom of the subbase. In cut situations, the following note, with a leader pointing to the slope line, shall be placed on the plans:

Slope line except where undisturbed material protrudes within this area.

Rock fill or boulders shall not be placed within two feet of top of box culverts. The following note, with leaders pointing to the limits, shall be placed on the plans:

No rock fill or boulders shall be placed within these limits.

In cut situations, if the material is soft silt or clay, the backfill limits shall be determined by the designer and submitted for review and approval with the Soils and Foundation Report.

13.1.3.10 Membrane Waterproofing Requirements

When the distance from the top of the box culvert roof to top of the roadway surface is less than two feet, membrane waterproofing shall be placed on the box culvert. The membrane waterproofing shall be "Membrane Waterproofing (Woven Glass Fabric)." The membrane shall cover the entire exterior surface of the roof and extend twelve inches down the sidewalls.

13.1.3.11 Railing and Fences

For railing and fence requirements, refer to Section 12.

13.1.4 Precast Concrete Box Culverts

Precast concrete box culverts shall be designed and detailed by the Contractor in accordance with the special provision "_x_ Precast Concrete Box Culvert." The designer is responsible for reviewing the Contractor's working drawing submittal for the box culverts. For additional information, refer to Article 17.1.3.

The designer is responsible for designing and detailing all other box culvert components, such as cutoff and return walls, nosings, sills, headwalls and wingwalls. For additional information, refer to Section 3.

13.1.5 Cast-In-Place Concrete Box Culverts

13.1.5.1 General

The designer is responsible for designing and detailing cast-in-place concrete box culverts including all other box culvert components, such as cutoff and return walls, nosings, sills, headwalls and wingwalls. For additional information, refer to Section 3.

13.1.5.2 Concrete

Cast-in-place concrete box culverts shall be constructed of "Class "A" Concrete."

13.1.5.3 Minimum Thickness of Floor, Sides and Roof

The minimum thickness of the culvert floor, sides and roof shall be twelve inches.

13.1.5.4 Reinforcement Details

The minimum reinforcement shall be #5 @ twelve inches.

The minimum cover over all reinforcement shall be two inches, except the cover over the outer reinforcement in the floor slab shall be three inches. The cover over all reinforcement in structures exposed to salt water shall be four inches.

13.1.5.5 Expansion, Contraction and Construction Joints

Expansion and contraction joints in the culvert floor, sides and roof shall be provided in accordance with AASHTO *Specifications*. Construction joints shall be placed as conditions warrant.

No reinforcement shall pass through expansion and construction joints. Reinforcement shall pass through construction joints.

13.2 REINFORCED CONCRETE JUNCTION BOXES

Vacant

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SIGN SUPPORTS

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Section 14 **SIGN SUPPORTS**

14.1 STRUCTURE MOUNTED SIGN SUPPORTS

14.1.1 General

A structure mounted sign support is a support that is connected to the fascia member and components of a bridge overpass and supports various types of traffic signs.

14.1.2 Design Responsibilities

The dimensions of the sign, the location of the sign over the roadway below, the angle between the sign and the centerline of the roadway below, and the tilt of the sign shall be determined by the Traffic Engineer. The structural designer is responsible for the design and details of the structure mounted sign support required supporting the traffic signs as required by the Traffic Engineer. Structure mounted sign supports require shop drawings that must be reviewed by the designer. For additional information, see Section 17.

14.1.3 Design Requirements

Structure mounted sign supports shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

The design of all sign support structures shall be based on 80 miles per hour.

Structure mounted sign supports are, by their nature, complex and difficult to model structures. In all but the simplest cases (small signs with virtually no skew), a rigorous three-dimensional analysis is required.

The analysis of structure mounted sign supports shall, in general, be based on pin connected truss members. However, simplified connections, such as angles welded back to back, can sometimes result in substantial eccentricities from the assumed truss nodes. More detailed analysis taking these eccentricities into account may sometimes be necessary in order to reasonably model the structure.

Structures involving larger sign panels and/or significant skew angles may also require more highly detailed and precisely fabricated designs to eliminate eccentricities at the nodes.

Sufficient members shall be employed to brace the structure in all directions and maintain structural stability under all design assumptions. Horizontal rail elements between trusses should be designed as continuous members.

14.1.4 Material Requirements

The sign supports shall be constructed with structural steel conforming to AASHTO M270, Grade 36. Generally, sign supports are constructed with angles and WT sections except where otherwise required as noted in 14.1.3. The minimum size angle shall be L 4 x 4 x 3/8". The use of metal sign posts as members for structure mounted sign supports is not permitted. All structural steel shall be hot-dip galvanized in accordance with ASTM A123.

High strength bolts shall conform to the requirements of ASTM A325, Type 1 and be mechanically galvanized in accordance with ASTM B695, Class 50. Carriage bolts shall conform to the requirements of ASTM A307 and be hot-dip galvanized in accordance with ASTM A123.

Welding shall conform to Article 7.1.4.

14.1.5 Detail Requirements

Generally, structure mounted signs are supported by a framework of trusses connected together with lateral bracing and anchored to the bridge. The trusses, typically composed of angles, should be placed normal to the bridge fascia. The length of the trusses depends on the length of the sign and the angle the sign forms with the bridge fascia (skew angle).

In general, placement of signs on structure mounted supports is discouraged on bridges with skew angles of greater than 30°. If the skew angle becomes excessive, particularly for larger signs, consideration should be given to placing the sign on a cantilever or overhead sign support structure adjacent to the bridge. The height of signs should be kept in reasonable proportion to the height of the sign support frame. Since the height of the frame is limited by the bridge superstructure depth, this limits the height of sign that can reasonably be supported in this manner. In general, the height of the sign should not exceed twice the height of the frame, particularly on bridges with significant skew.

The minimum distance from the sign to the bridge structure must allow for placement of the truss diagonal members. The lowest portion of a structure mounted sign support shall be a minimum of twelve inches above the lowest component of the fascia member of the bridge to which it is attached.

The truss members and lateral bracing are typically connected by shop and field welds. Generally, the truss sections of the supports are field welded to WT sections bolted to

the bridge fascia components. Bolted connections to steel members should be made with high strength bolts. Bolted connections to concrete members should be made by bolting through the component with carriage bolts and a plate washer.

For signs composed of interconnected extruded aluminum sign panels, the signs should be attached to WT members (sometimes referred to as hangers) with post clips. The post clips should be installed for the full height of the WT members on alternate sides. A sign stop should be placed at the bottom of the WT members. All members supporting sign and crown panels shall be positively connected to the sign support framework. The maximum spacing between the WT members is six feet. The maximum distance from a WT member to the edge of a sign shall be three feet. The minimum distance from a WT member to the edge of a sign shall be twelve inches.

14.1.6 Pay Items

Structure mounted sign supports shall be paid under the item "Structure Mounted Sign Support" which requires a special provision. The signs are traffic items, and shall be paid for under the appropriate traffic items.

14.2 TUBULAR AND TRUSS SIGN SUPPORT STRUCTURES

14.2.1 General

Tubular and truss sign support structures refer to the following types of sign supports described in the *Standard Specifications*:

- Tubular Arch Sign Support Structure,
- Tubular Arch Cantilever Support Structure,
- Overhead Truss Sign Support (Type), and
- Overhead Cantilever Sign Support (Type).

These sign supports are designed to carry extruded aluminum sign panels. Details for these structures are shown on traffic standard sheets prepared by the Department. These structures are designed to be supported by foundations embedded in the ground. The foundation details are shown on standard sheets prepared by the Department.

14.2.2 Design Responsibilities

14.2.2.1 Standard Sign Supports

The locations and types of tubular and truss sign support structures, the dimensions of the signs, the location of the signs over the roadway below, the angle between the signs and the centerline of the roadway below, and the tilt of the signs shall be determined by the Traffic Engineer.

If the tubular or truss sign support structures will be supported as shown on the standard sheets, no additional design or details are required by the designer. If any of the details on the standard plans are varied or altered, the designer should check all the details to ensure that they are applicable for the altered conditions.

If the tubular or truss sign support structures will support a sign structure other than an extruded aluminum sign, the designer shall analyze the entire support and foundation. The designer should also check all the details to ensure that they are applicable for the altered conditions.

14.2.2.2 Sign Supports Mounted on Structures

The locations and types of tubular and truss sign support structures on a bridge or wall, the dimensions of the signs, the location of the signs over the roadway below, the angle between the signs and the centerline of the roadway below, and the tilt of the signs shall be determined by the Traffic Engineer.

The tubular or truss sign support structures shown on the standard plans are not intended to be mounted on highway bridges, retaining walls or other structures. If an overhead or cantilever support is required to be mounted on a structure, it must be completely designed and detailed by the designer.

These structures shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. The design shall be based on 80 mph, with the appropriate adjustment for height based on the elevation of the structure above surrounding ground or water.

If practical, the sign support materials and details should be similar to those shown on the tubular and truss sign support standard sheets to simplify fabrication and maintain a uniform appearance along the highway.

14.2.2.3 Special Sign Supports

For sign structures that are to support signs that are not extruded aluminum panels (such as variable message signs), the support must be completely designed and detailed by the designer.

The structure shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. The design shall be based on 80 miles per hour.

14.2.3 Shop Drawings

The tubular and truss sign support structures require shop drawings to be submitted by the Contractor. For additional information, see Section 17.

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UTILITY INSTALLATIONS

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Section 15 **UTILITY INSTALLATIONS**

15.1 GENERAL DESIGN REQUIREMENTS

To ensure that the structure remains functional and aesthetically pleasing wherever possible, the following Sections will apply to the installation of utilities on structures.

15.2 UNDERGROUND FACILITIES

Permanent underground installations, which are to be carried on and are parallel to the longitudinal axis of the structure, shall be placed in an out of sight location between the beams. No part of the utility or its supporting structure shall project below the bottom of the bridge superstructure.

In those instances where the proposed superstructure type is not adaptable to carrying utilities in an out-of-sight location on the underside of the structure, an early determination must be made as to whether or not utilities are to be accommodated. If the utilities must be accommodated, the selection of superstructure type must be addressed accordingly.

In those instances where an existing structure type is not adaptable to carrying utilities in an out-of-sight location on the structure, the proposed utility installation shall be the subject of an individual study as to its disposition.

Underground facilities shall not be suspended from or attached to the outside face of the superstructure, unless otherwise approved by the Department.

Where aesthetics are a prime consideration, the utility shall be placed underground to the extent necessary to preserve the aesthetics of the structure and the surrounding area.

15.3 AERIAL FACILITIES

15.3.1 Aerial Facilities Passing Over Structure

Aerial facilities (telephone, electrical, cable television, etc.) located along a highway that continues onto a structure shall be made an underground installation at the ends of the structure and carried across the structure. These facilities shall be placed in an out of sight location either between the beams or inside of a sidewalk if available. Placing utilities inside of the sidewalk shall be used only for telephone or cable TV. Electric conduits shall in no case be cast inside of a sidewalk as excessive heat buildup may be detrimental to both the utility and the structure. No part of the utility or its supporting structure shall project below the bottom of the bridge superstructure. The facility should extend a minimum distance beyond the ends of the structure required to retain the aesthetics of the structure.

Where unnecessary expense would be incurred by going underground, facilities carried on support poles may be carried aerially alongside a structure if it is practical to span the entire crossing.

The determination to carry the utilities either aerially or underground shall be studied at an early stage of the design with regard to such factors as economy, aesthetics, safety, and maintaining the characteristics of the local environment.

15.3.2 Aerial Facilities Passing Under Structure

Aerial facilities (telephone, electrical, cable television, etc.) located along a highway that passes under a structure shall in no instance be permitted to pass over the structure but shall be attached to the underside of it. An underground installation within the structure limits should be considered. The underground portion of the installation shall extend a distance beyond the limits of the structure(s) required to retain the aesthetics of the structure.

Solutions to special or unusual conditions shall be determined at a field review with Department and Utility Company representatives. The field review team shall include the Design Engineer and the Utilities Engineer. In the event that a mutually agreeable solution cannot be reached, the matter shall be forwarded through channels to the Transportation Chief Engineer for a ruling.

15.4 UTILITIES ADJACENT TO STRUCTURE

When underground utilities (existing or proposed) are located in the vicinity of structures, a review of the utility installation relative to the substructure design is required to determine if protection of the substructure is necessary.

The factors to be considered are the type, size, and location of the utility, the pressure in the line, the soil conditions, the material composition of the utility and the structure foundation.

The initial installation and future maintenance of the utility shall be investigated for their effects on the structure.

If it is determined that protection of the utility is necessary, the following are variations that should be considered:

1. Relocation of the utility.
2. Relocation of the substructure unit.
3. Protection of the substructure unit with sheeting.

4. Sheeting the utility trench.
5. Placing the utility in adequate encasement (sleeves or deflectors).
6. Placing the substructure on piles.
7. Require material composition of the utility to be ductile iron, prestressed concrete or steel (desirable in all cases).
8. Use of shut-off valves on both sides of the bridge (desirable in all cases).

This does not preclude other possibilities, which the designer or the utility engineer may have to offer.

15.5 EMERGENCY TEMPORARY INSTALLATIONS

Temporary installations of an emergency nature may be placed on the sidewalk of a structure, but such installation must be either removed or replaced by a permanent out-of-sight installation within one year of the date of the temporary installation. Where sidewalks are not available, special consideration and study will be required to insure a safe and acceptable placement of the temporary installation.

Upon completion of the temporary installation, immediate steps shall be initiated to insure that the temporary installation is removed or replaced within the time limit above and in a manner acceptable to the Department.

15.6 HIGHWAY ILLUMINATION POLES

If poles for highway illumination are needed within the non-access lines in the proximity of the structure, the location and type of poles shall be approved by the Department.

Illumination poles routinely provided by manufacturers are intended to be mounted on fixed, ground mounted foundations. Mounting on non-fixed structures subject to deflection and vibration, such as bridge spans, may result in unacceptable movement or vibration of the pole, possibly resulting in structural failure of the pole or damage to lighting fixture. Therefore, mounting of illumination poles on bridge spans should be avoided whenever possible. If standard illumination poles must be mounted on the span, they should be mounted as near as possible to abutment or piers for spans up to 200 feet. For spans over 200 feet, they should not be mounted over 50 feet from abutment or pier locations. If illumination poles are required in areas outside these limits, they must meet one of the following criteria:

- Be of a non-standard design that has been specifically designed for placement on a moving structure, and be appropriate for the amplitude and frequency of the motion anticipated.

- Be of reduced height (under 30 feet mounting height) and certified by the manufacturer as appropriate for this application.

15.7 HIGH VOLTAGE TRANSMISSION FACILITIES

Long distance high voltage transmission facilities shall be the subject of a special study. Where aesthetics are a consideration, the placement of the facility underground should be considered. The final determination shall be weighed considering both the economics and aesthetics of the location in question. If required, the alternate proposals shall be referred to the Transportation Chief Engineer for final determination.

Section 16
BRIDGE REPAIR & REHABILITATION

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Section 17
POST DESIGN RESPONSIBILITIES

17.1 CONTRACTOR INQUIRIES

17.1.1 General

It is the designer's responsibility to respond to questions with respect to the contract documents that arise both during the bidding process and during construction. The preparation of answers to these questions shall be considered a normal part of the work.

17.1.2 Inquiries During the Bidding Process

Contractors are directed that all questions during the bidding process shall be submitted to the Manager of Contracts in writing. If the designer receives questions from a potential bidder directly, their questions should not be answered and the designer should direct them to send the questions to the Manager of Contracts. All questions that require design input will be forwarded to the designer and responses to these questions should be prepared in an expeditious manner.

17.1.3 Inquires During Construction

Once construction has started, the designer may address verbal requests for clarification of the contract documents from the Contractor. If the Contractor requests a written response or the questions are beyond that of a simple clarification, he should be directed to submit a written request for information through the Office of Construction. These requests may be forwarded to the designer for review.

Before any deviation from the contract plans will be considered, a formal written request from the Contractor must be made to the Office of Construction and written approval secured before any change in the design will be sanctioned. Errors and inconsistencies must be handled in a like manner.

17.2 CHANGES TO THE CONTRACT DOCUMENTS

17.2.1 Changes by Addendum

17.2.1.1 General

The method by which changes to the contract documents are accomplished after advertising but prior to bid opening is through an addendum issued by the Manager of Contracts. Changes to the contract documents may be initiated by the designer, construction personnel or another unit in the Department and typically require revisions to the contract documents (plans and specifications), items and/or

quantities. Changes to the contract documents should be performed by the designer who shall prepare all plans and specifications along with the quantity and cost estimates required for the addendum. The Office of Contract Administration shall determine if sufficient time is available to process and release an addendum prior to bid opening.

As soon as a need for an addendum is identified, the Department's Bridge Project Engineer shall coordinate with the Office of Contract Administration and the Unit of Contract Development and establish dates as to when the addendum is due. If sufficient time is not available to issue an addendum, the changes shall be issued as a Construction Order after the project is awarded.

The designer shall obtain the original Mylars from the Department's Engineering Records Center located at 160 Pascone Place, Newington, CT. If the designer is a consultant, written approval from the Department is required.

In the case of a consultant-designed project, the consultant shall return all Mylars along with all new or revised CADD files to the Department with the addendum package. The Department shall be responsible for ensuring the Mylars are properly filled out by the Consultant and are properly returned to the Engineering Records Center at Pascone Place.

All documents prepared for an addendum are collected by the Office of Contract Development and forwarded to the Manager of Contracts for distribution to the prospective bidders. An addendum is not dated, but is identified by its addendum number. The actual official date for the issuance of the addendum is determined by the Office of Contract Administration after the receipt of the addendum from the Contract Development Unit.

The following Sections describe the procedures used by the designer to revise drawings and specifications along with the preparation of the necessary material required for an addendum.

Changes to the contract plans may also be described in writing to facilitate their distribution to the prospective bidders. In order to provide permanent documentation of changes made solely in writing by addendum, upon award of the contract, the plans may have to be modified in accordance with Section 17.2.2, and forwarded to the Office of Construction for the initiation of a construction order. The Mylars of sheets voided or replaced by addendum must be physically voided upon award of the contract.

17.2.1.2 *Modifications to the Contract Plans*

Modification to the contract plans shall be done in accordance with the following procedures.

17.2.1.2.1 Title Sheet Revision

When an addendum is required on a project, the designer shall complete a box on the original title sheet entitled "List of Drawing Revisions." This list shall be cumulative for each addendum or construction order issued.

17.2.1.2.2 New Sheets

Changes that require new sheets to be added to the project plans shall be handled in one of two ways:

1. If the new sheet does not have to be placed in a specific location within the project plans, the new sheet shall be numbered sequentially from the last sheet of the project plans. The total number of sheets noted on the project plans stays the same. A note shall be placed on the new sheet stating, "NEW SHEET ADDED BY ADDENDUM NO. Y," where "Y" equals the addendum number. This note shall be located directly above the title block. The revision block is not filled out for an addendum.
2. If the designer determines that the new sheet must go in a specific location within the project plans, the new sheet number shall be the number of the sheet it most closely relates to followed by -1. For example, if the new drawing must be placed in the project plans right after sheet 57, the new sheet shall be numbered 57-1. The total number of sheets noted on the project plans stays the same. A note shall be placed on the new sheet stating, "NEW SHEET ADDED BY ADDENDUM NO. Y," where "Y" equals the addendum number. This note shall be located directly above the title block.

In addition, the drawing number of the new sheet shall be the drawing number of the sheet it most closely relates to followed by -1. For example, if the new drawing must be placed in the project plans right after drawing number C-5, the drawing number shall be C-5-1.

If applicable, the approval block on the new Mylar shall be signed. A Professional Engineer or Architect shall seal new sheets when prepared by a consultant.

17.2.1.2.3 Revisions to Existing Plans

The original sheet shall not be modified with the exception of the placement of a note stating "THIS SHEET REPLACED BY ADDENDUM NO. Y," where "Y" equals the addendum number. This note shall be located directly above the title block. The original CADD file and original Mylar are kept as permanent records.

The revised sheets shall be made from a copy of the current CADD file and edited as noted below:

- The sheet number is not changed for an addendum.
- The drawing number (C-1, A-2, S-1, etc.) is not changed for an addendum.
- In an addendum, the revised sheet is considered to replace, in total, the original. However, as in a construction order request, areas of the sheet being revised are to be clouded to highlight that portion(s) of the sheet being changed.
- A note shall be placed on the replacement sheet simply stating "ADDENDUM NUMBER Y," where "Y" equals the addendum number. This note shall be located directly above the title block.
- The revision block is to be filled out for an addendum that is revising an existing sheet. A numbered triangle will be placed within the clouded area and a like numbered triangle will be placed in the revision block. The description in the revision block will reference the addendum number.
- If the original Mylar was signed in the approval block, the revised Mylar shall be signed and dated in the approval block by the responsible individual.
- If the original Mylar contained a Professional Engineer or Architect's seal, the revised Mylar shall be sealed by the responsible Professional Engineer or Architect.

If a sheet requires further revisions by a subsequent addendum, the addendum shall be prepared, as detailed above, using a copy of the previously modified sheet (electronic file). This procedure will result in changes made to a particular sheet being cumulative and a record kept of all sheets issued at each stage.

When revising plans that were not produced on CADD, changes that require revisions to the existing plans shall be made on Mylar copies of the original Mylar.

Note: When preparing an Addendum that will change quantities on a project that includes a "Detailed Estimate Sheet," never revise the "Detailed Estimate Sheet." A "Detailed Estimate Sheet" is never included in an addendum. Also, the "Quantities" box shown on the General Plan sheet for any structure is never to be revised.

Revisions to plan sheets shall be done through the issuing of a replacement plan sheet, except in rare occasions when doing so would result in a postponement to the scheduled bid opening that could have an adverse effect on the project.

The Transportation Principal Engineer of Design, Transportation Principal Engineer of Contract Development/Cost Estimating, and the Transportation Manager of Contracts shall make this determination. In cases such as these, the revision to the plan sheet shall be done within the text of the addendum or by issuing an 8½" x 11" sketch. The designer will place a note on the Mylar being revised that states "THIS SHEET IS REVISED BY ADDENDUM NO. 'Y'," where 'Y' equals the addendum number.

17.2.1.2.4 Deletion of Existing Plans

Plans that are deleted by addendum shall have a note on the original sheet, stating "THIS SHEET DELETED BY ADDENDUM NO. Y," where "Y" equals the addendum number. Under no circumstances are the CADD files to be physically deleted or are the original Mylars to be disposed of.

17.2.1.3 Modification to the Contract Specifications

The specifications governing the work shown on revised plans, replacement sheets, and/or new sheets are the *Standard Specifications*, Supplemental Specifications and the special provisions in effect at the time the addendum is issued. Changes to the contract specifications may be required to correct errors discovered during the bidding process. The corrections may be described in writing to facilitate their distribution to the prospective bidders.

In those cases where the existing specifications are not adequate to describe new or revised work covered by the addendum, a new special provision must be prepared. When a specification section is modified, the complete specification section shall be reissued. All changes shall be appropriately marked by a vertical line in the right margin to allow for quickly identifying changes made to the specification.

Each page of the specification section shall be marked in the bottom right corner with "ADDENDUM NO. Y," where "Y" equals the addendum number.

A revised Table of Contents for the contract specifications will be prepared when adding, revising, or deleting specification sections. The Table of Contents should be appropriately marked indicating which sections were added, revised, or deleted, and the addendum associated with the revision. The addendum number associated with the revision will be indicated in the bottom right corner. The revised Table of Contents will be used as a cover sheet for the revised special provisions. The revised Table of Contents should be cumulative from addendum to addendum.

In order to provide permanent documentation of changes made solely in writing by addendum, upon award of the contract, the specifications may have to be modified in accordance with Section 17.2.2, and forwarded to the Office of Construction for the initiation of a construction order.

17.2.1.4 Quantity and Cost Estimates

Changes to the contract items shall be described in writing. The bid proposal forms are revised to reflect these item changes. Items and quantities shown in the "Quantity" box on the General Plan are never to be revised, struck-out or supplemented, except when a complete set of new structure sheets is added to a project for a structure that was not in the project at advertising. A table of "Quantities," with items, units and quantities, should be included on the General Plan sheet for the new structure.

Quantity Estimate: A list of all items added or deleted from the original quantity estimate shall be prepared. The list shall specify if the quantity is an increase, decrease, or a new item with associated quantity.

Do not revise the "Detailed Estimate Sheet" if present within the project plans. The change in quantities and/or any new items and associated quantities are listed on the Transmittal Memorandum.

Cost Estimate: The Engineer's Estimate shall be updated to reflect any changes to the Estimate due to the addendum. For new items, the designer shall obtain and use the weighted unit prices from the Department's Cost Estimating Section for items where data exists on unit prices. The original estimated unit costs used to prepare the Engineer's Estimate (inflated to current year costs) shall be used for developing costs on items currently listed within the Engineer's Estimate.

17.2.2 Changes by Construction Order

17.2.2.1 General

The method by which the design is changed after a project has been awarded is through a construction order issued by the Office of Construction.

Changes to a project may be initiated by the designer, construction personnel or another unit in the Department and typically require revisions to the contract documents (plans and specifications), items and/or quantity takeoffs including computations. Changes to the contract documents should be performed by the designer who shall prepare all plans, specifications, quantity takeoffs and cost estimates and justification statements to be included in the construction order package.

The designer shall obtain the original Mylars from the Department's Engineering Records Center located at 160 Pascone Place, Newington, CT. If the designer is a consultant, written approval from the Department is required.

In the case of a consultant-designed project, the consultant shall return all Mylars along with all new or revised CADD files to the Department with the construction order package. The Department shall be responsible for ensuring the Mylars are properly filled out by the Consultant and are properly returned to the Engineering Records Center.

Prior to preparing any of the documentation required for the initiation of a construction order, District Construction should be consulted by the initiator on the timeliness of the request and the availability of funding must be confirmed with the financial office. The designer should provide District Construction with the estimated cost for the revised work required by the construction order request. This information is to be used by the District to verify the availability of contingency funds and for the District to prepare a Recommended Project Memorandum if required.

The following Sections describe the procedures used by the designer to revise drawings and specifications along with the preparation of the necessary material required for a Construction Order request.

17.2.2.2 Modifications to the Contract Plans

Modification to the contract plans shall be done in accordance with the following.

17.2.2.2.1 Title Sheet Revisions

When a construction order is required on a project, the designer shall complete the box entitled "List of Drawing Revisions" on the original title sheet. Should the "List of Drawing Revisions" be filled, a new sheet (1A) shall be added for the purpose of continuing the list of drawing revisions. A note must be added at the bottom of the "List of Drawing Revisions" box to refer to sheet 1A.

17.2.2.2.2 New Sheets

Changes that require new sheets to be added to the project plans shall be handled in one of two ways:

1. If the new sheet does not have to be placed in a specific location within the project plans, the new sheet shall be numbered sequentially from the last sheet of the project plans. The total number of sheets noted on the project plans stays the same. A note shall be placed on the new sheet stating, "NEW SHEET ADDED BY CONSTRUCTION ORDER REQUEST - mm/dd/yy" where "mm/dd/yy" equals the month, day and year the change order request was submitted. This note shall be located directly above the title block.

2. If the designer determines that the new sheet must go in a specific location within the project plans the new sheet number shall be the number of the sheet it most closely relates to followed by -1. For example, if the new drawing must be placed in the project plans right after sheet 57, the new sheet shall be numbered 57-1. The total number of sheets noted on the project plans stays the same. A note shall be placed on the new sheet stating, "NEW SHEET ADDED BY CONSTRUCTION ORDER REQUEST-mm/dd/yy" where "mm/dd/yy" equals the month, day and year the change order request was submitted. This note shall be located directly above the title block.

In addition, the drawing number of the new sheet shall be the drawing number of the sheet it most closely relates followed by -1. For example, if the new drawing must be placed in the project plans right after drawing number C-5, the drawing number shall be C-5-1.

If applicable, the approval block on the new Mylar shall be signed on the new Mylar. New sheets shall be sealed by a Professional Engineer or Architect when prepared by a consultant.

17.2.2.2.3 Revisions to Existing Sheets

The original sheets shall not be altered with the exception of the placement of the following note stating, "FOR REVISIONS OF CONSTRUCTION ORDER REQUEST - mm/dd/yy, SEE SHEET NO. XXA." This note shall be located directly above the title block. The original sheets need not be printed and issued with the Construction Order Request.

The revised sheets shall be made from a copy of the CADD file and edited as follows:

- The sheets shall be like-numbered and include a letter designation to indicate a revised sheet. For example, a revision to sheet no. 23 shall be numbered 23A for the first construction order request affecting that sheet, 23B for the second, etc.
- In addition, the drawing number shall be changed to reflect a construction order affecting that sheet. For example, C-1 becomes C-1A, then C-1B, etc. each time that sheet is affected by a construction order request.
- Areas of the drawing changed with each revision shall be clouded and the appropriate revision number shall be placed in a triangle next to the clouded area. This shall coincide with the information supplied in the revision block.

- Any details to be deleted shall be crossed out with an “X” on the revised sheet. Details shown on the original Mylar or CADD file, but no longer required, shall not be deleted on the revised Mylar or from the CADD file, but shall be crossed out. Also, as indicated earlier, under no circumstances should the original Mylar or CADD file be altered, except as noted above. Engineering judgment must be used to produce clear and concise information for the contractor.
- The revised sheet shall have a note stating, “REVISED BY CONSTRUCTION ORDER REQUEST - mm/dd/yy,” where “mm/dd/yy” equals the month, day and year the change order request was submitted. This note shall be located directly above the title block.
- The revision block shall be filled out indicating the revision number, date, and a description of the changes. The revision number is specific to a particular sheet and is a numerical tracking of the number of successive changes made to a particular sheet. All changes made to a particular sheet under the same construction order request will have the same revision number.
- If the original Mylar was signed in the approval block, the revised Mylar shall be signed and dated in the approval block by the responsible individual.
- If the original Mylar contained a Professional Engineer or Architect’s seal, the revised Mylar shall be sealed by the responsible Professional Engineer or Architect.
- A sheet requiring further revisions by subsequent construction order requests shall be prepared, as detailed above, using a copy of the previously modified sheet. This procedure will result in the storage of each sheet as it was issued at advertising and as it was issued on each construction order request.

If plans were not produced on CADD, changes that require revisions to the existing plans shall be made on Mylar copies of the original Mylar.

Note: When preparing a Construction Order request on a project that includes a “Detailed Estimate Sheet,” never revise the Detailed Estimate Sheet. A Detailed Estimate Sheet is never included in a Construction Order request. Also, the “Quantities” box shown on the General Plan sheet for any structure is never to be revised.

17.2.2.2.4 Replacement of Existing Sheets

This procedure is to be used only when the changes to an existing sheet are significant enough to require a new sheet. Engineering judgment must be used to produce clear and concise information for the contractor.

The original sheets shall not be altered with the exception of the placement of the following note stating, "THIS SHEET REPLACED BY CONSTRUCTION ORDER REQUEST - mm/dd/yy, SEE SHEET XX-1" where "mm/dd/yy" equals the month, day and year the construction order request was submitted. This note shall be located directly above the title block. Under no circumstances are the CADD files to be physically deleted or original Mylars disposed of. The original sheets need not be printed and issued with the Construction Order Request. The replacement sheet shall be handled as a new sheet as detailed above.

17.2.2.2.5 Voiding of Existing Sheets

Sheets voided by a construction order request shall have a note added stating "VOIDED BY CONSTRUCTION ORDER REQUEST - mm/dd/yy" where "mm/dd/yy" equals the month, day and year the construction order request was submitted. Under no circumstances are the CADD files to be physically deleted or original Mylars disposed of. The voided sheets need not be printed and issued with the Construction Order Request.

17.2.2.3 *Modifications to the Contract Specifications*

The specifications governing the work shown on revised plans, replacement sheets, and/or new sheets are the *Standard Specifications*, Supplemental Specifications and the special provisions in effect at the time the construction order is prepared. The *Standard Specifications* and Supplemental Specifications shall be those listed on the Title sheet and in the General Notes. The specifications may include specifications incorporated into the project by addendum during the advertisement of the project or by previous construction orders.

In those cases where the existing specifications are not adequate to describe the new or revised work covered by the construction order, a new special provision must be prepared. When a specification section is modified, the complete specification section shall be reissued. All changes shall be appropriately marked by a vertical line in the right margin to allow for quickly identifying changes made to the specification.

Each page of the specification section shall be marked in the bottom right corner with "ADDED BY CONSTRUCTION ORDER," or "REVISED BY CONSTRUCTION ORDER," as appropriate.

17.2.2.4 *Quantity and Cost Estimates*

Items and quantities shown in the "Estimated Quantities" box are never to be revised, struck-out or supplemented, except when a complete set of new structure sheets is added to a project for a structure that was not in the project at award. A

table of "Estimated Quantities," with items, units and quantities, should be included on the General Plan sheet for the new structure.

Quantity Estimate: A list of all items added or deleted from the original quantity estimate shall be prepared. The list shall specify if the quantity is an increase, decrease, or a new item with its associated quantity.

Do not revise the DETAILED ESTIMATE SHEET if present within the project plans. The change in quantity and/or any new items and associated quantities are listed on the Transmittal Memorandum.

Cost Estimate: A cost estimate shall be prepared. For Unit Price items, use the Bid Unit price for the construction project to estimate the cost of the construction order request. (Note: When dealing with unit prices, unit prices may be subject to renegotiation when the quantity decreases or increases by 25% or more over the original quantity). Costs shall also be provided for new items to assist inspection personnel in negotiating with the contractor. For new items where data exists on unit prices, the designer shall obtain and use the weighted unit prices from the Department's Cost Estimating Section.

17.2.2.5 Construction Order Memoranda

The transmittal memorandum requesting the initiation of a construction order shall be addressed from the appropriate Manager of Design or Principal Engineer of Traffic to the District Engineering Manager having jurisdiction over the project and should be prepared on the standard Department memorandum form (#COM-09A).

The memorandum should include the following information:

- A detailed description of the changes requested and the number and description of the attachments to be transmitted and/or material included with the memorandum. The distribution requirements should be determined by the unit issuing the construction order request. The number of attachments required should be obtained from the Construction Project Manager.
- Justification for the changes, including a copy of the letter or memorandum requesting the change, if applicable, and who requested the change, including a commitment to provide funding (if necessary). Identify the funding source if known.
- A listing of each new, revised, replaced and/or voided sheet(s).
- A listing of each new, revised, replaced and/or voided special provision(s).

- A list of the changes in the estimated quantities for the project (increase, decrease). The list should also include any item that is new to the project or any item that is deleted as a result of the revised work. Item numbers of items already in the project should be provided. Item numbers for items that are not currently in the contract should be provided if known. Mark each new item with an asterisk and provide a note at the bottom of the table defining the asterisk as identifying a new contract item.
- The estimated increase in cost or credit associated with the change order request.
- A statement certifying that "District No. Construction has confirmed that sufficient construction funds are available for the necessary changes." The Department Project Engineer shall be responsible for verifying, with the District having jurisdiction over the project, that sufficient funding is available in the contingency fund. If the District indicates that there is not sufficient funding, then a commitment to provide funding shall be obtained, by the Department Project Engineer, prior to issuing the change order request. The following statement shall be added in lieu of the above, "The responsible fiscal office has indicated that funding will be made available for this construction order."
- A statement that the Federal Highway Administration concurs with the requests is required on all FHWA full oversight projects.

17.3 SHOP DRAWINGS

17.3.1 General

The following procedures for the handling of shop drawings apply to all projects in which the designer (Consultant Engineer or Department staff) is responsible for the approval of shop drawings. Shop drawings are defined as:

Drawings, including proposed details, diagrams, schedules, procedures and other supporting data, prepared by a Contractor to supplement the Contract documents, showing all information necessary for fabrication of items for which some specific design or detail appears in the Contract.

The designer shall review, check and approve when satisfactory all shop drawings and construction details submitted by the Contractor. Shop drawings are required for items such as structural steel, reinforcing steel and elastomeric bearings.

Nine copies of each shop drawing will be sent directly from the Contractor to the designer (Consulting Engineer or Department staff) for review except in the case of a structure carrying a railroad. In this case, the Contractor shall submit extra copies of the

superstructure shop drawings to the designer. The number of copies shall be determined by the requirements of the particular railroad involved.

The designer shall review; note corrections if required, stamp and distribute all shop drawings submitted by the Contractor.

For structures carrying a railroad, the Designer shall forward the extra copies (unstamped), with the designer's comments marked thereon, to the railroad for their review. The railroad will return one copy, marked with their comments, to the designer. The designer shall then combine all comments, stamp the drawings, and distribute them.

During the review of requests from the Contractor for substitutions or modifications to the contract plans, the Department may solicit the Consultant Engineer's opinion as to the acceptability of such a request. The preparation of such opinions shall be considered as part of the normal work required for the checking of shop plans.

The requirements for checking of shop drawings by the designer covers solely the checking of these drawings and does not authorize the designer to make or approve any modifications or adjustments of the design and details shown on the contract documents.

On large projects where large numbers of shop drawings are anticipated, the designer will include the Special Provision "Section 1.05 Control of the Work" which adds "Article 1.05.02-4 - Schedule of Submissions" to the contract documents. This article directs the Contractor that, prior to the submission of any working, shop or erection drawings, he shall prepare and submit for approval a schedule for all proposed working and shop drawings. The Contractor is directed to schedule the submission of shop drawings so that approximately 30 calendar days (beginning on the date of receipt) is allowed for review for routine work. For work of more complexity, the time for review will be increased in proportion to the complexity of the work. The Contractor is directed to adjust his schedules so that an additional approximate 15-calendar day period is provided for each resubmittal.

17.3.2 Shop Plan Review Designations

To assure uniformity in the review of all shop drawings, one of the following designations shall be stamped on each copy of a drawing to indicate the result of the review:

"APPROVED"To be used when there are no corrections or comments. The approved drawings must conform in all respects to the contract plans.

"APPROVED AS NOTED"To be used when the corrections are only minor in nature. The Contractor may proceed

subject to the notations on the plans. No resubmission will be made.

“REVISE & RESUBMIT”To be used when the corrections are major in nature.

Each shop drawing must bear the date of review and the signature of the individual responsible for review. It is emphasized that these are the only designations that may be stamped on drawings. The following is an example of an appropriate stamp for use in the review of shop drawings:

ABCD Consulting Engineers 456 Main Street Anytown, CT	
Reviewed _____ (Printed Name) _____	Date: <u> 9/12/04 </u>
By:	
<input checked="" type="checkbox"/>	APPROVED
	APPROVED AS NOTED
	REVIEW AND RESUBMIT

SHOP DRAWING REVIEW STAMP

17.3.3 Shop Drawing Handling and Distribution

17.3.3.1 Drawings marked “Approved” or “Approved as Noted”

- For projects designed by a Consulting Engineer, two copies of each drawing shall be retained by the Consultant Engineer (one copy, including a copy of the letter of transmittal, for the Department and one copy for the Consultant Engineer).
- For projects designed by the Department’s staff, one copy of each drawing and a copy of the letter of transmittal shall be retained by Department staff.
- Three copies of each drawing shall be returned to the Contractor with a letter of transmittal.
- Three copies of each drawing and a copy of the letter of transmittal shall be sent to the District Construction Office in charge of the construction project.
- One copy of each drawing and a copy of the letter of transmittal shall be sent to the Materials Testing Division. This applies to all shop drawings with the exception of those for reinforcing steel.

- In the case of a structure carrying a railroad, one copy of each superstructure drawing shall be sent to the Railroad.
- For structure mounted sign supports, one copy of each drawing and a copy of the letter of transmittal shall be sent to the Office of Traffic Engineering.
- One copy of the letter of transmittal shall be sent to the Office of Consultant Design (Structures).

17.3.3.2 Drawings Marked “Revise and Resubmit”

- For projects designed by a Consulting Engineer, two copies of each drawing shall be retained by the Consultant Engineer (one copy, including a copy of the letter of transmittal, for the Department and one copy for the Consultant Engineer).
- For projects designed by the Department’s staff, one copy of each drawing shall be retained by Department staff along with a copy of the letter of transmittal.
- Two copies of each drawing shall be returned to the Contractor with a letter of transmittal.
- A copy of the letter of transmittal shall be sent to the District Construction Office having jurisdiction over the construction project.
- A copy of the letter of transmittal shall be sent to the Office of Consultant Design (Structures).
- One copy of shop drawings for precast/prestressed superstructure elements shall be forwarded two the office of Bridge Safety and Evaluation.

The remaining copies of the shop drawings shall be destroyed.

17.3.3.3 Letter of Transmittal

The letter of transmittal (referred to above) shall be sent from the designer to the Contractor and include the following information:

- Project number and town - such as Project No. 15-999, Bridgeport.
- Project description - crossing location, such as I-95 over Metro-North Railroad.
- Shop drawing item description - such as Elastomeric Bearing Shop Drawings.
- Drawing number and description - such as R-01, Endwall reinforcing.

- Results of review - "Approved," "Approved as Noted," "Revise and Resubmit." If a shop drawing is stamped "Revise and Resubmit," a reason explaining how this result was arrived at should be included in the transmittal.
- Number of copies of each drawing transmitted.

17.3.3.4 Special Instructions for Consulting Engineers

The Consulting Engineer shall retain and file one copy of each reviewed shop drawing, along with a copy of each letter of transmittal, for the Department. Upon completion of construction of the project, the complete file, along with an index, shall be transmitted to the Office of Consultant Design (Structures) where permanent storage arrangements will be made.

17.3.3.5 Review of Welding Procedure Specifications

Per the *Bridge Welding Code*, welding procedure specifications should be submitted for approval. The welding procedures are typically submitted with the structural steel shop drawings. The Division of Materials Testing is responsible for the review, approval and distribution of all welding procedure specifications that are submitted for all projects designed by Department's staff or a Consulting Engineer.

17.3.3.6 Review of Tubular and Truss Sign Support Structures

Tubular and truss sign support structures refer to the following types of sign supports described in the *Standard Specifications*:

- Tubular Sign Support Structure,
- Tubular Cantilever Sign Support,
- Overhead Truss Sign Support (Type ___), and
- Overhead Cantilever Sign Support (Type ___).

Shop drawings for tubular and truss sign support structures should be submitted by the Contractor to the Office of Traffic Engineering for review.

If the sign structures are supported on foundations embedded in the ground as shown on standard plans prepared by the Department, the Office of Traffic Engineering will forward two copies of each drawing to the Bridge Design Unit for a structural review. The Bridge Design Unit will review, note corrections if required, and return one marked-up copy of each drawing to the Office of Traffic Engineering. The drawings should not be stamped by the reviewer. The reviewer should inform Traffic Engineering of the acceptability of the drawings.

For sign structures not meeting the requirements above, the Office of Traffic Engineering will forward two copies of each drawing to the designer for a structural

review. The designer should review, note corrections if required, and return one marked-up copy of each drawing to the Office of Traffic Engineering. The drawings should not be stamped by the reviewer. The reviewer should inform Traffic Engineering of the acceptability of the drawings.

The Office of Traffic Engineering is responsible for adding any structural review comments on the remaining shop drawings, stamping the drawings and distributing the shop drawings.

17.4 WORKING DRAWINGS

17.4.1 General

Working drawings are defined as:

Drawings, calculations, procedures and other supporting data prepared by a Contractor documenting the Contractor's proposed design, details, materials, construction methods and equipment for any construction for which no specific design or detail appears in the Contract.

Working drawing submittals may be required for permanent structures, temporary structures, or construction methods. Examples of permanent structures requiring working drawings are precast concrete box culverts and proprietary retaining walls. Examples of temporary structures requiring working drawings include cofferdams, temporary sheeting, falsework, centering, frameworks, temporary slab supports, temporary bridges, and containment and collection structures for field painting. Examples of construction methods requiring working drawing submittals include structure demolition, erection, and bridge superstructure jacking.

The *Standard Specifications* require the Contractor to prepare and submit 9 copies of each working drawing submittal to the Office of Construction for review. The Office of Construction may forward the working drawings to the designer for review and comment. The designer shall review, comment if required, and stamp all working drawing submittals in accordance with Article 17.4.2.

The designer has no authority to approve working drawing submittals. The approval of all working drawing submittals is the responsibility of the Office of Construction.

On large projects where large numbers of working drawing submittals are anticipated, the designer should include the Special Provision "Section 1.05 - Control of the Work" which adds "Article 1.05.02-4 - Schedule of Submissions" to the contract documents. This article directs the Contractor that, prior to the submission of any working drawings, he shall prepare and submit, for approval, a schedule for all working drawings. This article also directs the Contractor to schedule the submission of working drawings so that approximately 30 calendar days (beginning on the date of receipt) is allowed for

review for routine work. For work of more complexity, the time for review will be increased in proportion to the complexity of the work. The Contractor is directed to adjust his schedules so that an additional approximate 15-calendar day period is provided for each resubmittal.

17.4.2 Working Drawing Review Designations

To assure uniformity in the review of all working drawings, one of the following designations shall be stamped on each copy of a drawing to indicate the result of the review:

“REVIEWED”To be used when the plans are acceptable and the designer has no comments.

“REVIEWED WITH COMMENTS”To be used when the plans are not acceptable as presented and the designer has comments which need to be addressed.

Each working drawing must bear the date of review and the signature of the individual responsible for review. The following is an example of an appropriate stamp for use in the review of working drawings:

<p>ABCD Consulting Engineers 456 Main Street Anytown, CT</p>	
Reviewed	_____(Signature Required)_____ Date: <u>9/12/96</u>
By:	_____ (Printed Name)
X	REVIEWED
	REVIEWED WITH COMMENTS

WORKING DRAWING REVIEW STAMP

17.4.3 Working Drawing Handling and Distribution

17.4.3.1 Projects Designed by Department Staff

The working drawing submittal shall be distributed as follows:

- One copy of each working drawing submittal shall be retained by Department staff along with a copy of the transmittal memorandum.

- The remaining copies of the working drawing submittal and a transmittal memorandum shall be sent to the District Construction Office having jurisdiction over the construction project.

In the transmittal memorandum, the designer shall make a recommendation to approve or not approve the submission.

17.4.3.2 *Projects Designed by a Consulting Engineer*

The working drawing submittal shall be distributed as follows:

- Two copies of each working drawing submittal shall be retained by the Consultant Engineer (one copy, including a copy of the letter of transmittal, for the Department and one copy for the Consultant Engineer).
- The remaining copies of each working drawing submittal and a letter of transmittal shall be sent to the Office of Consultant Design (Structures).

The Consulting Engineer shall make a recommendation to approve or not approve the Contractor's working drawing submission. The Office of Consultant Design will review the submission, add comments if required, and transmit the working drawing submittal to the Office of Construction.

The Consulting Engineer shall retain and file one copy of each reviewed working drawing submission, along with a copy of each letter of transmittal, for the Department. Upon completion of construction of the project, the complete file, along with an index, shall be transmitted to the Office of Consultant Design (Structures) where permanent storage arrangements will be made.

DIVISION II

CONTRACT PLAN NOTES,
TABLES & NOTICES

Appendix A
PLAN NOTES

A.1 GENERAL NOTES

A.1.1 Guidelines for Use

Certain "General Notes" are required to be shown on the general plan sheets. The actual notes required shall be determined with the aid of the following guidelines:

<u>Note No.</u>	<u>Requirements for use</u>
G1	Must be shown on the General Plan Sheet.
G2	Must be shown on the General Plan Sheet.
G3	Only the classes of concrete and grades of reinforcing steel used in the structure shall be indicated. Indicate the applicable structural steel designations, F_y (specified minimum yield point of steel) and the corresponding thicknesses, for the type of steel used in the structure only.
G4	Use this note for structures supporting Interstate System project live loads regardless of whether or not the alternate loading is used.
G5	Use this note for projects not covered above.
G6	For structure detailed without a 2½" Bituminous Concrete Overlay.
G7	For structure detailed with a 2½" Bituminous Concrete Overlay.
G8	For structures designed with steel members, use this note.
G9	Use is limited to the repair of, repainting of, or alterations to existing structures.
G10	For all new structures that require painting.
G11	For all new structures of weathering steel that therefore will not require painting.
G12	For all new structures of weathering steel that will not require the ends of the girders to be painted at deck joints.
G13	Must be shown on the General Plan Sheet.

- | <u>Note No.</u> | <u>Requirements for use</u> |
|-----------------|---|
| G14 | The words PILE LOADS shall be deleted when there are no piles in the structure. |
| G15 | Must be shown on the General Plan Sheet. |
| G16 | To be used where existing structures are being modified or repaired. |

A.1.2 LISTING OF GENERAL NOTES

G1 SPECIFICATIONS: Connecticut Department of Transportation Form 814A (1995), Supplemental Specification dated (mm/yy) and Special Provisions.

G2 DESIGN SPECIFICATIONS: *Standard Specifications for Highway Bridges* (AASHTO-year), with the Interim Specifications up to and including (year), as supplemented by the Connecticut Department of Transportation *Bridge Design Manual* (2003).

G3 ALLOWABLE DESIGN STRESSES:

Class "A" & Class "C" Concrete Based on $f'_c = 3000$ psi
 Class "F" Concrete.....Based on $f'_c = 4000$ psi
 Class " " ConcreteBased on $f'_c = ()$ psi

Reinforcement
 (ASTM A615 Grade 60)..... $f_y = 60000$ psi

Structural Steel
 (AASHTO M270, Grade 50)..... $F_y = 50000$ psi
 (AASHTO M270, Grade 50W) $F_y = 50000$ psi
 (AASHTO M270, Grade HPS 70W)..... $F_y = 70000$ psi
 (AASHTO M270, Grade 100, up to 2 ½" thick)..... $F_y = 100000$ psi
 (AASHTO M270, Grade 100W, up to 2½" thick) $F_y = 100000$ psi
 (AASHTO M270, Grade 100, over 2½" to 4")..... $F_y = 90000$ psi
 (AASHTO M270, Grade 100W, over 2½" to 4") $F_y = 90000$ psi

G4 LIVE LOAD: HS20 24000 pound dual axles at four feet c.c.

G5 LIVE LOAD: HS 20

G6 FUTURE PAVING ALLOWANCE: 30 pounds per square foot

- G7 FUTURE PAVING ALLOWANCE: None
- G8 STRUCTURAL STEEL: See Structure Sheet Notes for designations and requirements.
- G9 PAINT: Paint shall conform to the requirements of the special provision, "Field Painting of Structure (Site No. ____)." The color of the topcoat material on the structural steel shall conform to Federal Standard Color No. ____, (Color).

ADD THE FOLLOWING IF STEEL BOX GIRDERS ARE USED:

The interior portions of the boxes shall be painted white.

- G10 PAINT: Paint shall conform to the requirements of the special provision, "Structural Steel (Site No. __)." The color of the topcoat material on the structural steel shall conform to Federal Standard Color No. ____, (Color).

ADD THE FOLLOWING IF STEEL BOX GIRDERS ARE USED:

The interior portions of the boxes shall be painted white.

- G11 PAINT: No painting of structural steel is required. Steel surfaces are to be prepared for weathering in accordance with the *Specifications*.
- G12 PAINT: Painting of the structural steel is only required at the ends of the girders. Steel surfaces are to be prepared for weathering in accordance with the *Specifications*.
- G13 BITUMINOUS CONCRETE OVERLAY: This shall consist of two lifts. The first shall be Bituminous Concrete - Class (2) (1" thick) and the second shall be Bituminous Concrete - Class (1) (1½" thick).
- G14 FOUNDATION PRESSURES AND PILE LOADS: The various Group Loadings noted on the substructure plan sheets refer to the Group Loads as given in the *AASHTO Standard Specifications for Highway Bridges*.
- G15 DIMENSIONS: When decimal dimensions are given to less than three decimal places, the omitted digits shall be assumed to be zeros.
- G16 EXISTING DIMENSIONS: Dimensions of the existing structure shown on these plans are for general reference only. They have been taken from the original design drawings and are not guaranteed. The Contractor shall take all field measurements necessary to assure proper fit of the finished work and shall assume full responsibility for their accuracy.

When shop drawings based on field measurements are submitted for approval, the field measurements shall also be submitted for reference by the reviewer.

A.2 CONCRETE NOTES

A.2.1 Guidelines for Use

Certain Concrete Notes are required to be shown on the plans. The actual notes required shall be determined with the aid of the following guidelines:

<u>Note No.</u>	<u>Requirements for use</u>
C1	Use this note on structures where Remain-In-Place forms are not to be allowed.
C2	Use this note if the extra load for Remain-In-Place forms has been included in the design of the structure or any portion of it (such as box girders). Indicate the load in pounds per square foot and the location where it applies.
C3	For structures designed with steel members, use this note. For temporary supports, indicate only the type of construction that applies.
C4	For structures designed with prestressed, precast concrete members, use this note.
C5	For all structures except structures with U-Type Wings and reinforced concrete box culverts.
C6	For all structures with U-Type Wings except reinforced concrete box culverts.
C7	For reinforced concrete box culverts.
C8	For reinforced concrete box culverts with cast-in-place concrete piles.
C9	For structures with adjacent prestressed deck units without a concrete deck. Delete the components that are not applicable.
C10	For all structures with concrete bridge decks. Delete components that are not applicable.

- C11 For structures with cast-in-place concrete piles excluding reinforced concrete box culvert.
- C12 Must be shown on the General Plan Sheet.
- C13 Must be shown on the General Plan Sheet.
- C14 Must be shown on the General Plan Sheet.
- C15 For structures designed with Grade 60 reinforcement.
- C16 For structures designed with Grade 60 reinforcement and other grades of reinforcing steel.
- C17 For all structures with a concrete deck slab. Use the applicable note for the situation, with or without sidewalks and with or without piers. If the structure has approach slabs, add the last note as indicated.
- C18 For all structures constructed of adjacent concrete deck units. Use the applicable note for the situation, with or without sidewalks.
- C19 Must be shown on the General Plan Sheet where applicable. Generally, used only when the slab rides over the backwall.
- C20 Must be shown on the General Plan Sheet.
- C21 Must be shown on the General Plan Sheet. Generally, used only when the slab rides over the backwall and bridge is on elastomeric bearings.
- C22 Must be shown on the General Plan Sheet.

A.2.2 LISTING OF CONCRETE NOTES

- C1 REMAIN-IN-PLACE FORMS: The use of remain-in-place forms on this structure is not allowed.
- C2 REMAIN-IN-PLACE FORMS: The use of remain-in-place forms shall be allowed inside of box girders only. The box girders have been designed for the additional weight of 15 pounds per square foot for the remain-in-place forms inside to boxes.
- C3 COMPOSITE CONSTRUCTION: No temporary intermediate supports shall be used during the placing and setting of the concrete deck slab. Temporary supports may be used for structural steel erection only.

Construction loads and dead loads will be permitted when directed by the Engineer but only when the concrete has reached a strength of $f'_c = 3500$ psi. Live loads (traffic) will be permitted on the structure after the concrete has reached a strength of $f'_c = 4000$ psi.

C4 COMPOSITE CONSTRUCTION: No temporary intermediate supports shall be used prior to and during the placing and setting of the concrete deck slab. Construction loads and dead loads will be permitted when directed by the Engineer but only when the concrete has reached a strength of $f'_c = 3500$ psi. Live loads (traffic) will be permitted on the structure after the concrete has reached a strength of $f'_c = 4000$ psi.

C5 CLASS "A" CONCRETE: Class "A" Concrete shall be used for the entire substructure.

or

CLASS "A" CONCRETE: Class "A" Concrete shall be used for the entire substructure with the exception of the Class "F" Concrete used in the pier stems and pier caps.

C6 CLASS "A" CONCRETE: Class "A" Concrete shall be used for the entire substructure and the parapets of U-Type Wings.

or

CLASS "A" CONCRETE: Class "A" Concrete shall be used for the entire substructure and the parapets of U-Type Wings with the exception of the Class "F" Concrete used in the pier stems and pier caps.

C7 CLASS "A" CONCRETE: Class "A" Concrete shall be used throughout.

C8 CLASS "A" CONCRETE: Class "A" Concrete shall be used throughout except for the Class "C" Concrete used in Cast-In-Place Piles.

C9 CLASS "F" CONCRETE: Class "F" Concrete shall be used on the superstructure for headers, sidewalks, and parapets.

C10 CLASS "F" CONCRETE: Class "F" Concrete shall be used for bridge decks including sidewalks, parapets and approach slabs.

- C11 CLASS "C" CONCRETE: Class "C" Concrete shall be used for Cast-In-Place Concrete Piles.
- C12 JOINT SEAL: See Special Provisions.
- C13 EXPOSED EDGES: Exposed edges of concrete shall be beveled 1"x1" unless dimensioned otherwise.
- C14 CONCRETE COVER: All reinforcement shall have two inches cover unless dimensioned otherwise.
- C15 REINFORCEMENT: All reinforcement shall be ASTM A615 Grade 60.
- C16 REINFORCEMENT: All reinforcement shall be ASTM A615 Grade 60 unless noted otherwise.
- C17 EPOXY COATED REINFORCING BARS: All reinforcement in the superstructure including the concrete deck slab and the parapets shall be epoxy coated unless otherwise noted. These bars shall be included in the pay item for "Deformed Steel Bars (Epoxy Coated)."

or

EPOXY COATED REINFORCING BARS: All reinforcement in the superstructure including the concrete deck slab, sidewalks and the parapets shall be epoxy coated unless otherwise noted. These bars shall be included in the pay item for "Deformed Steel Bars (Epoxy Coated)."

ADD THE FOLLOWING IF APPLICABLE:

All reinforcement in the top mat of the concrete approach slabs including those in the headers shall be epoxy coated. These bars shall be included in the item "Deformed Steel Bars (Epoxy Coated)."

- C18 EPOXY COATED REINFORCING BARS: All reinforcement, except the strands in the adjacent precast concrete deck units or box beams with no concrete deck shall be epoxy coated and included in the pay item for "Precast Concrete Deck Unit ()." All reinforcement in the parapets on the superstructure shall be epoxy coated and shall be included in the pay item for "Deformed Steel Bars (Epoxy Coated)."

or

EPOXY COATED REINFORCING BARS: All reinforcement, except the strands, in the adjacent precast concrete deck units or box beams with no concrete deck shall be epoxy coated and included in the pay item for "Precast Concrete Deck Unit ()." All reinforcement in the parapets and sidewalks on the superstructure shall be epoxy coated and shall be included in the pay item "Deformed Steel Bars (Epoxy Coated)."

C19 FELT: The cost of furnishing and placing 15-pound roofing felt is included in the item for "Class 'A' Concrete".

C20 PREFORMED EXPANSION JOINT FILLER: The cost of furnishing and installing Preformed Expansion Joint Filler shall be included in the cost of the item "Class 'A' Concrete."

C21 CLOSED CELL ELASTOMER: The cost of furnishing and installing Closed Cell Elastomer shall be included in the cost of the item "Class 'A' Concrete."

C22 CONSTRUCTION JOINTS: Construction joints, other than those shown on the plans, will not be permitted without the prior approval of the Engineer.

A.3 INSPECTION OF FIELD WELDS

The following quantity table is required to be shown on all General Plan Sheets:

INSPECTION OF FIELD WELDS		
METHODS	UNIT	QUANTITY
Ultrasonic	inch	
Magnetic Particle	feet	

A.4 CONCRETE DISTRIBUTION

The following Concrete Distribution box is required to be shown on the General Plan Sheet for all structures except box culverts:

CONCRETE DISTRIBUTION		
Superstructure	C.Y.	
Substructure	C.Y.	
Footings	C.Y.	
Total	C.Y.	

A.5 NOTICE TO BRIDGE INSPECTORS

The following box shall be shown on the General Plan sheet for all bridges. The designer shall list any items that may require special inspection such as fracture critical members, hangers, joints, highly stressed members, etc.

NOTICE TO BRIDGE INSPECTORS	
<p>The Department’s Bridge Safety procedures require this bridge to be inspected for, but not limited to, all appropriate components indicated in the governing manuals for bridge inspection. Attention must be given to inspecting the following special components and details. (The listing for components for specific attention shall not be construed to reduce the importance of inspection of any other component of the structure.) The frequency of inspection of this structure shall be in accordance with the governing manuals for bridge inspection, unless otherwise directed by the Manager of Bridge Safety and Evaluation.</p>	
Component or Detail	Structure Sheet Reference

Appendix B
STRUCTURAL STEEL NOTES

B.1 GENERAL

Certain notes pertaining to the fabrication of structural steel are required to be shown on the plans. The actual notes required depend on the girder classification. Girder classifications shown below, and the notes required for each classification, are listed in TABLE B-1.

Note No. 14 should be used as required when the ratio of the unsupported top flange length (feet) to the top flange width (feet) at the section of maximum compressive stress is equal to or greater than one hundred (100).

Steel box girders require the same notes as for welded girders. In addition, Note No. 15 should be used for all box girder structures. Additional notes may be required for special conditions required by box girders.

B.2 GIRDER CLASSIFICATIONS

B.2.1 Simple Spans

- Class "A" - Rolled Beams.
- Class "B" - Welded Girders.
- Class "C" - Welded Girders with Field Splices.
- Class "D" - Welded Curved Girders with Field Splices (Heat curving allowed).
- Class "E" - Welded Curved Girders with Field Splices (Heat curving not allowed).
- Class "F" - Welded Curved Girders w/o Field Splices (Heat curving allowed).
- Class "G" - Welded Curved Girders w/o Field Splices (Heat curving not allowed).

B.2.2 Continuous Spans

- Class "H" - Rolled Beams.
- Class "I" - Curved Rolled Beams.
- Class "J" - Welded Girders.
- Class "K" - Welded Curved Girders (Heat curving allowed).
- Class "L" - Welded Curved Girders (Heat curving not allowed).

GIRDER CLASSIFICATIONS

	A	B	C	D	E	F	G	H	I	J	K	L
1	x	x	x	x	x	x	x	x	x	x	x	x
2	x	x	x	x	x	x	x	x	x	x	x	x
3	x	x	x	x	x	x	x	x	x	x	x	x
4				x		x					x	
5					x		x					x
6		x	x		x		x			x		x
7				x		x					x	
8	x	x	x	x	x	x	x	x	x	x	x	x
9		x	x	x	x	x	x			x	x	x
10		x	x	x	x	x	x			x	x	x
11		x	x	x	x	x	x			x	x	x
12	x	x	x	x	x	x	x	x	x	x	x	x
13	x	x	x	x	x	x	x	x	x	x	x	x

x designates notes that must be included on the plans.

TABLE B-1

B.3 LISTING OF STRUCTURAL STEEL NOTES

1. For Non-Fracture Critical bridge members use one of the following notes:

“Structural Steel (Low Alloy) shall conform to AASHTO M270, Grade 50 T2”

“Structural Steel (Low Alloy) shall conform to AASHTO M270, Grade 50 WT2”

For Fracture Critical bridge members use one of the following notes:

“Structural Steel (Low Alloy) shall conform to AASHTO M270, Grade 50 F2”

“Structural Steel (Low Alloy) shall conform to AASHTO M270, Grade 50 WF2”

Where corrosion resistant steel is required:

“ * shall conform to AASHTO M270, Grade 50 WT2”

(* Insert component parts, such as bearings, expansion dams, troughs, etc.)

2. “Welding details, procedures and testing methods shall conform to the ANSI/AASHTO/AWS D1.5-(year) - *Bridge Welding Code*, unless otherwise noted on the plans.”

3. "Field splices will not be allowed except with the written permission of the Engineer prior to the submission of shop plans. If allowed, these splices shall be designed by the Contractor and approved by the Engineer. The cost of these splices, including the cost of design, shall be at no extra expense to the State."

or

"Bolted field splices, other than those indicated on the plans, will not be allowed except with the written permission of the Engineer prior to the submission of shop plans. If allowed, these splices shall be designed by the Contractor and approved by the Engineer. The cost of these splices, including the cost of design, shall be at no extra expense to the State. Welded field splices will not be allowed."

4. "All welded girders shall be fabricated to the required horizontal curvature by heat curving or by cutting the flanges from larger size plates. Where curvature is provided by cutting the flanges, the Contractor shall indicate on his shop drawings the location of any additional splices required."
5. "All welded girders shall be fabricated to the required horizontal curvature by cutting the flanges from larger size plates. Heat curving will not be allowed. The Contractor shall indicate on his shop drawings the location of any additional splices required."
6. "All web to flange, web to bearing stiffener and bearing stiffener to flange fillet welds shall be inspected by the magnetic particle method."
7. "All web to flange, web to bearing stiffener and bearing stiffener to flange fillet welds shall be inspected in their entirety by the magnetic particle method after heat curving."
8. "Multiple pass welds, inspected by the magnetic particle method shall have each pass or layer inspected and accepted before proceeding to the next pass or layer, as determined by the Engineer."
9. "Shop web splices shall be located within the middle third of the span."
10. "Shop flange splices shall be located a minimum of six inches from web splices."
11. "Flange or web splices shall be located a minimum of six inches from stiffeners and connection plates."
12. "Ends of beams shall be vertical after the application of full dead loads."

or

"Bearing stiffeners and the ends of girders shall be vertical after the application of full dead loads."

or

"Bearing and intermediate stiffeners and the ends of girders shall be vertical after the application of full dead loads."

13. "The structural steel fabricators shall be certified under the AISC Quality Control Program as noted below:

Category SBr - Simple Steel Bridge Structures:"

Typical work includes: Highway sign structures, inspection platforms, bridge components such as cross frames and unspliced rolled beam bridges.

Category MBr - Major Steel Bridges:"

All bridge structures other than unspliced rolled beam bridges.

or

"The structural steel fabricators shall be certified under the AISC Quality Control Program as noted below:

Category SBrF - Simple Steel Bridge Structures:"

Typical work includes: Highway sign structures, inspection platforms, bridge components such as cross frames and unspliced rolled beam bridges.

Category MBrF - Major Steel Bridges:"

All bridge structures other than unspliced rolled beam bridges.

14. "The Contractor shall take the proper precautions to ensure the stability of all structural elements until the total structure is in being.

15. "It shall be the Contractor's responsibility to provide any additional temporary bracing required to maintain the geometry of the individual box girders, as well as the total steel structure, throughout all phases of construction including placement of the concrete deck."

DIVISION III

DESIGN AIDS

DIVISION III

DESIGN AIDS

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SECTION 10 - BURIED STRUCTURES

10.1 - Precast Concrete Box Culverts

Vacant	10.1.1
Precast Box Culvert - Typical Section	10.1.2
Precast Box Culvert - Cast-In-Place Cutoff and Return Wall Detail (<i>Rev. 1/05</i>)	10.1.3
Precast Box Culvert - Cast-In-Place Nose and Footing Detail (<i>Rev. 1/05</i>)	10.1.4a
Precast Box Culvert - Cast-In-Place Nose Section	10.1.4b
Precast Box Culvert - Cast-In-Place Nose Footing Section	10.1.4c
Precast Culvert Notes	10.1.5
Typical Box Culvert Wingwall Layout.....	10.1.6
Vacant	10.1.7

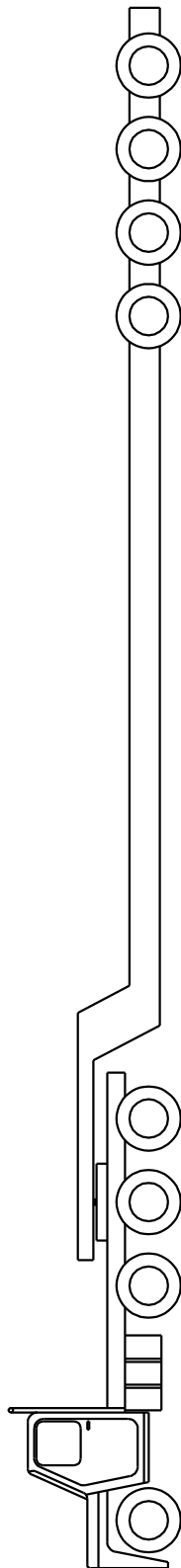
10.2 - Cast-in-Place Concrete Box Culverts

Cast-In-Place Box Culvert - Reinforcement Details.....	10.2.1
Joint and Backfill Details for Box Culverts	10.2.2

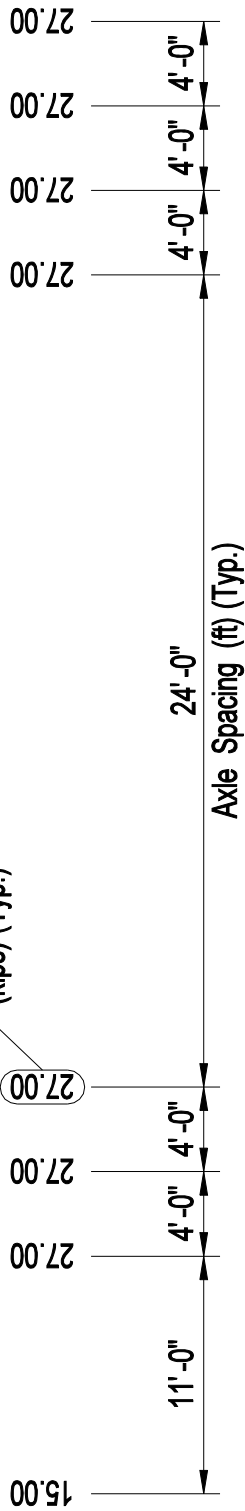
10.3 - Junction Boxes vacant

SECTION 11 - SIGN SUPPORTS vacant

CONNECTICUT DEPARTMENT OF TRANSPORTATION BRIDGE DESIGN MANUAL



Axle Load
(kips) (Typ.)



DESIGN OPERATING VEHICLE

204 kips on 8 axles

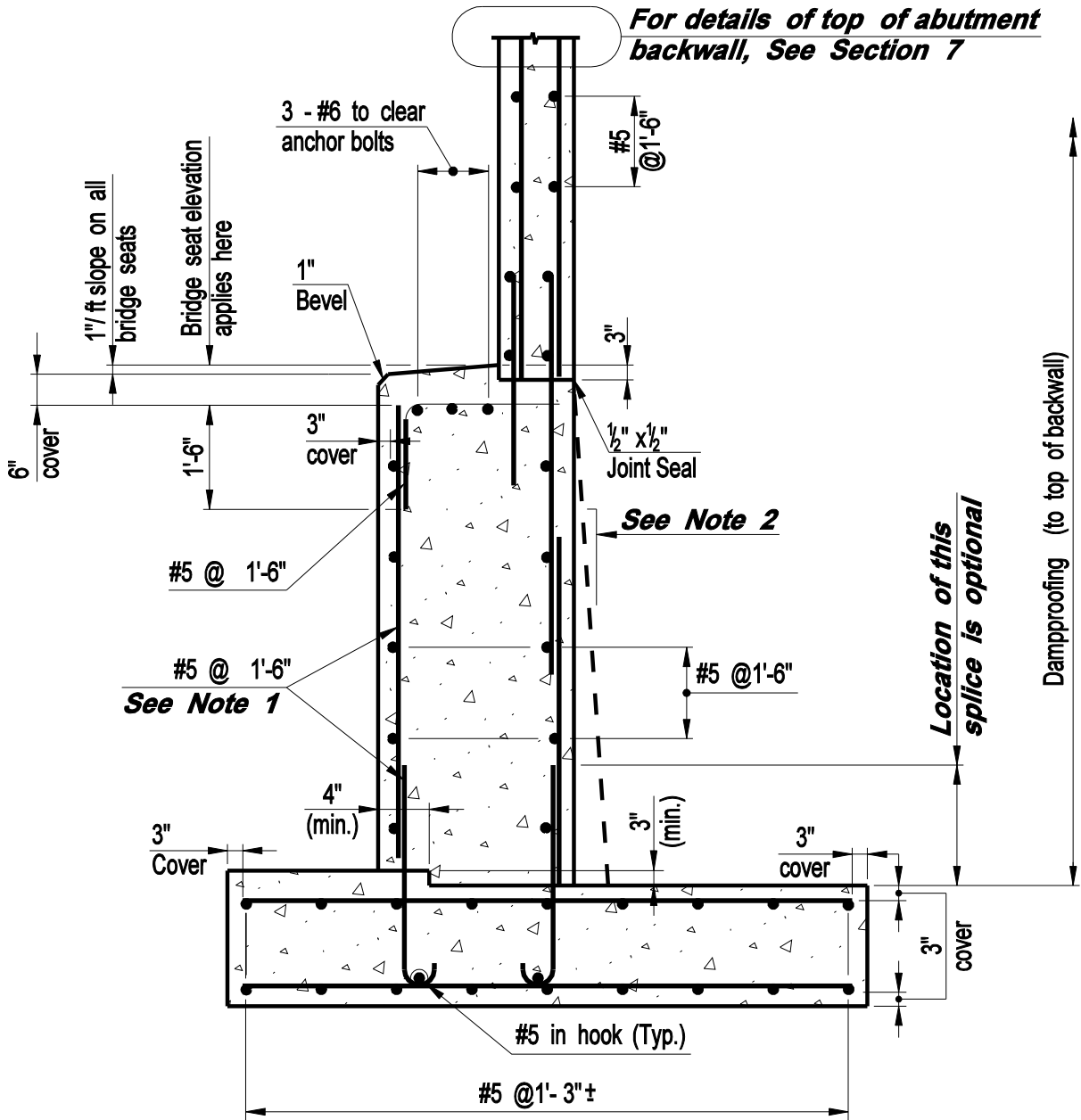
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

DESIGN OPERATING
VEHICLE
(204 kips ON 8 AXLES)

Issue Date: 10/03

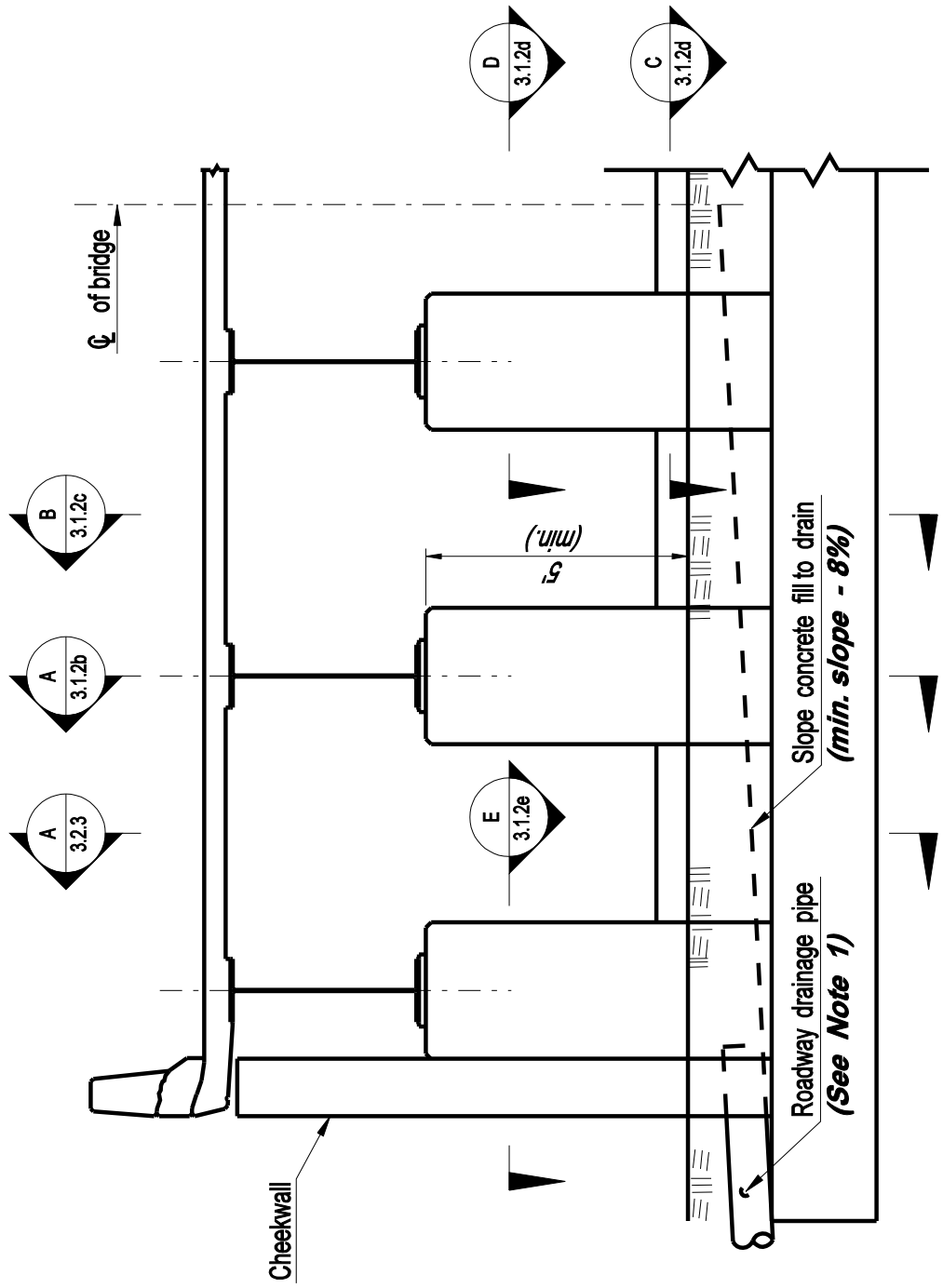
Revision Date:

Plate Number:
1.1.1



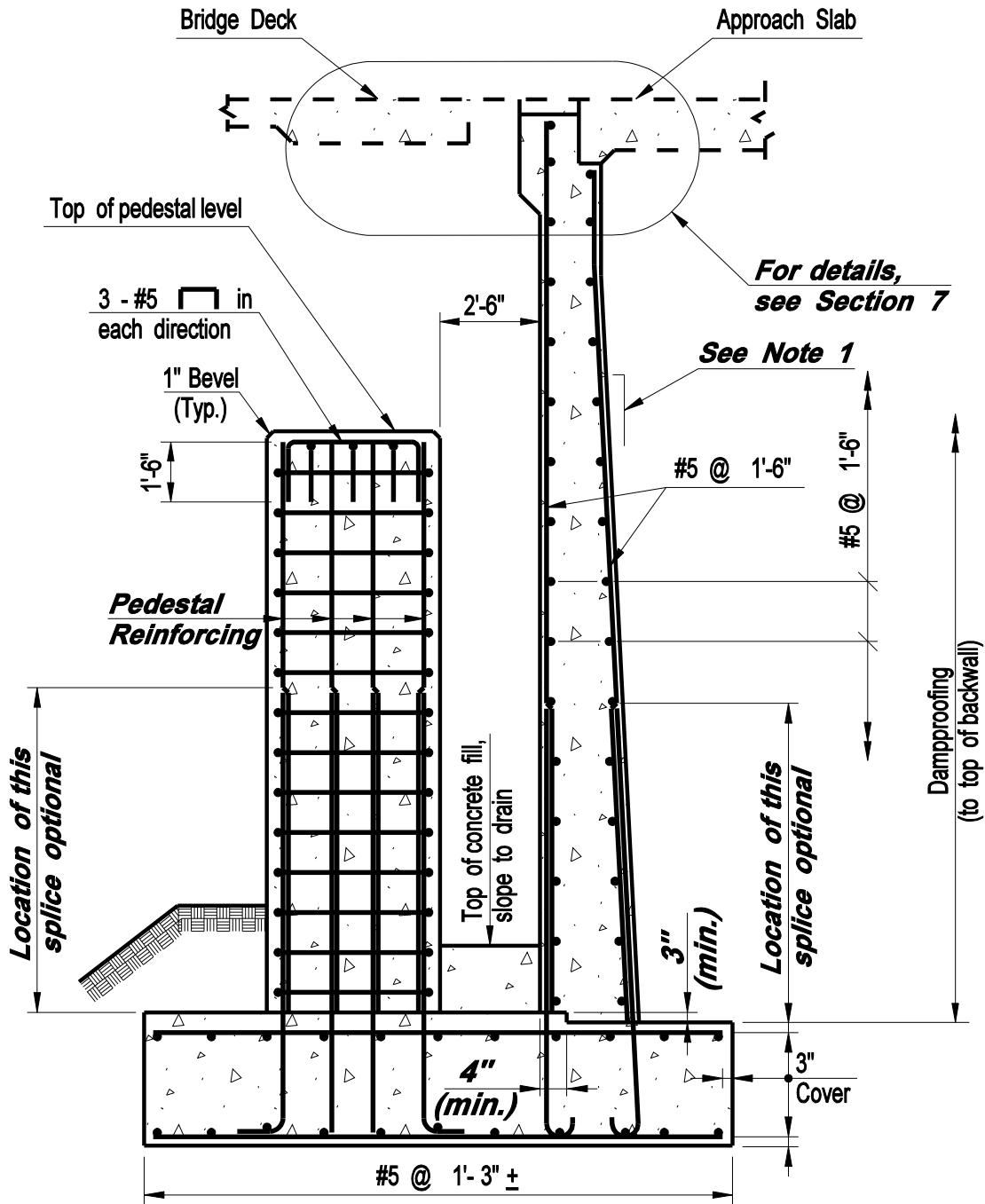
NOTES:

- 1. This reinforcement shall be designed for seismic forces.**
- 2. The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.**



DESIGN INFORMATION

1. Designer shall determine the size of the outlet pipe and shall connect it to the roadway drainage system. Minimum size shall be 12".



SECTION A
3.1.2a

DESIGN INFORMATION

- 1. The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.**

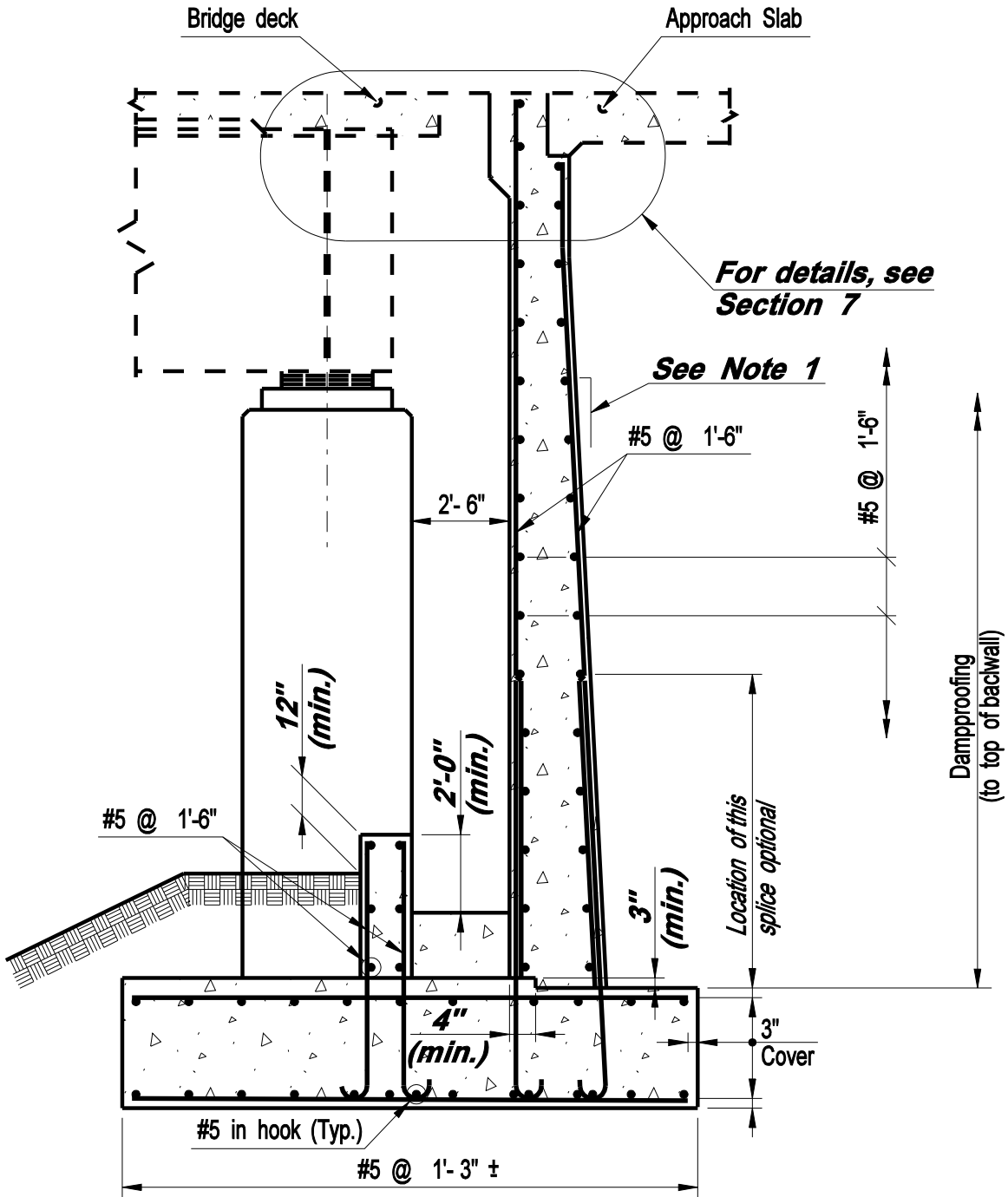
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

PEDESTAL TYPE ABUTMENT
SECTION A

Issue Date: 10/03

Revision Date:

Plate Number:
3.1.2b



SECTION B
3.1.2a

DESIGN INFORMATION

1. The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.

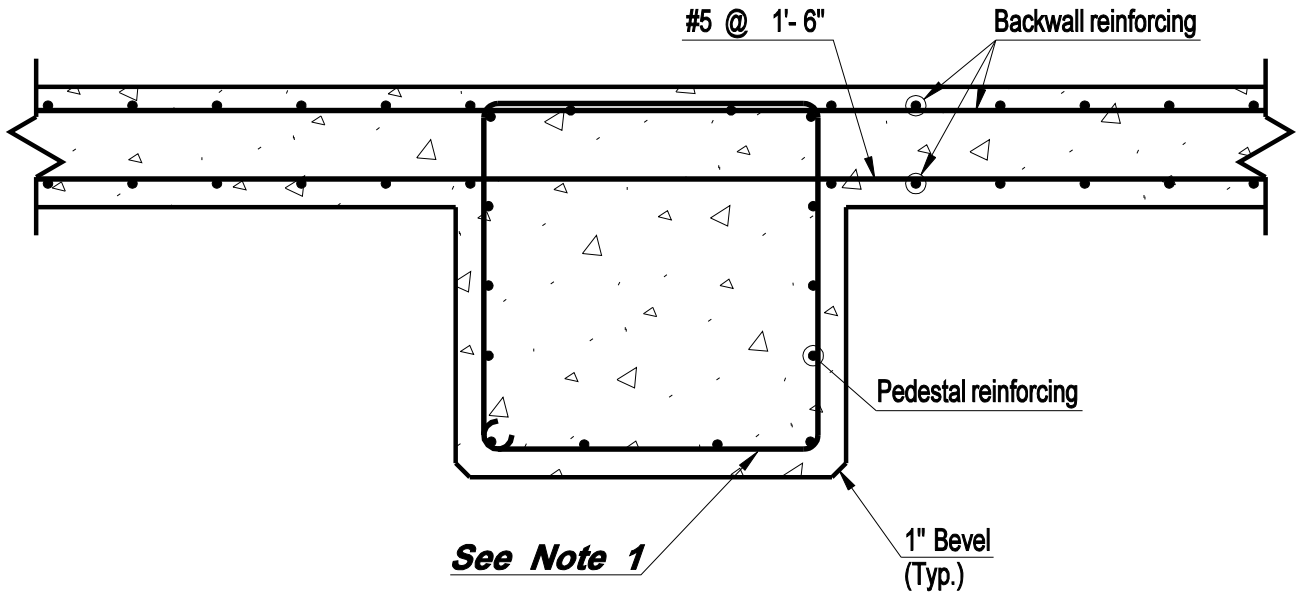
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**PEDESTAL TYPE ABUTMENT
SECTION B**

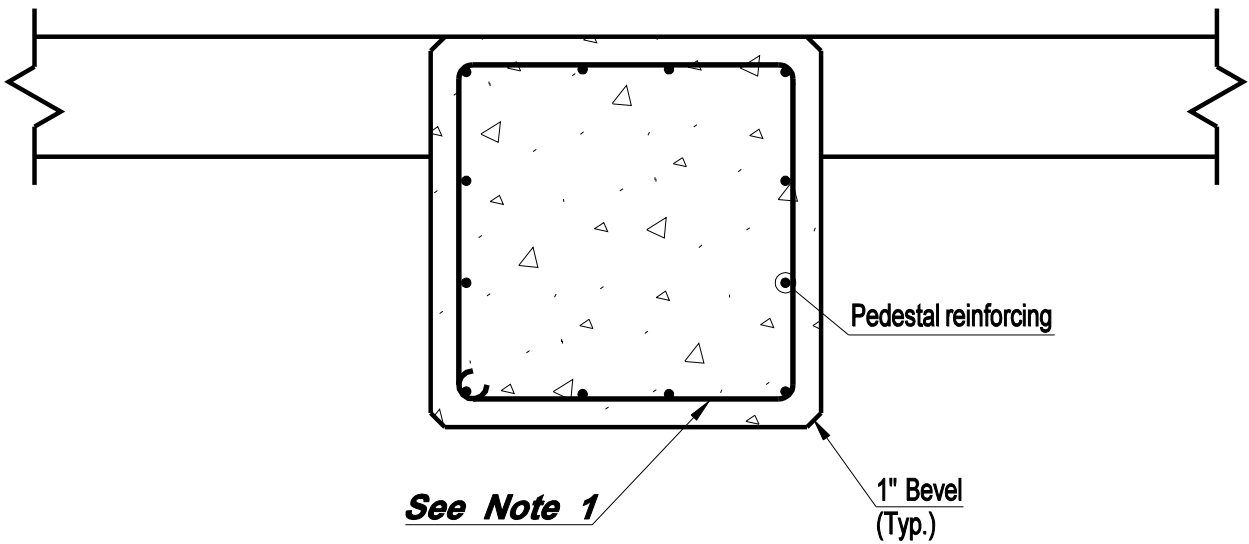
Issue Date: 10/03

Revision Date:

Plate Number:
3.1.2c



SECTION C
3.1.2a



SECTION D
3.1.2a

DESIGN INFORMATION

1. Ties to be designed in accordance with AASHTO requirements.

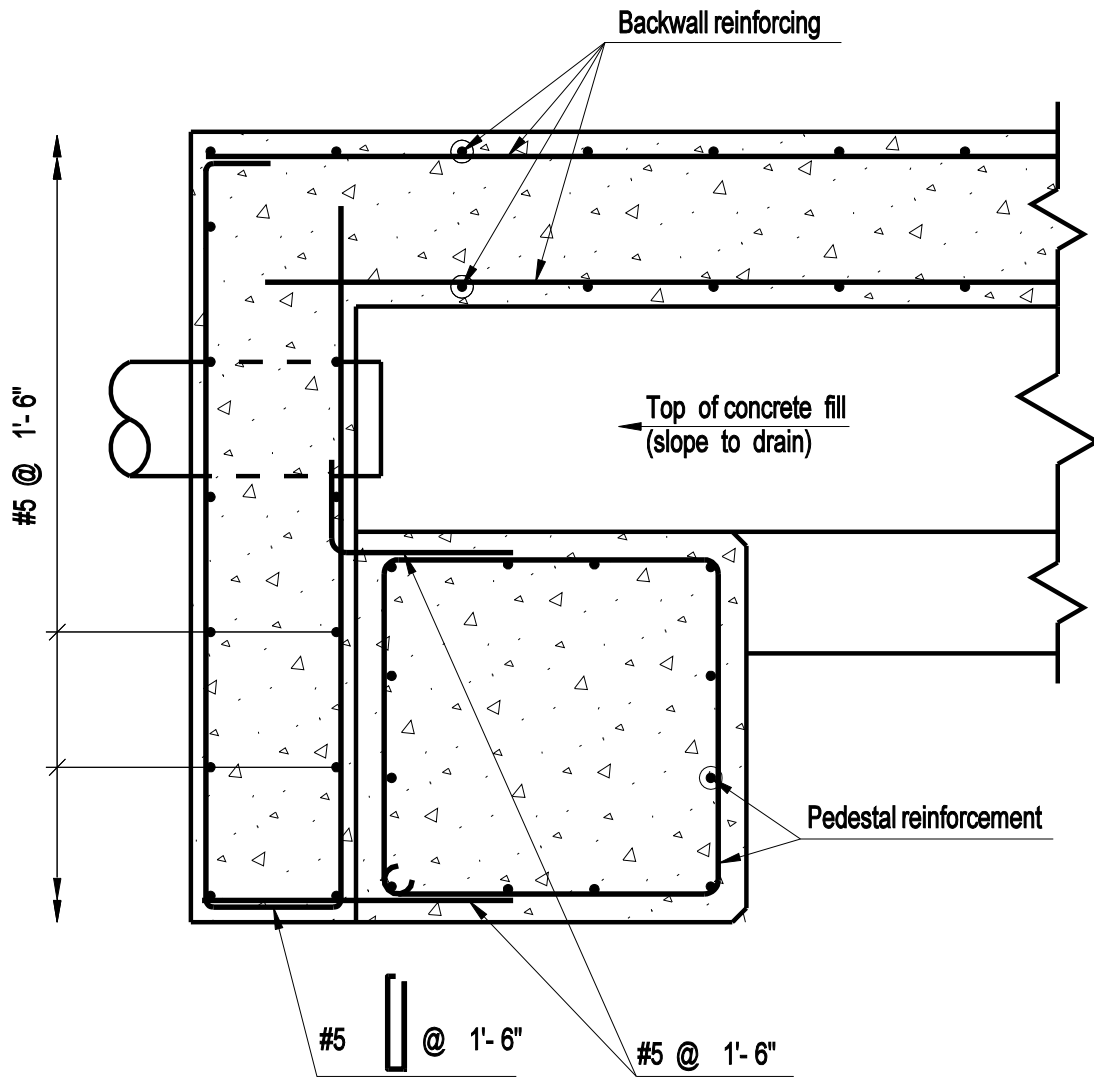
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

PEDESTAL TYPE ABUTMENT
PEDESTAL REINFORCEMENT

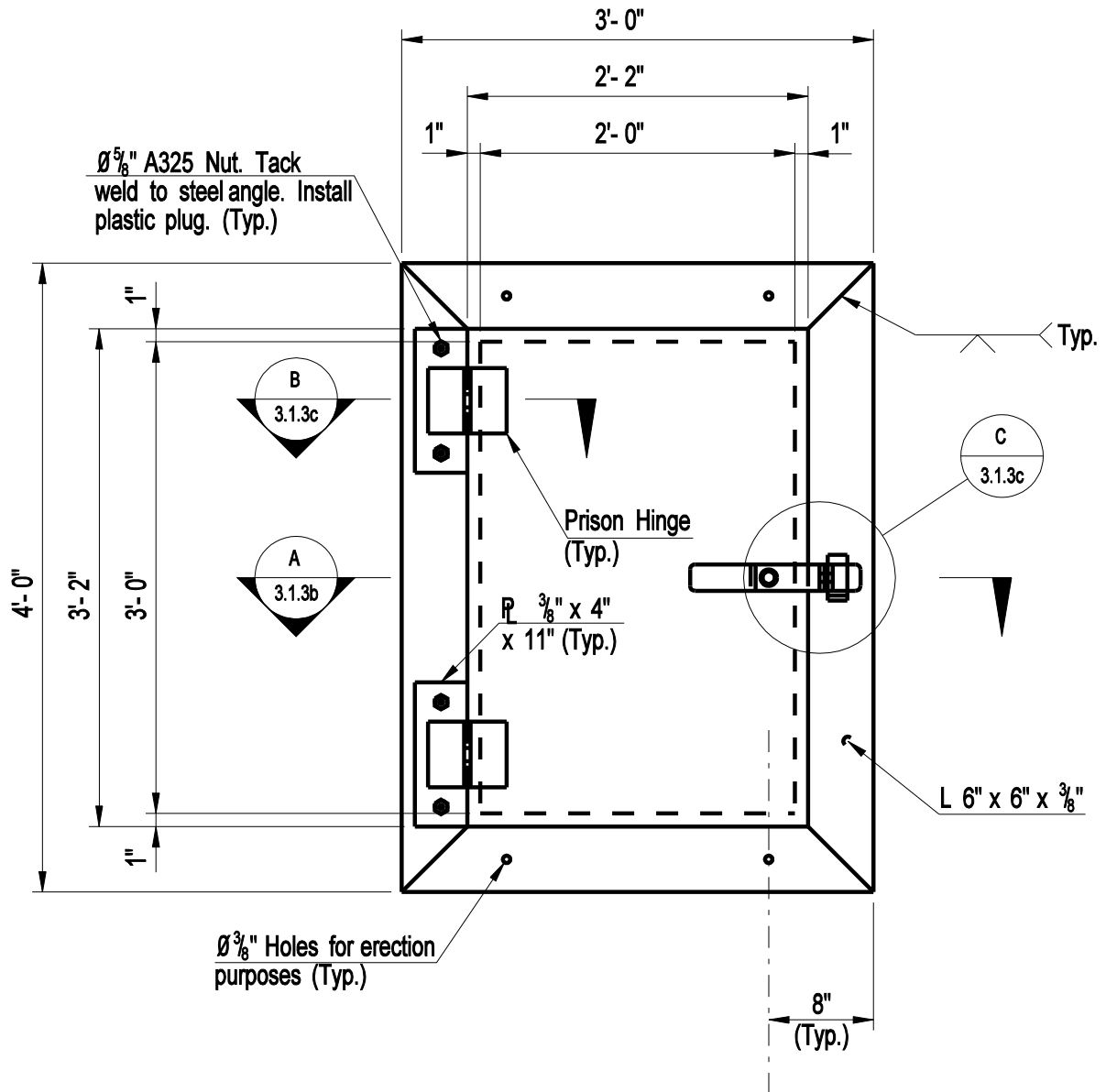
Issue Date: 10/03

Revision Date:

Plate Number:
3.1.2d

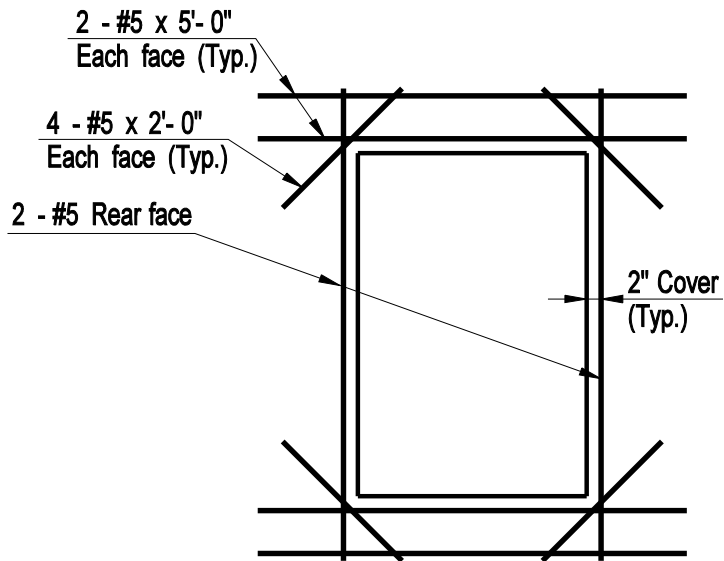


SECTION E
3.1.2a

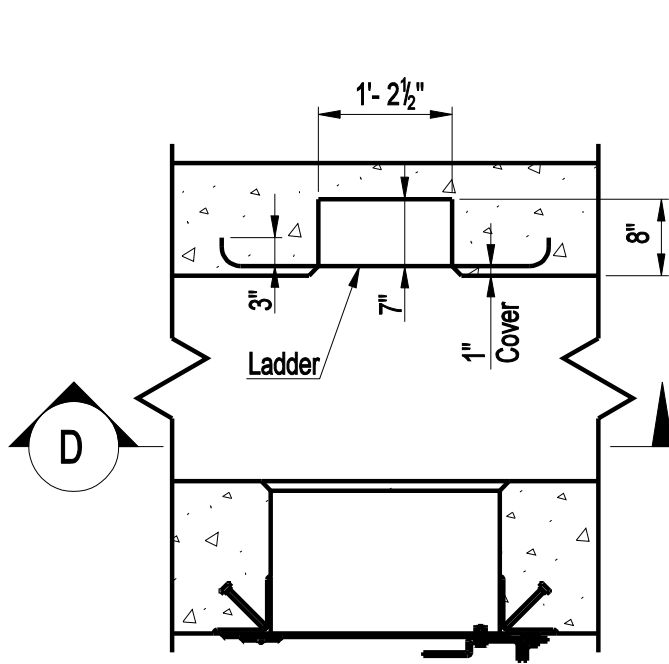


NOTES:

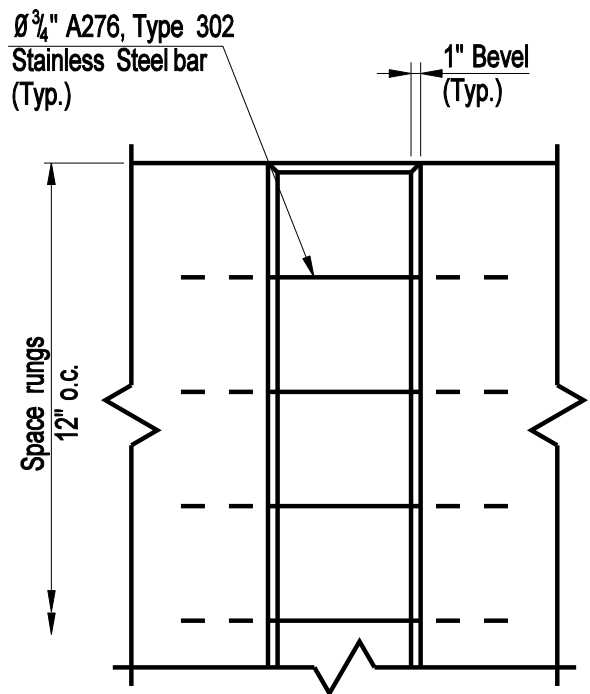
1. Material for access door and frame shall conform to the requirements of AASHTO M270 Grade 50.
2. Frame and door assembly shall be galvanized in accordance with ASTM A123 after fabrication.



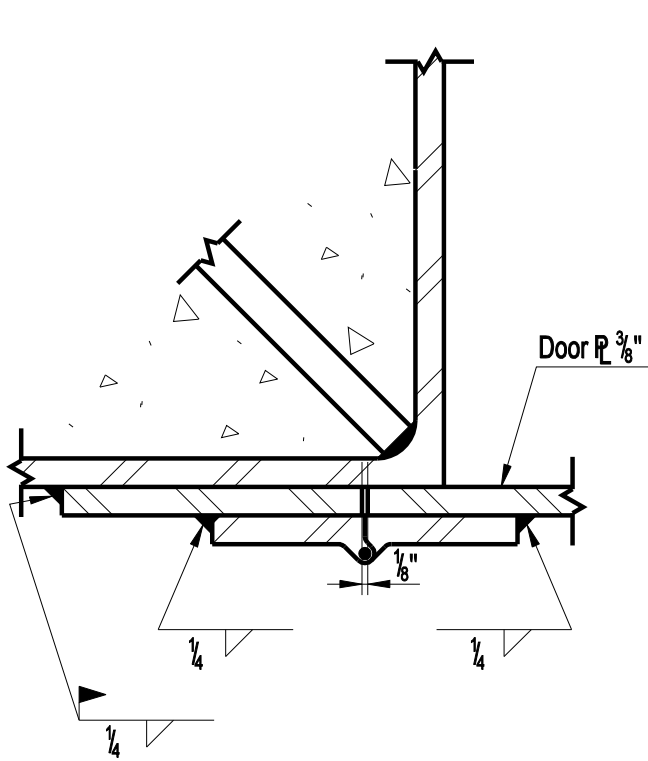
**ADDITIONAL REINFORCING
AT ACCESS DOOR**



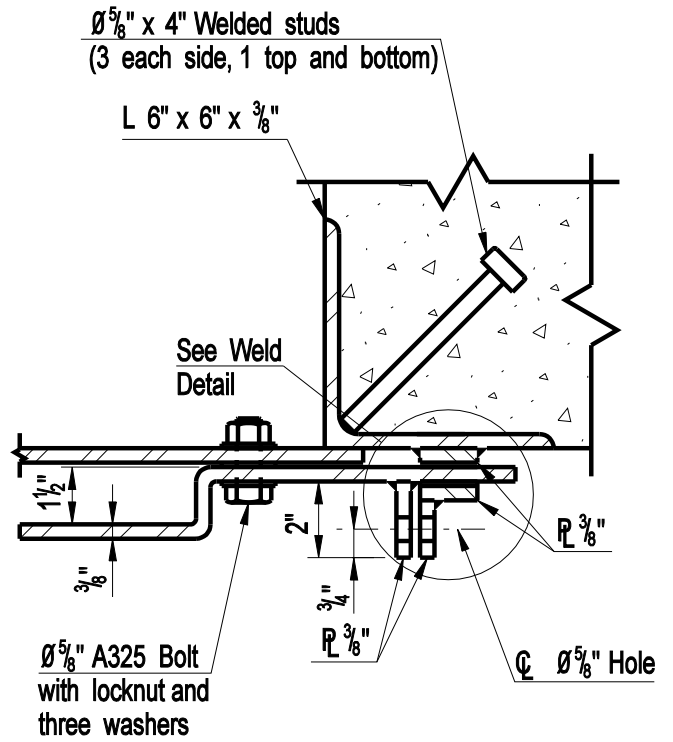
SECTION A
3.1.3a



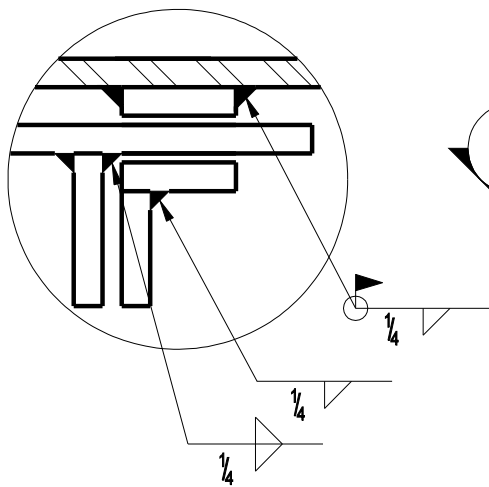
VIEW D



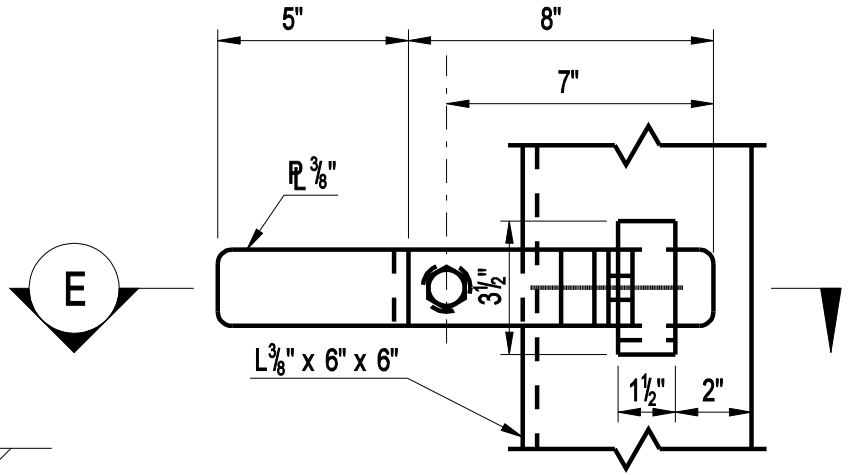
SECTION B



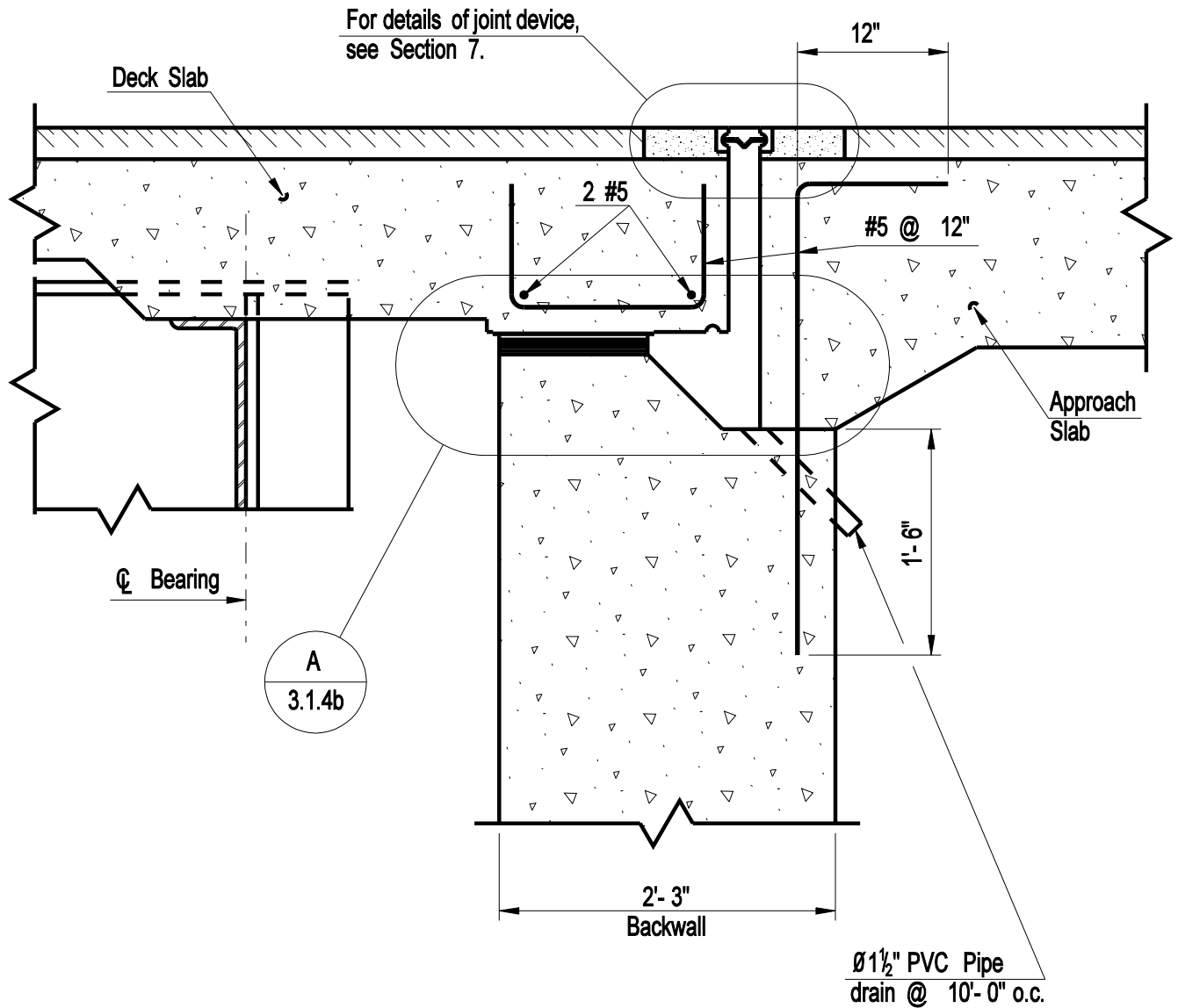
SECTION E



WELD DETAIL

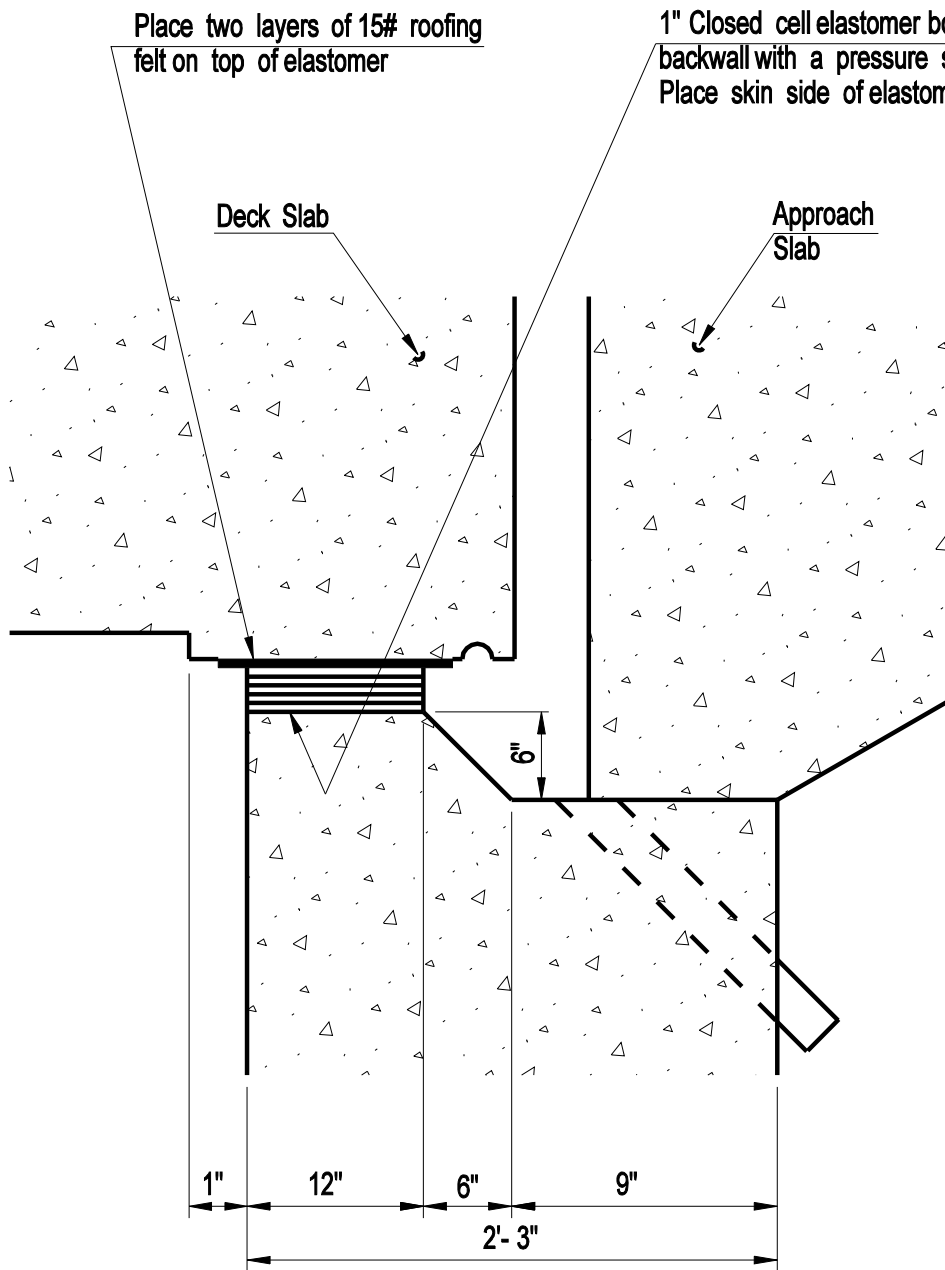


LATCH DETAIL C

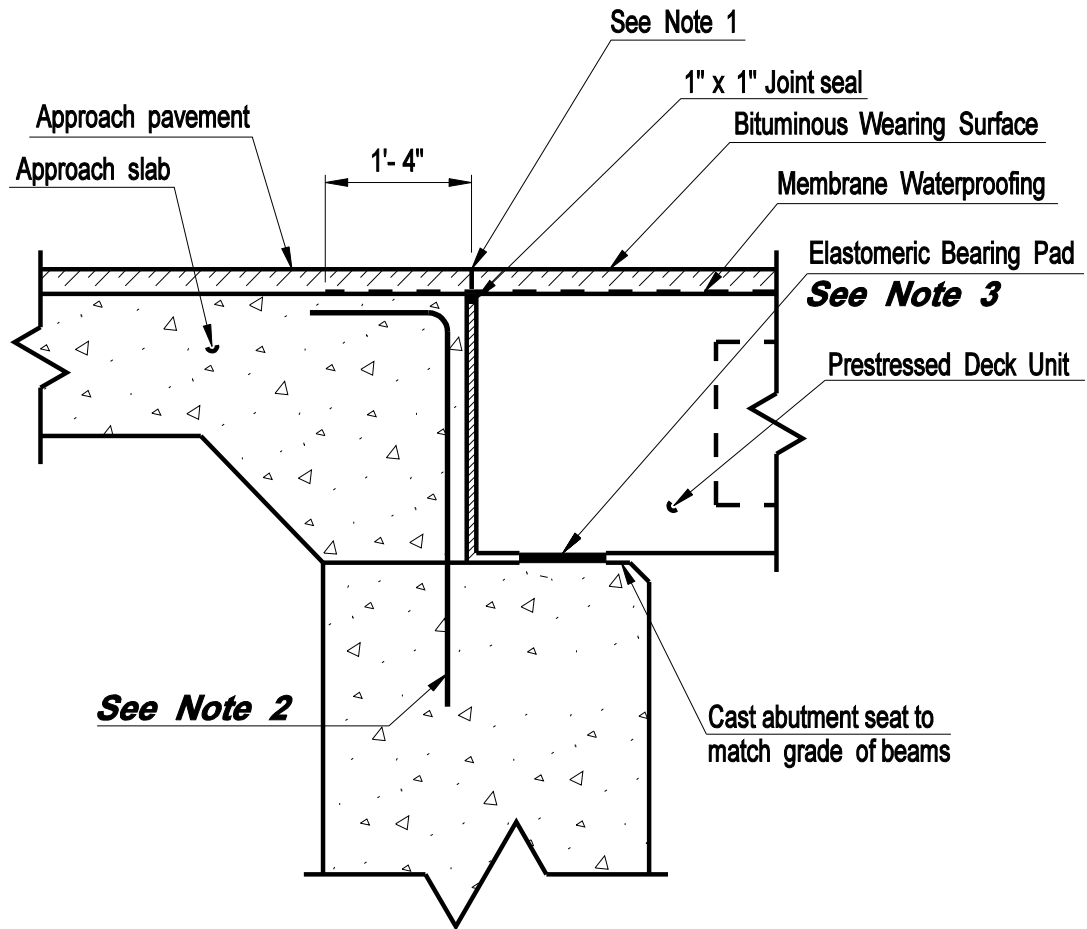


NOTES:

1. For slab information not shown, see Section 6.
2. For approach slab details, see Section 6.



DETAIL A



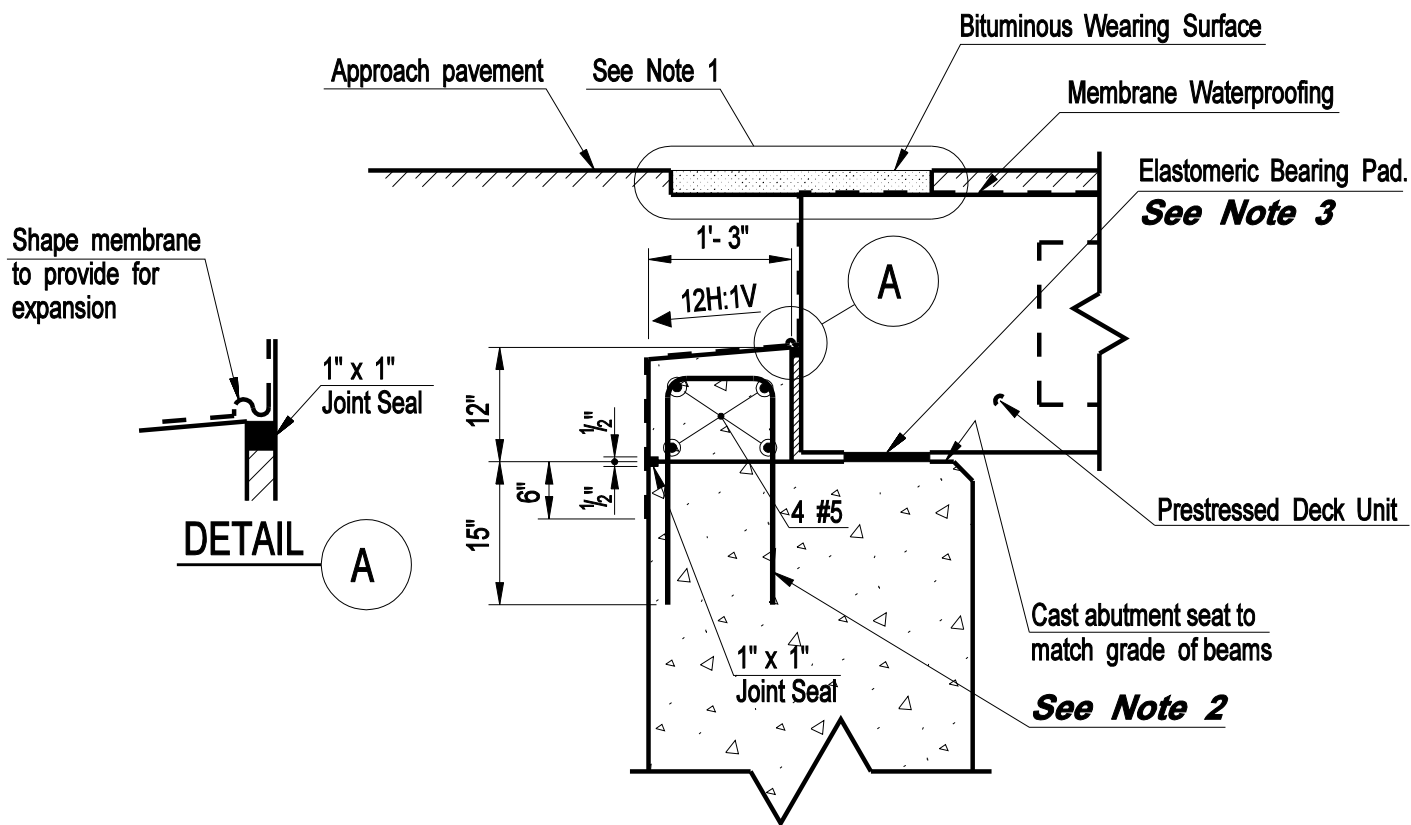
TYPICAL SECTION THROUGH ABUTMENT AT BEARING

NOTES:

1. Cut bituminous overlay with $\frac{3}{8}$ " wide by $1\frac{3}{4}$ " deep kerf and fill with pourable sealant. To be paid for under the item "Sawing and Sealing Joints in Bituminous Pavement".

DESIGN INFORMATION:

- 2. *The approach slab and cheekwall reinforcement shall be designed to resist longitudinal and transverse seismic forces.*
- 3. *Elastomeric Bearing shall be designed according to Section 14 of the AASHTO specifications.*



TYPICAL SECTION THROUGH ABUTMENT AT BEARING

NOTES:

1. For details of joint device, see Section 7

DESIGN INFORMATION:

- 2. The backwall and cheekwall shall be designed to resist longitudinal and transverse seismic forces.**
- 3. Elastomeric Bearing shall be designed according to Section 14 of the AASHTO specifications.**
- 4. This detail should be used only with the express permission of the Department. In most cases, approach slabs shall be used as detailed on Plate 3.1.5. See Article 5.8, Section I for warrants for use.**

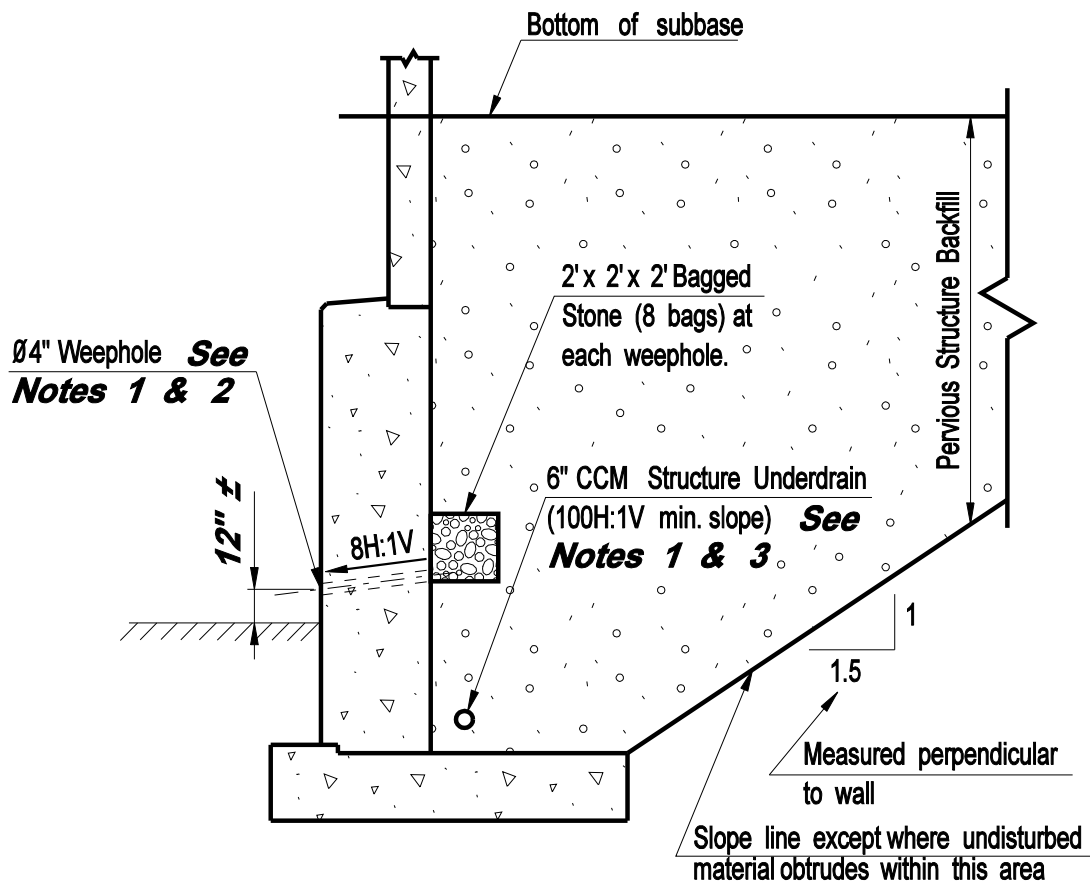
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**ABUTMENT DETAILS FOR
PRECAST CONCRETE
DECK UNITS WITHOUT
APPROACH SLAB**

Issue Date: 10/03

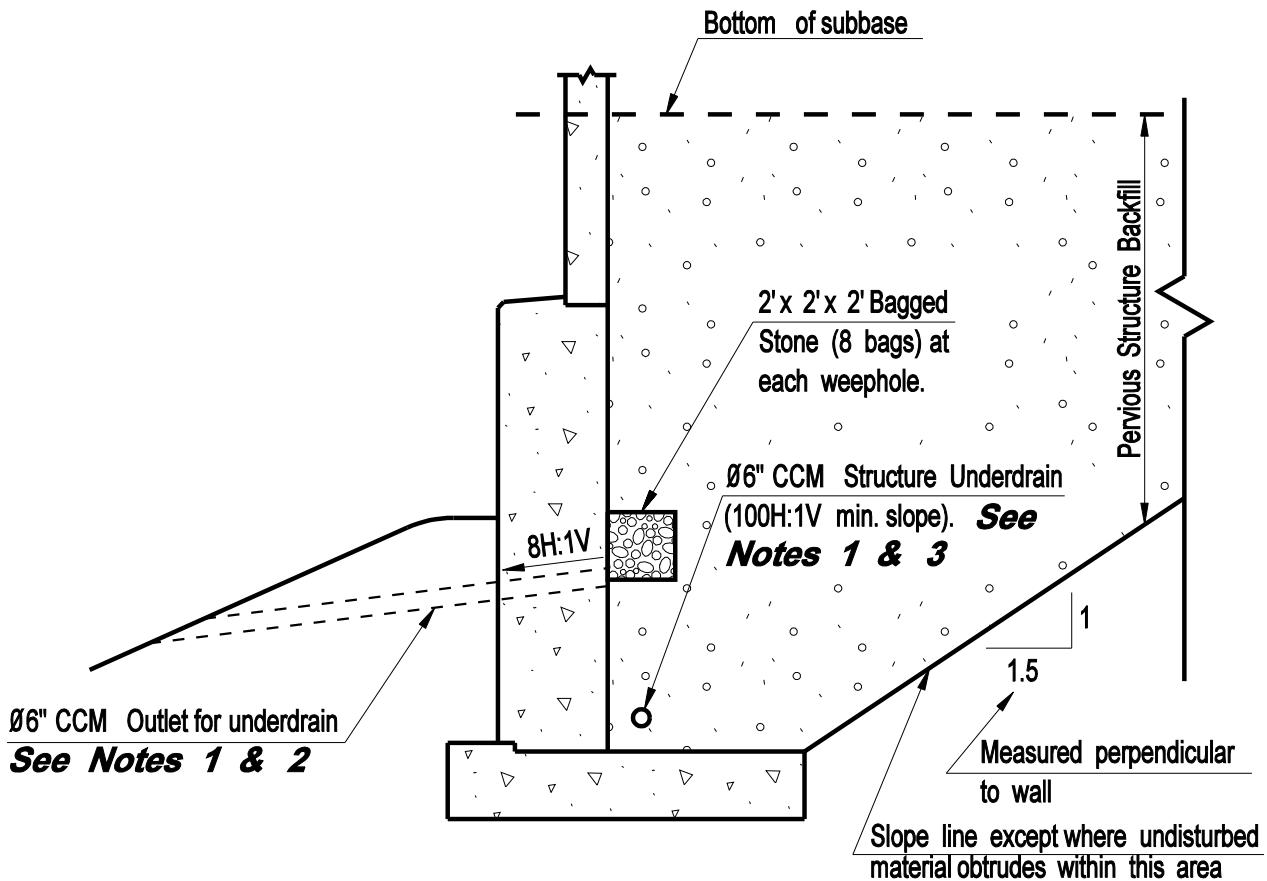
Revision Date: 01/05

Plate Number:
3.1.6



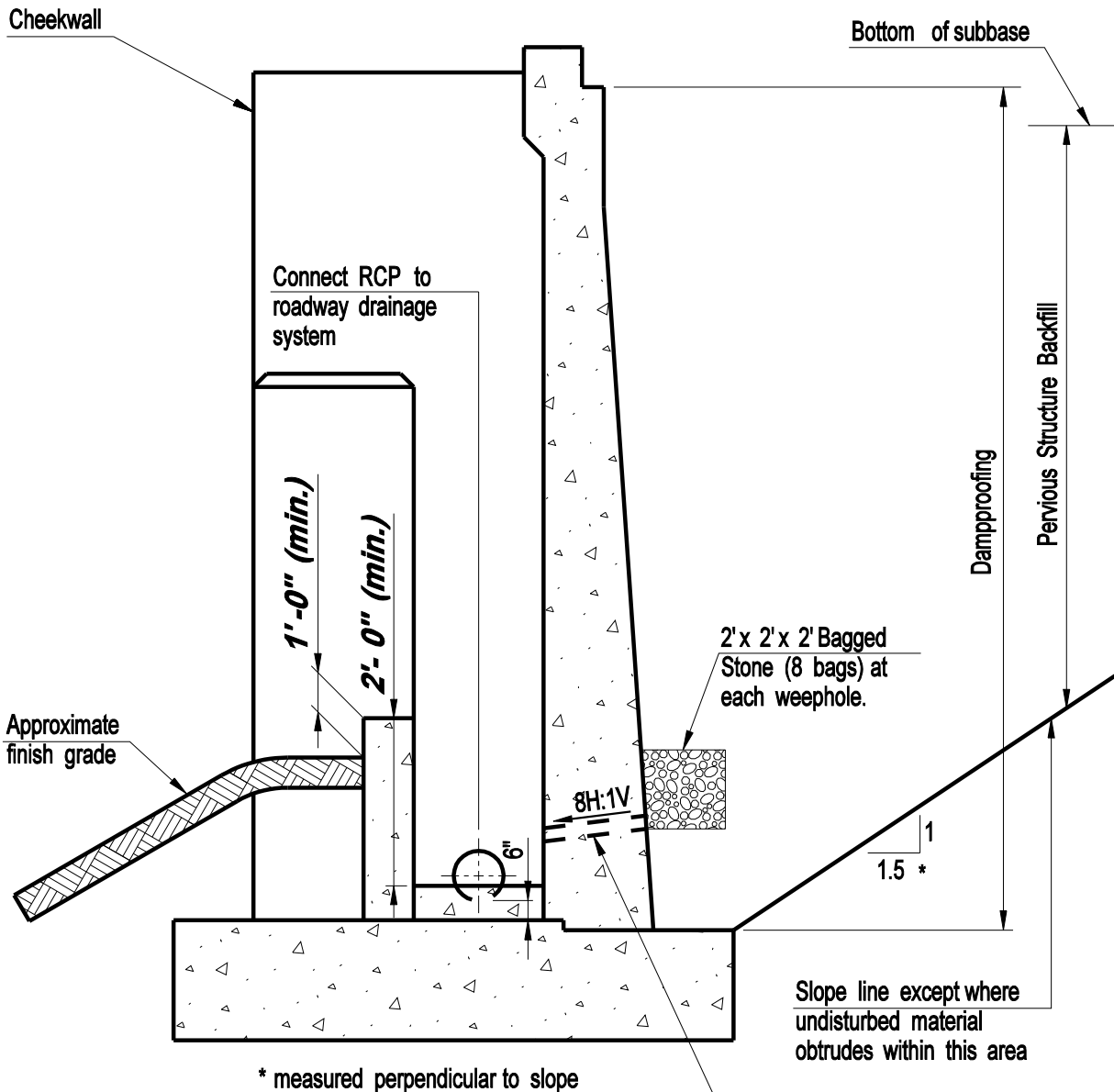
DESIGN INFORMATION

- 1. Plans should show either 4" weepholes or 6" structure underdrain. See Division I.**
- 2. Horizontal spacing and invert elevations of weepholes at the front face of abutment shall be shown on the abutment elevation views on the plans.**
- 3. 6" CCM Structure Underdrain and 6" CCM Outlet for Underdrain shall be included as Bridge Pay Items.**



DESIGN INFORMATION

- 1. Plans should show either 4" weepholes or 6" structure underdrain. See Division I.**
- 2. Horizontal spacing and invert elevations of extended weepholes at the front face of abutment shall be shown on the abutment elevation views on the plans.**
- 3. 6" CCM Structure Underdrain and 6" CCM Outlet for Underdrain shall be included as Bridge Pay Items.**



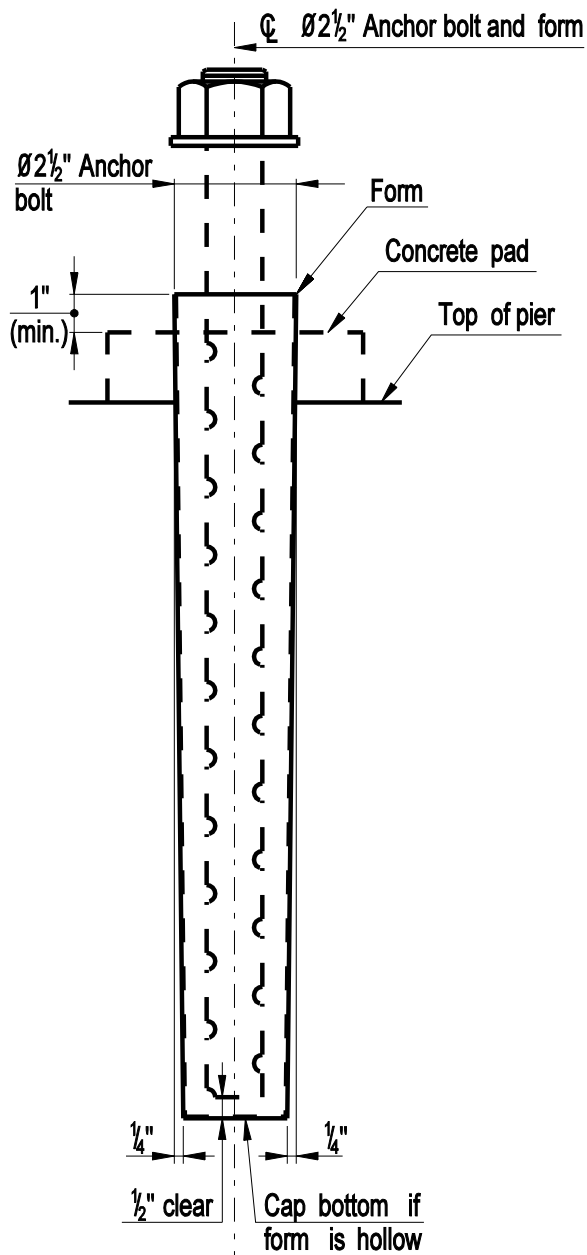
SECTION A
3.1.2a

Ø4" Weepholes *See Notes 1 & 2*

DESIGN INFORMATION

- 1. Plan should show either 4" weep hole or 6" structure underdrain. See Section I.**
- 2. Horizontal spacing and invert locations of weepholes shall be shown on the abutment elevation views on the plans.**

CONNECTICUT BRIDGE DESIGN MANUAL	PEDESTAL TYPE ABUTMENT DRAINAGE AND BACKFILL REQUIREMENTS	Issue Date: 10/03
		Revision Date:
		Plate Number: 3.2.3

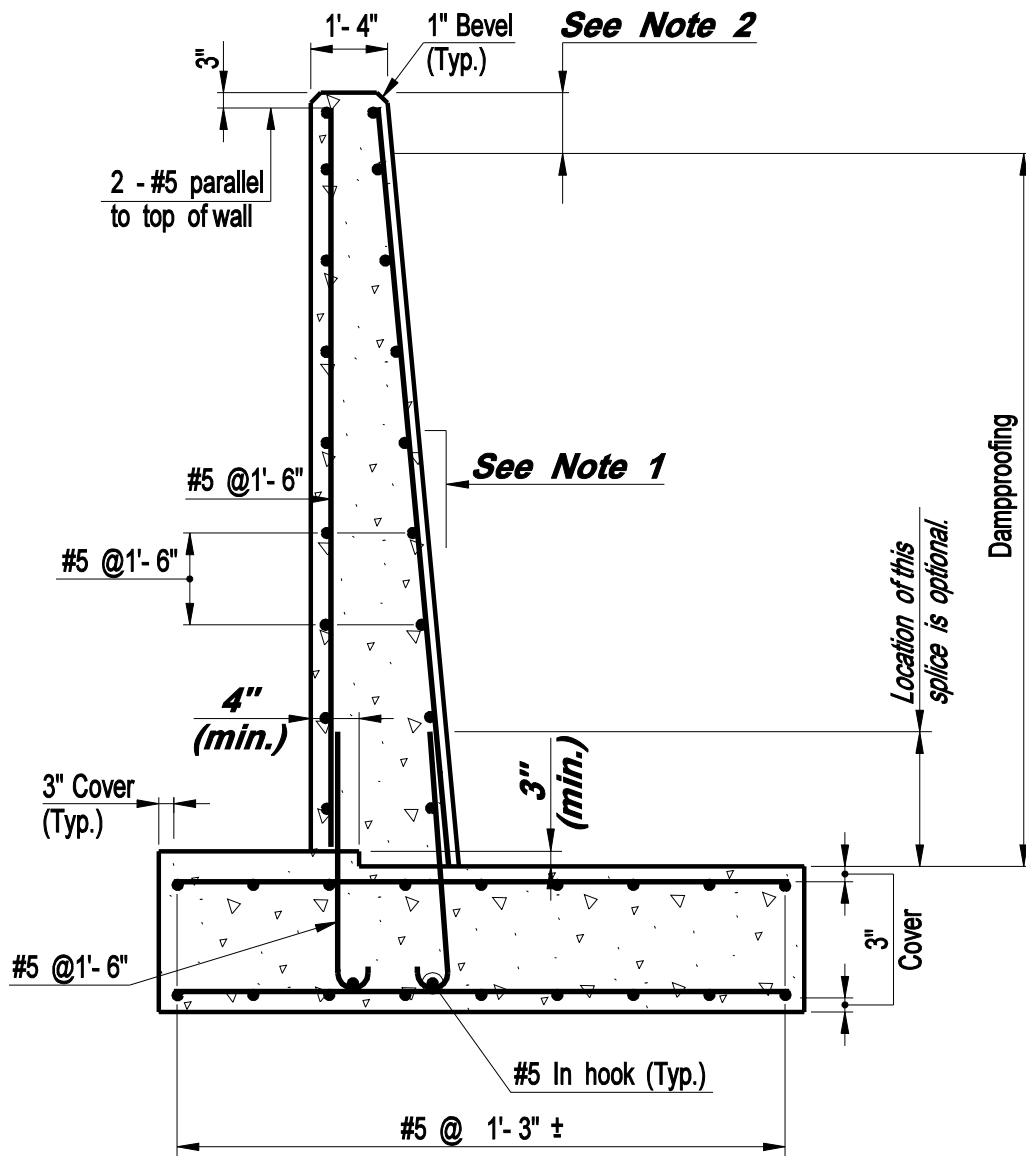


NOTES:

Forms shall be unoled, held in place accurately by template, and removed after concrete has hardened. Anchor bolts shall be set accurately and grouted with non-shrink grout. The cost of furnishing and installing forms to be included in the item "Class F Concrete".

DESIGN INFORMATION

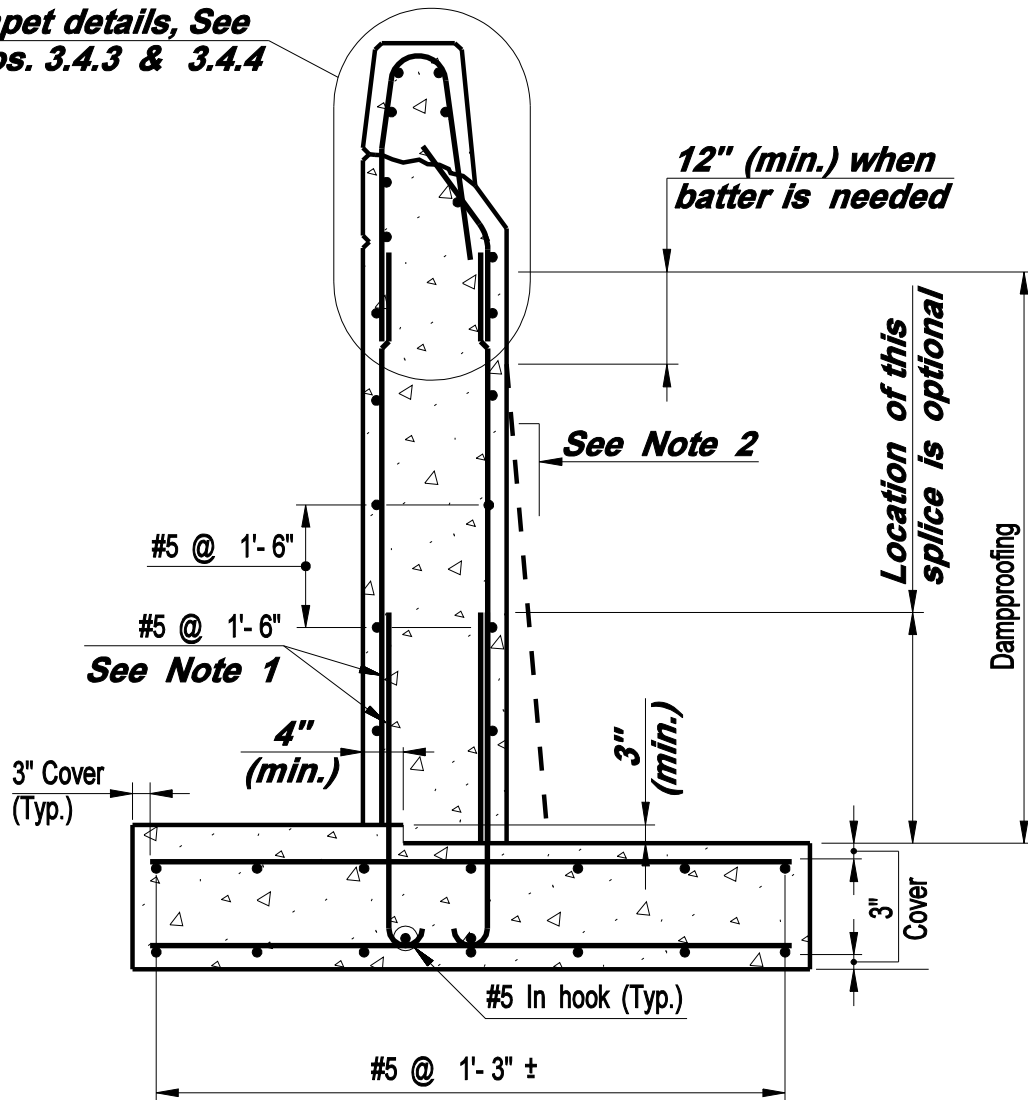
Designer to determine the exact location of forms in relation to reinforcement and, if necessary, respace or add extra rows of reinforcing. Forms are to be used primarily at piers but may also be used elsewhere at the discretion of the designer.



DESIGN INFORMATION

- 1. The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.**
- 2. This dimension may be increased to follow finished grade.**

*For parapet details, See
Plate Nos. 3.4.3 & 3.4.4*



DESIGN INFORMATION

1. *This reinforcement shall be designed for seismic forces.*
2. *The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.*

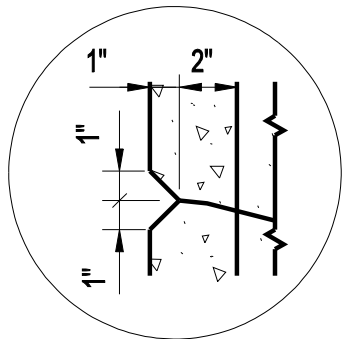
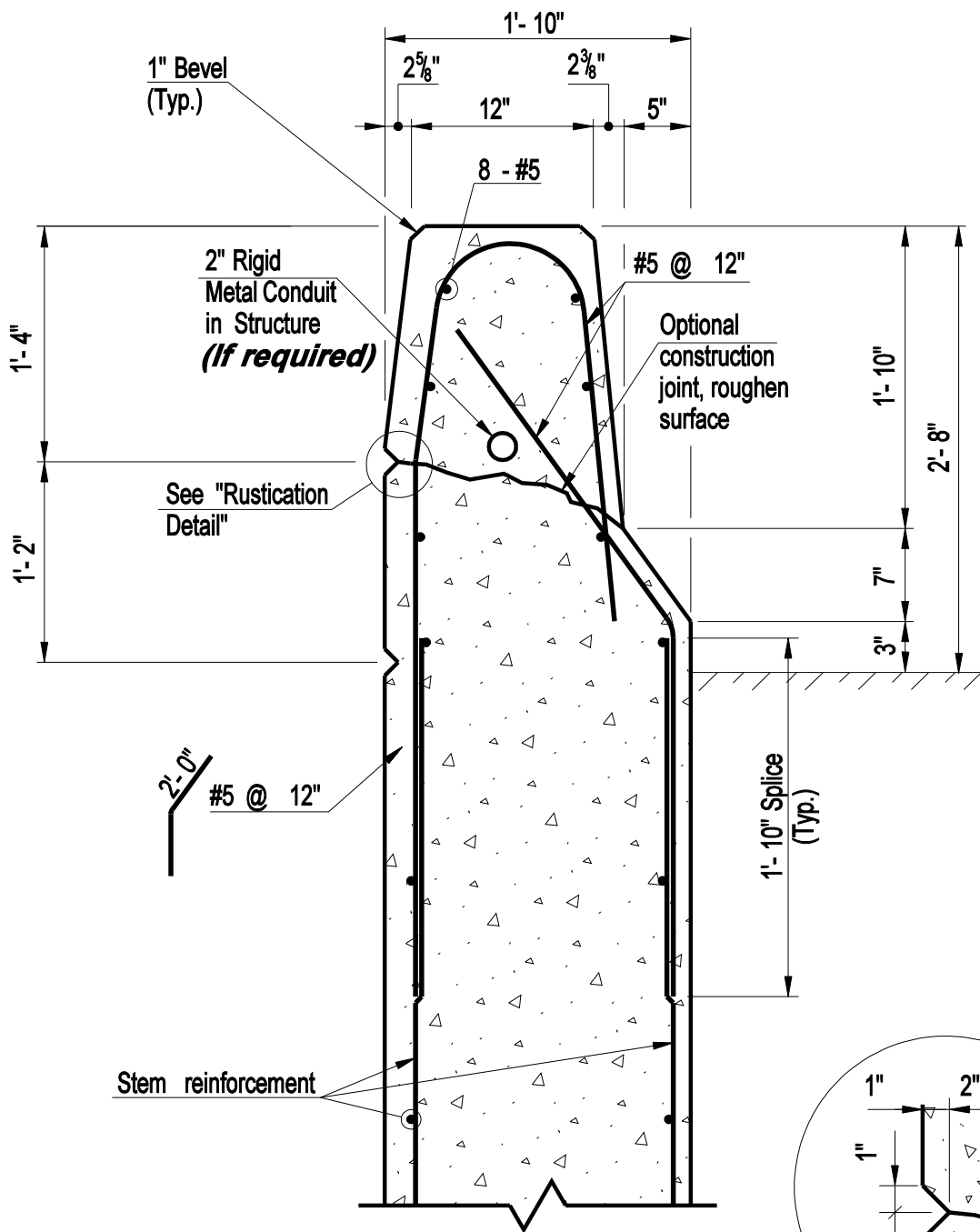
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**U - TYPE WINGWALL OR
RETAINING
WALL WITH SLOPED CURB**

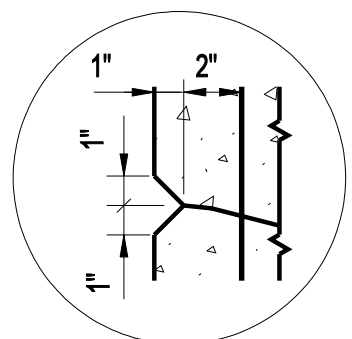
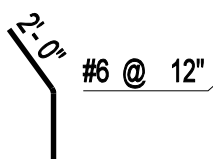
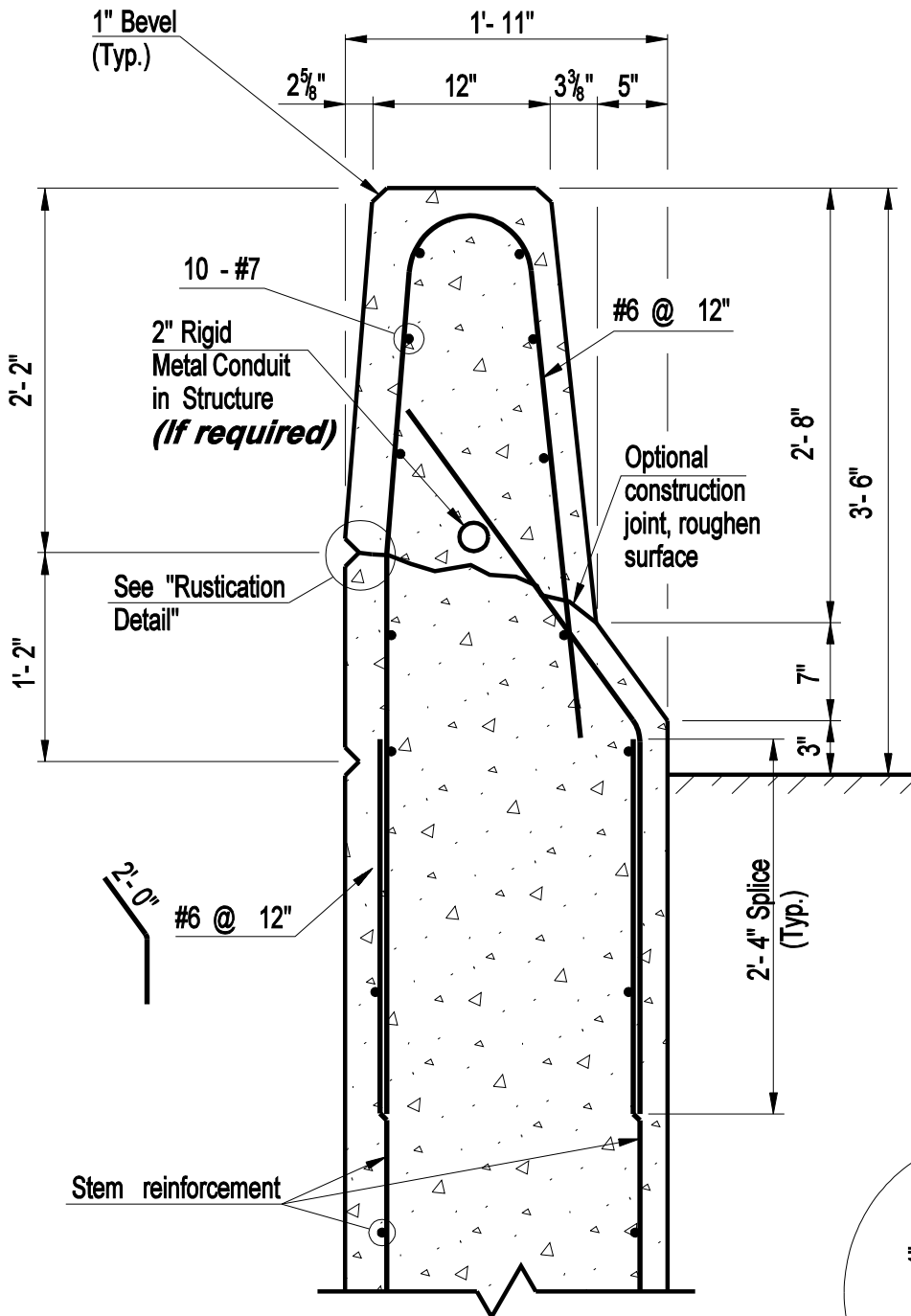
Issue Date: 10/03

Revision Date:

Plate Number:
3.4.2



Rustication Detail



Rustication Detail

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

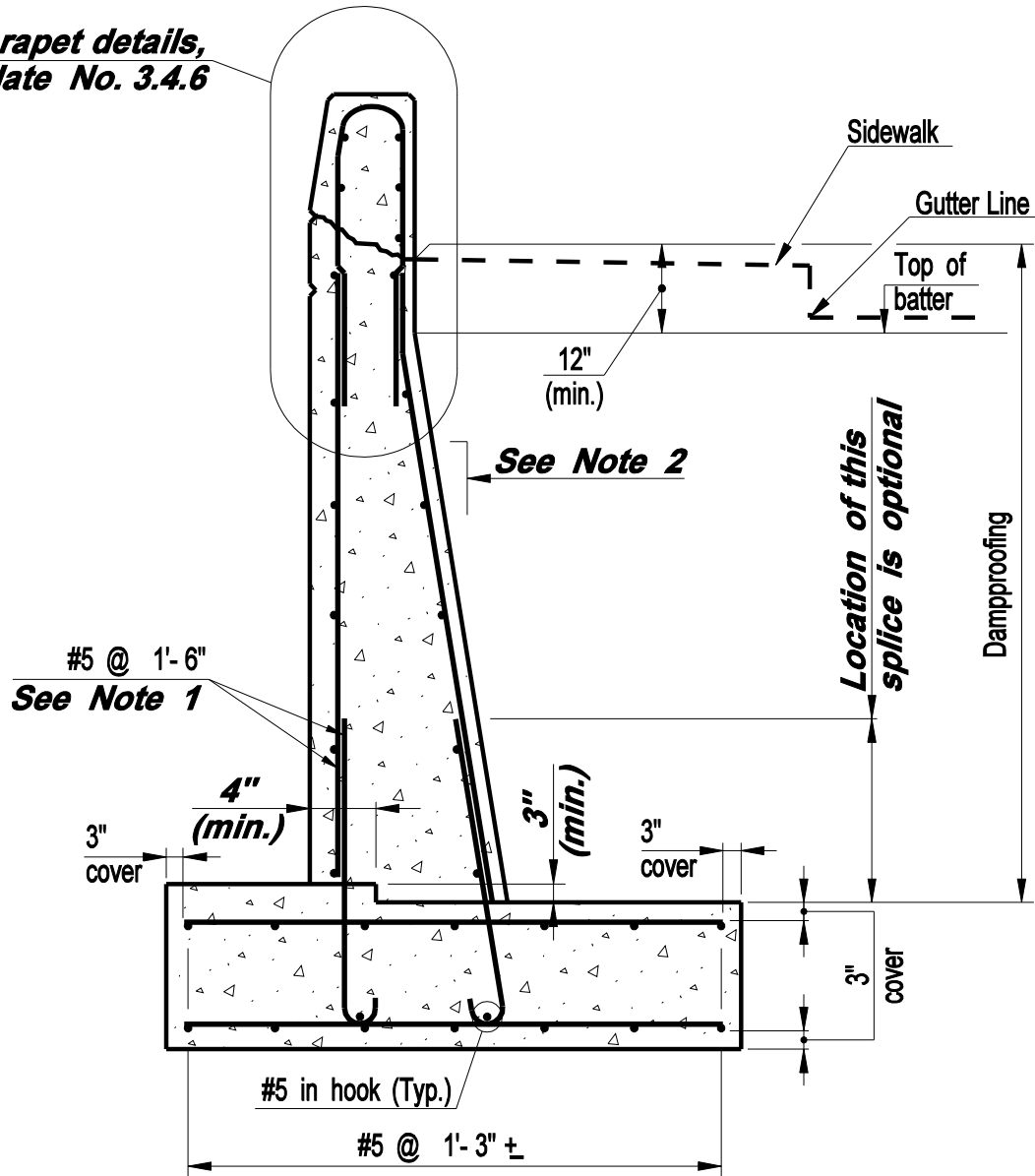
**STANDARD WINGWALL PARAPET
(42" HIGH)**

Issue Date: 10/03

Revision Date:

Plate Number:
3.4.4

***For parapet details,
See Plate No. 3.4.6***



DESIGN INFORMATION

1. *This reinforcement shall be designed for seismic forces.*
2. *The rear face of the stem shall be battered if additional width at the base of the stem is required. The minimum batter shall be 1H:12V. Maintain a uniform top of batter elevation.*

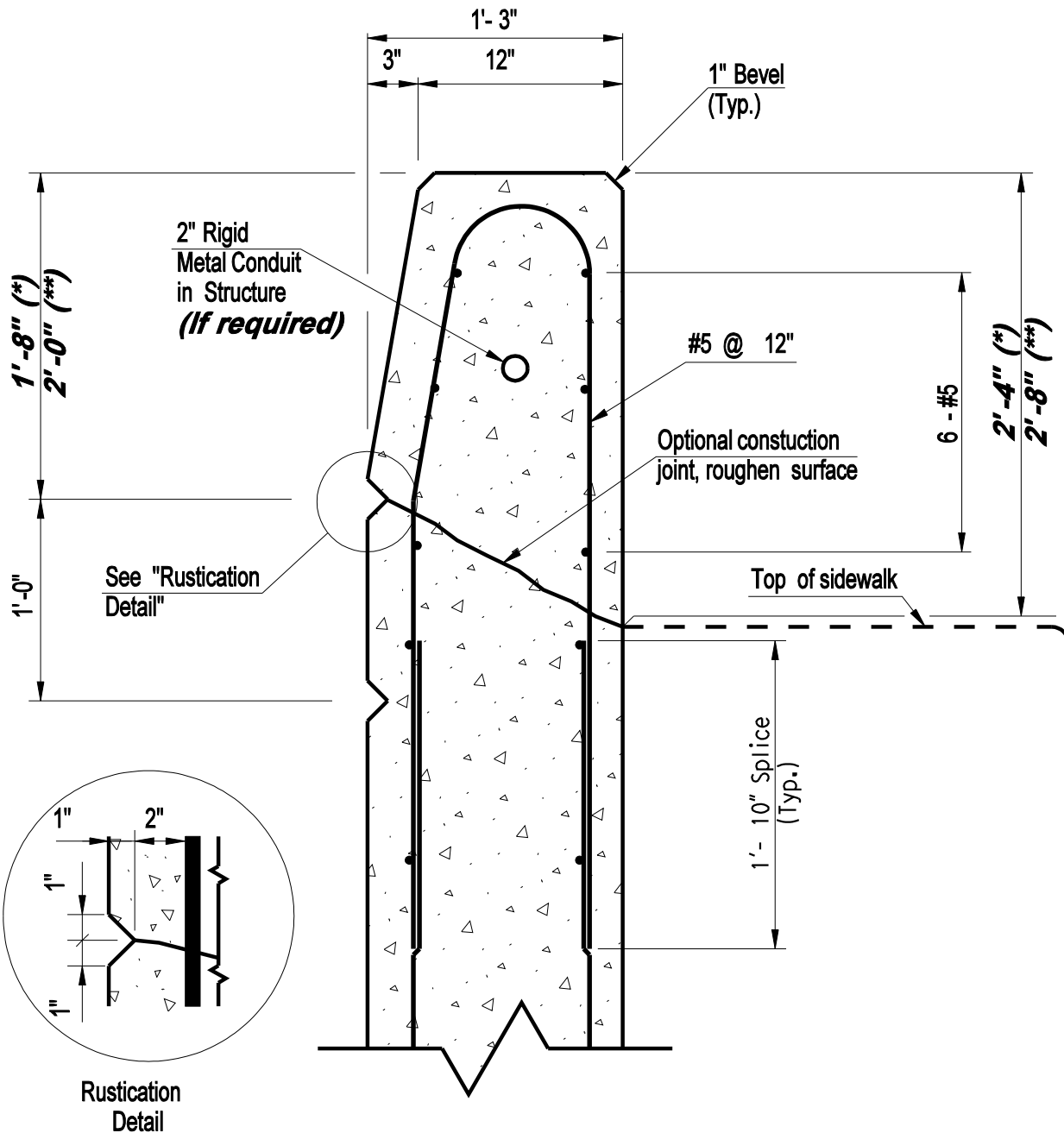
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**U-TYPE WINGWALL
OR RETAINING
WALL WITH SIDEWALK**

Issue Date: 10/03

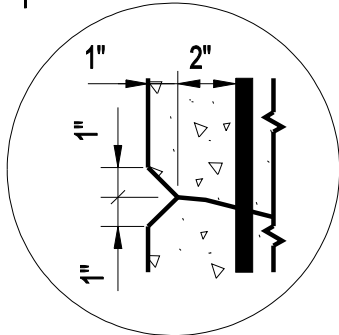
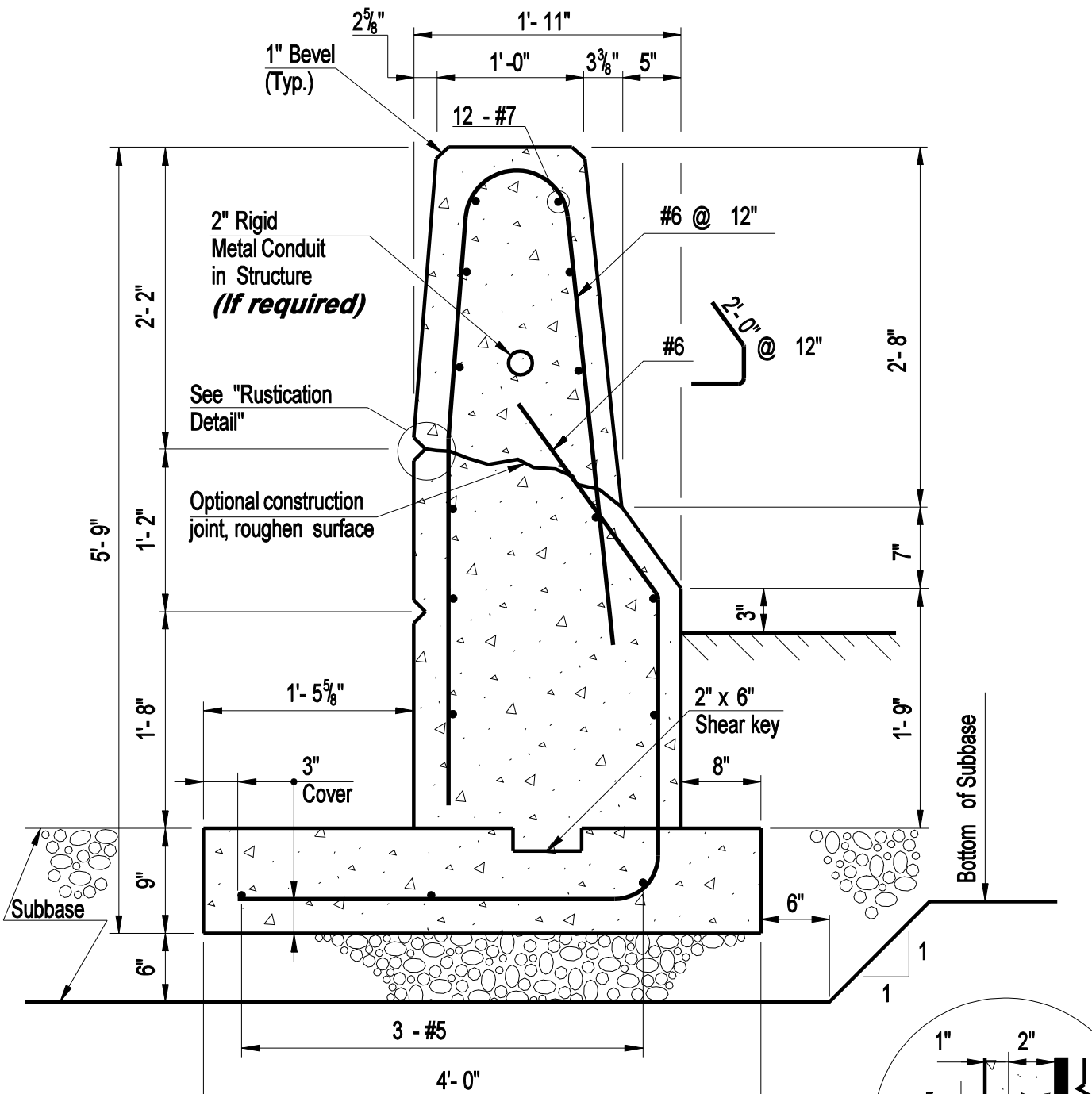
Revision Date: 01/05

Plate Number:
3.4.5



DESIGN INFORMATION

- * with protective fence
- ** with pedestrian railing



Rustication Detail

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

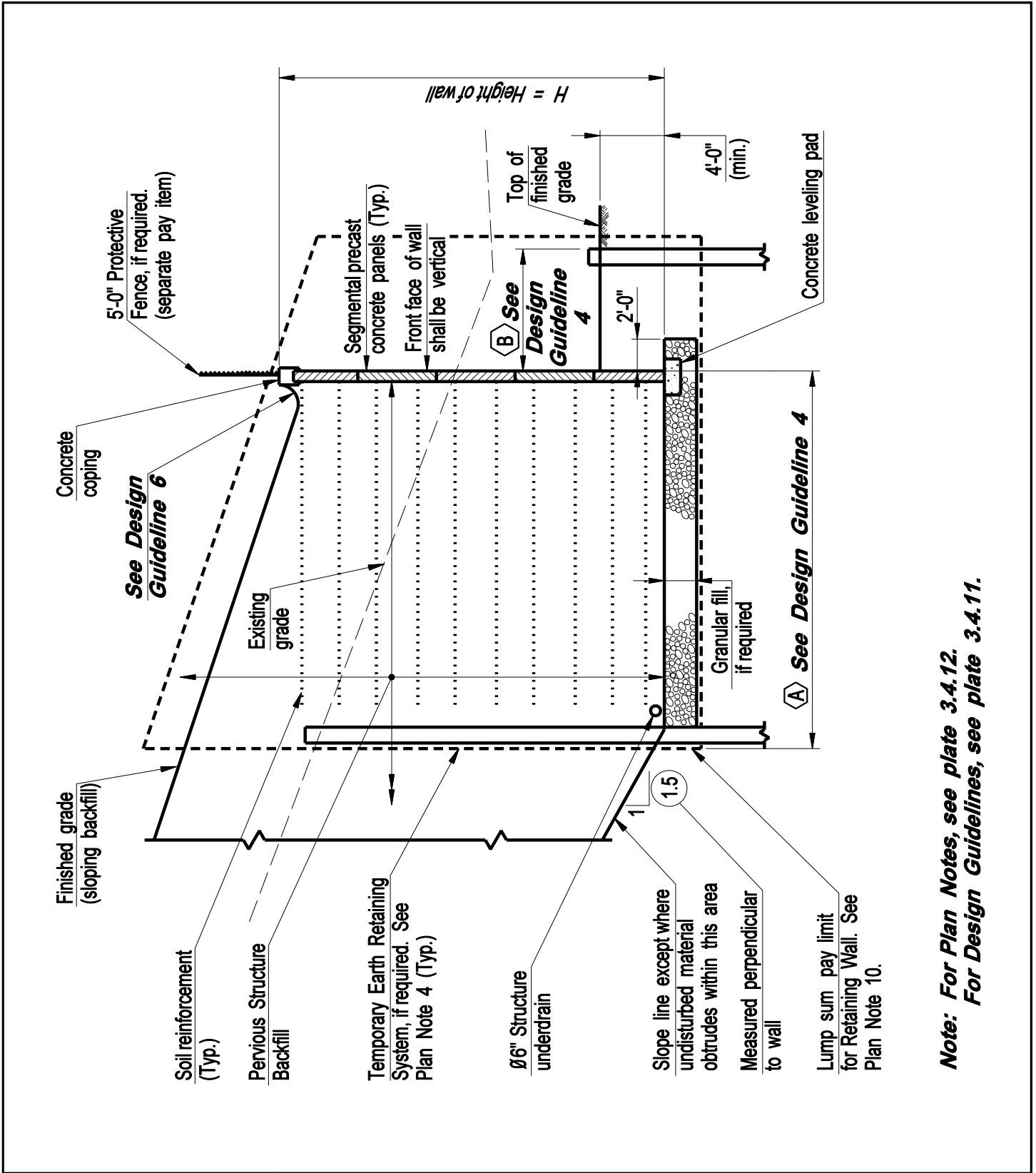
**CONCRETE BARRIER WALL
(42" HIGH)**

Issue Date: 10/03

Revision Date:

Plate Number:

3.4.8

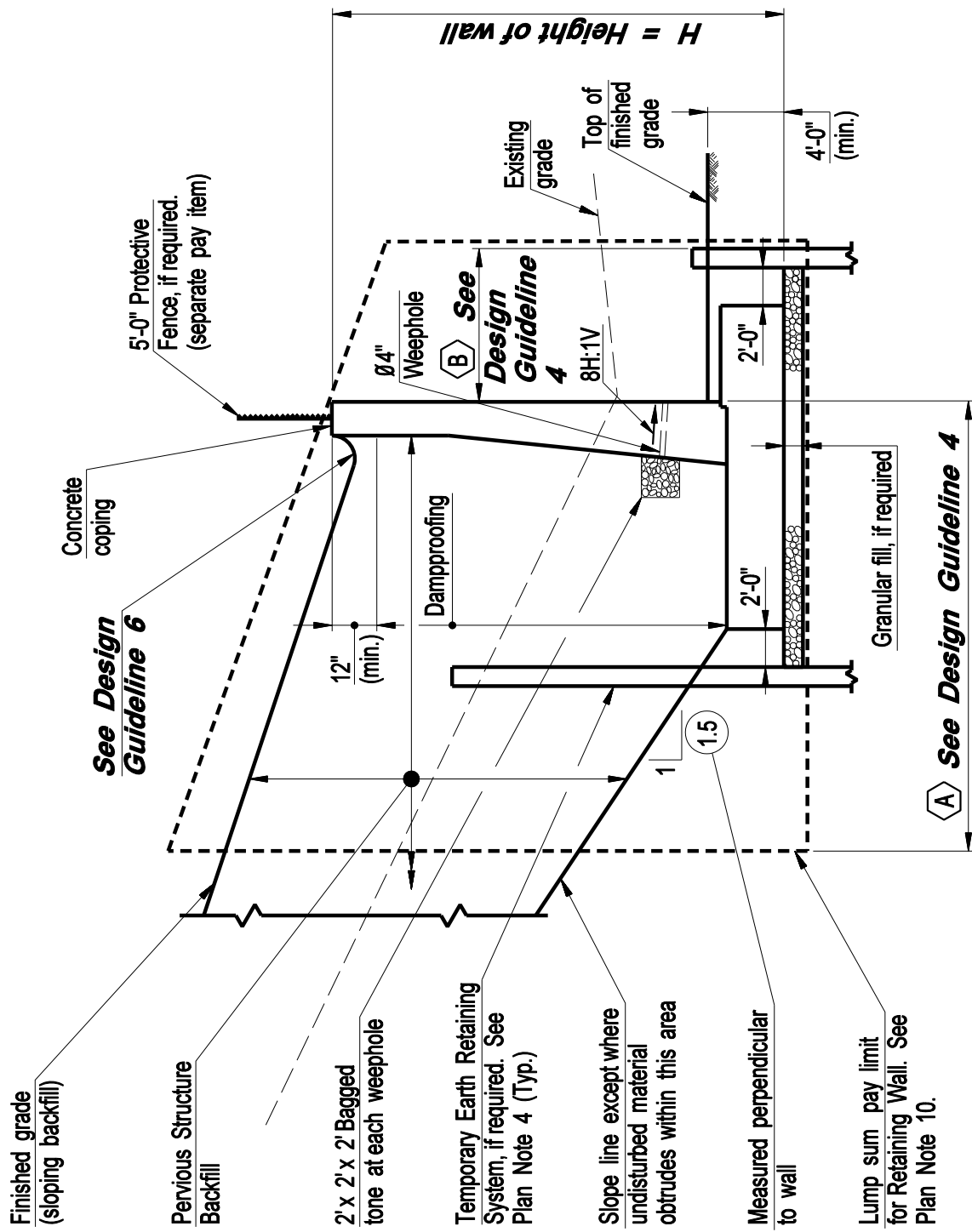


Note: For Plan Notes, see plate 3.4.12.
For Design Guidelines, see plate 3.4.11.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**TYPICAL SECTION
MECHANICALLY STABILIZED
EARTH WALL (SLOPING BACKFILL)**

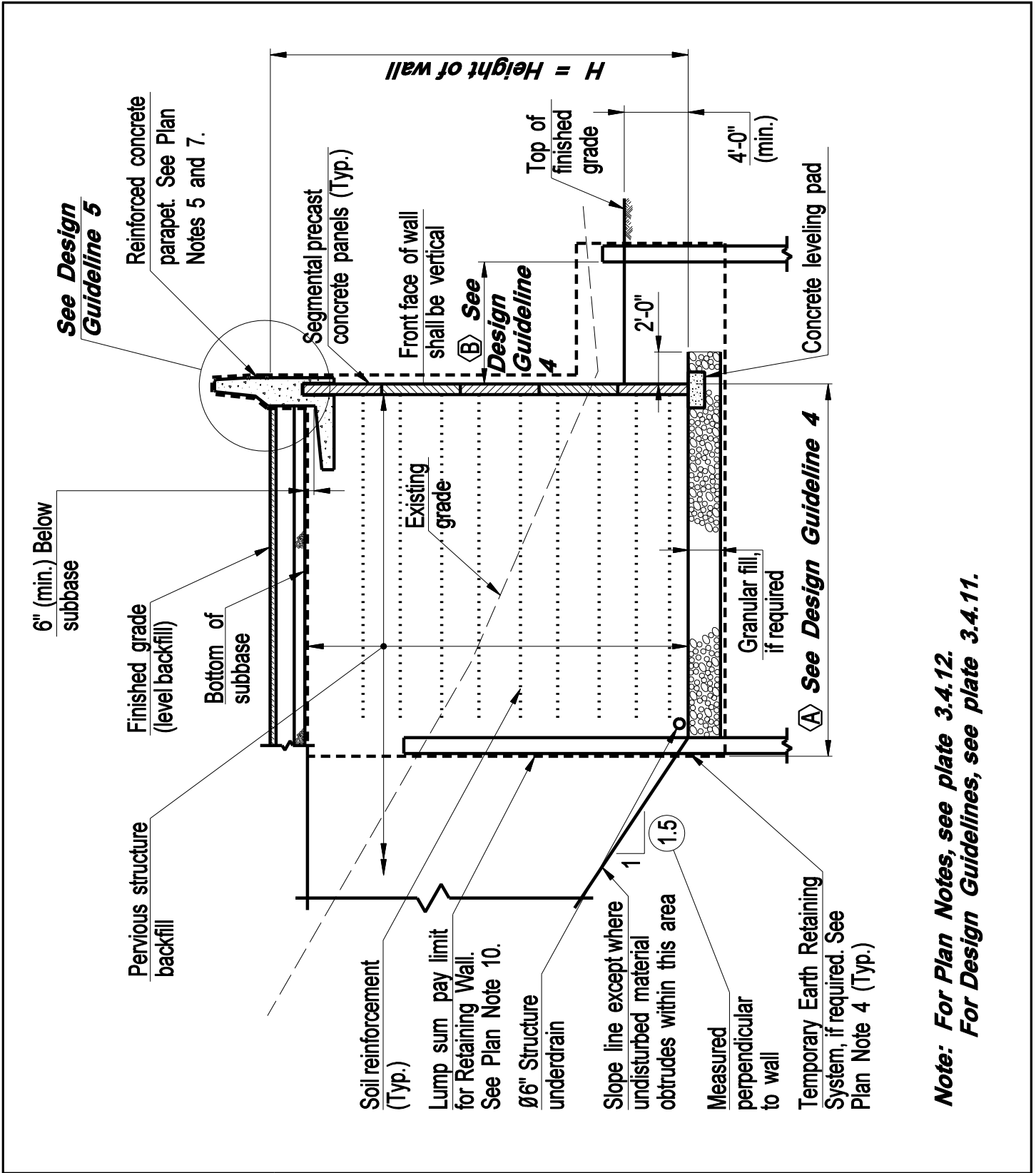
Issue Date:	10/03
Revision Date:	3/09
Plate Number:	3.4.9b



**CONNECTICUT
BRIDGE DESIGN
MANUAL**

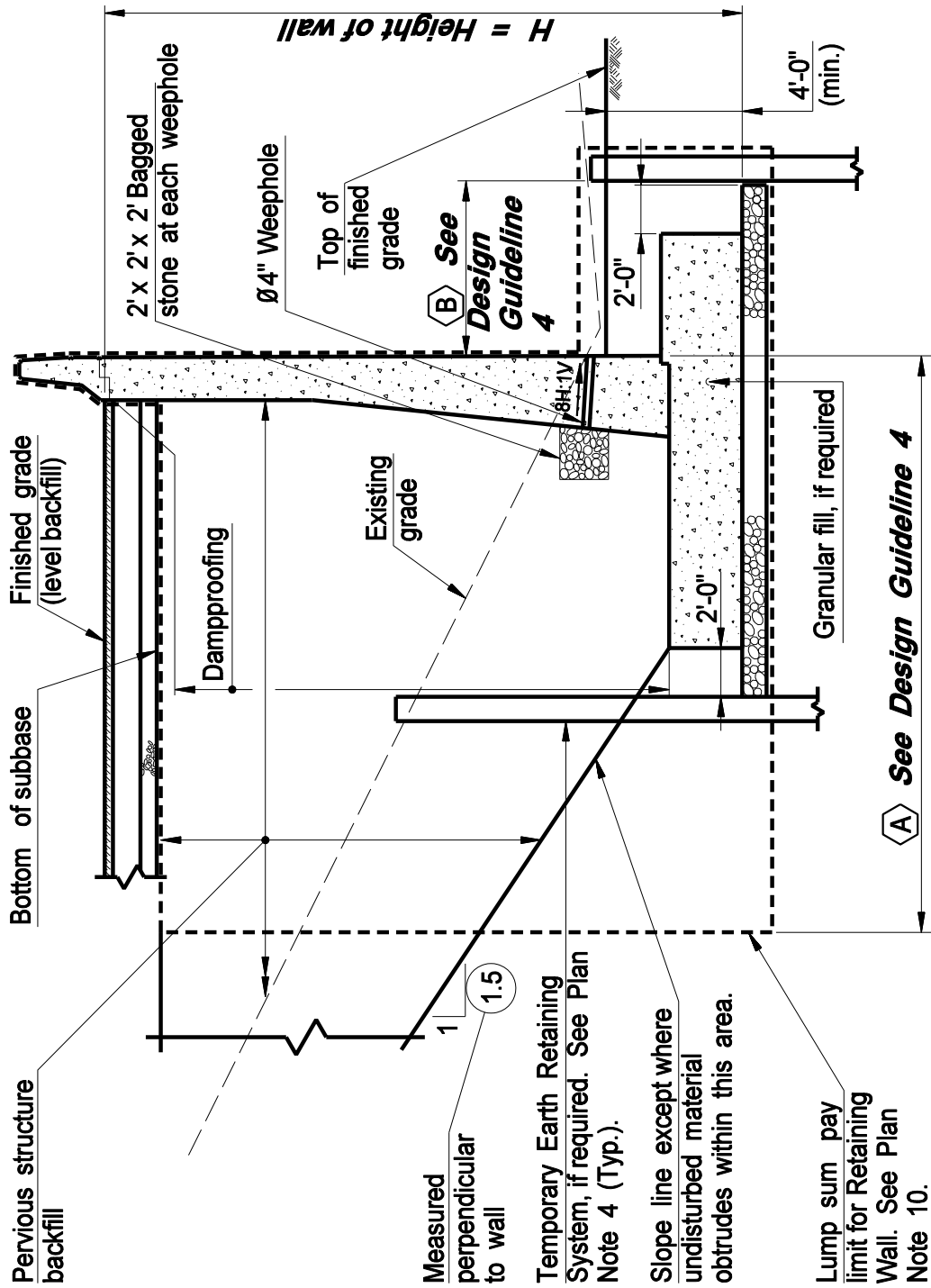
**TYPICAL SECTION
CAST-IN-PLACE
REINFORCED CONCRETE
(SLOPING BACKFILL)**

Issue Date:	10/03
Revision Date:	3/09
Plate Number:	3.4.9c



**Note: For Plan Notes, see plate 3.4.12.
For Design Guidelines, see plate 3.4.11.**

CONNECTICUT BRIDGE DESIGN MANUAL	TYPICAL SECTION MECHANICALLY STABILIZED EARTH WALL (LEVEL BACKFILL)	Issue Date: 10/03
		Revision Date: 3/09
		Plate Number: 3.4.10b



**Note: For Plan Notes see plate 3.4.12.
For Design Guidelines, see plate 3.4.11.**

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**TYPICAL SECTION CAST-IN-PLACE
REINFORCED CONCRETE
(LEVEL BACKFILL)**

Issue Date:	10/03
Revision Date:	3/09
Plate Number:	3.4.10c

DESIGN GUIDELINES:

- 1. The Proprietary Walls shall be designed, detailed, and constructed in accordance with the special provision "Retaining Wall (Site No._)".**
- 2. Proprietary walls shall not be designed for seismic forces.**
- 3. Wall height (H) for Mechanically Stabilized Earth Wall and Prefabricated Modular Wall sections shall be the same as for the Cast-in-Place Reinforced Concrete Wall type sections. Wall height (H) is equal to the distance measured from the bottom footing elevation to the finished grade.**
- 4. Pay limits for Mechanically Stabilized Earth Wall and Prefabricated Modular Wall sections shall be the same as for the Cast-in-Place Reinforced Concrete Wall Type section. The Designer shall determine all dimensions associated with the pay limits and show these dimensions on the plans. All horizontal pay limits are measured from the front face of the Cast-In-Place Concrete Wall.**
 - ⓑ Dimension shall be equal to 2'-0" plus the toe length.**
 - ⓐ Dimension ,as a minimum, shall be equal to (0.8)H plus 2'-0".**
- 5. If a Cast-in-place Reinforced Concrete wall alternate is not provided, the Engineer shall provide detailing and reinforcement of the parapet section above the gutter lines.**
- 6. Provide for surface drainage if necessary. Extent and details of ditch to be determined by the highway Engineer.**

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

DESIGN INFORMATION
FOR ALTERNATE WALLS

Issue Date: 10/03

Revision Date: 3/09

Plate Number:
3.4.11

PLAN NOTES:

1. The Contractor shall select, design, (for proprietary walls only) and construct one of the following wall options in accordance with the special provision "Retaining Wall (Site No. _)".

(List of appropriate wall manufacturers)

2. The maximum allowable bearing pressure = ()

3. VACANT

4. Temporary Earth Retaining System below pay limits and any tiebacks and bracing associated with same shall be included in the lump sum cost of the wall.

5. Details shown on this sheet are not specific. The Contractor's Designer shall modify each section for each specific site.

6. Light standard anchorages, junction boxes, and rigid metal conduit shall be included in the lump sum pay item "Retaining Wall (Site No. ____)".

7. The detailing and reinforcement of the parapet section above the gutter line shall be as shown for the Cast-In-Place Reinforced Concrete Wall section or as detailed elsewhere on the plans.

8. Reinforcing to have 2" cover except where shown otherwise.

9. All dimensions are specified with the applicable units of measurement.

10. Any additional pervious structure backfill required outside this limit shall also be included in the lump sum price.

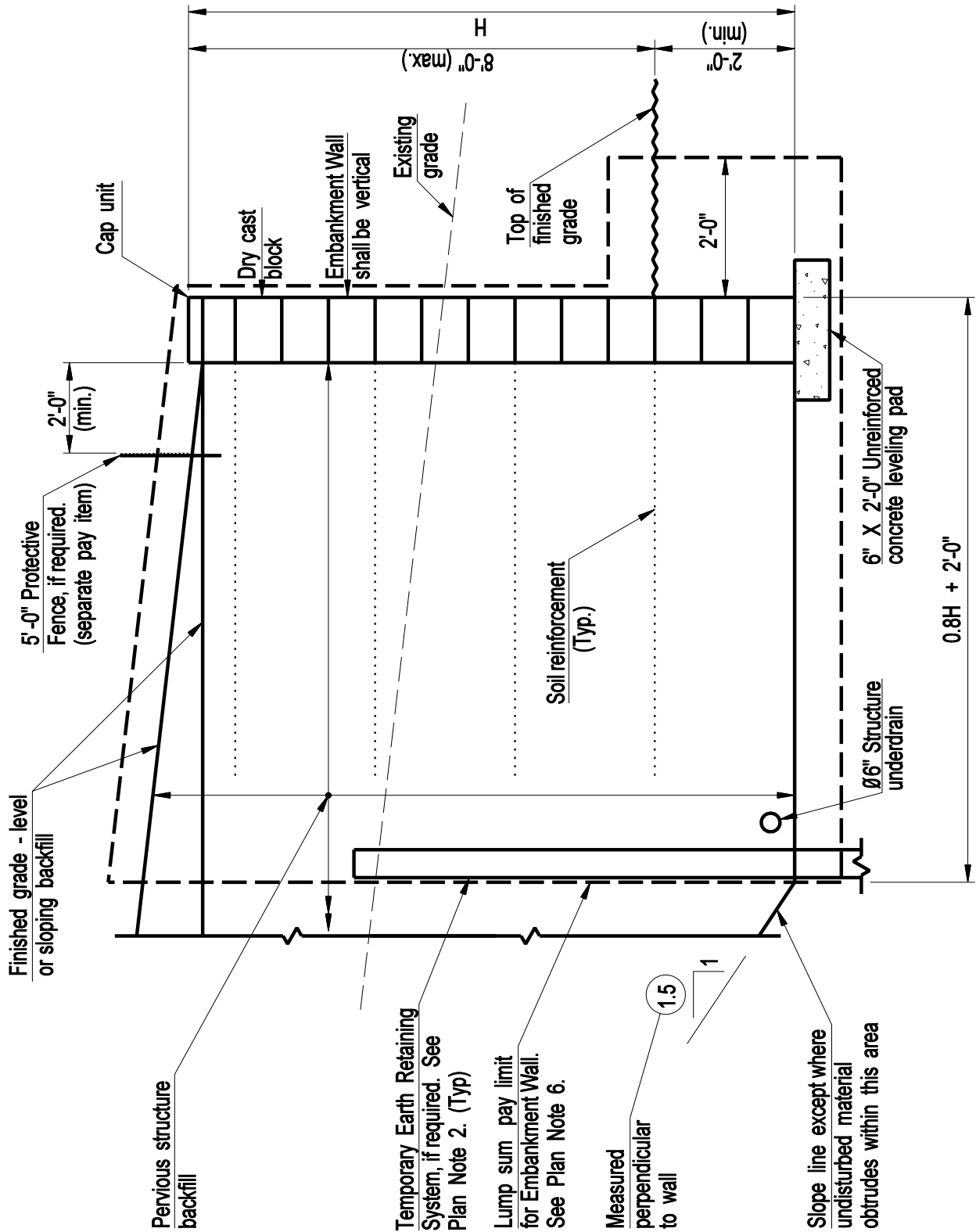
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**PLAN NOTES
FOR ALTERNATE WALLS**

Issue Date: 10/03

Revision Date: 3/09

Plate Number:
3.4.12



Note: For Plan Notes, see plate No. 3.4.14.

CONNECTICUT BRIDGE DESIGN MANUAL	TYPICAL SECTION EMBANKMENT WALL	Issue Date: 10/03
		Revision Date: 3/09
		Plate Number: 3.4.13

PLAN NOTES:

1. The Embankment Wall shall be designed, detailed and constructed in accordance with the special provision "Embankment Wall (Site No.)".
2. Temporary Earth Retaining System below pay limits and any tiebacks and bracing associated with the sheet piling shall be included in the lump sum cost of the wall.
3. Details shown on this sheet are not specific. The Contractor's Designer should modify the section for each specific site.
4. The Contractor shall select, design (for proprietary walls only) and construct one of the wall options as listed in the special provision "Embankment Wall (Site No.)".
5. The color of the dry cast block shall be ()
6. Any additional pervious structure backfill required outside this limit shall also be included in the lump sum price.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

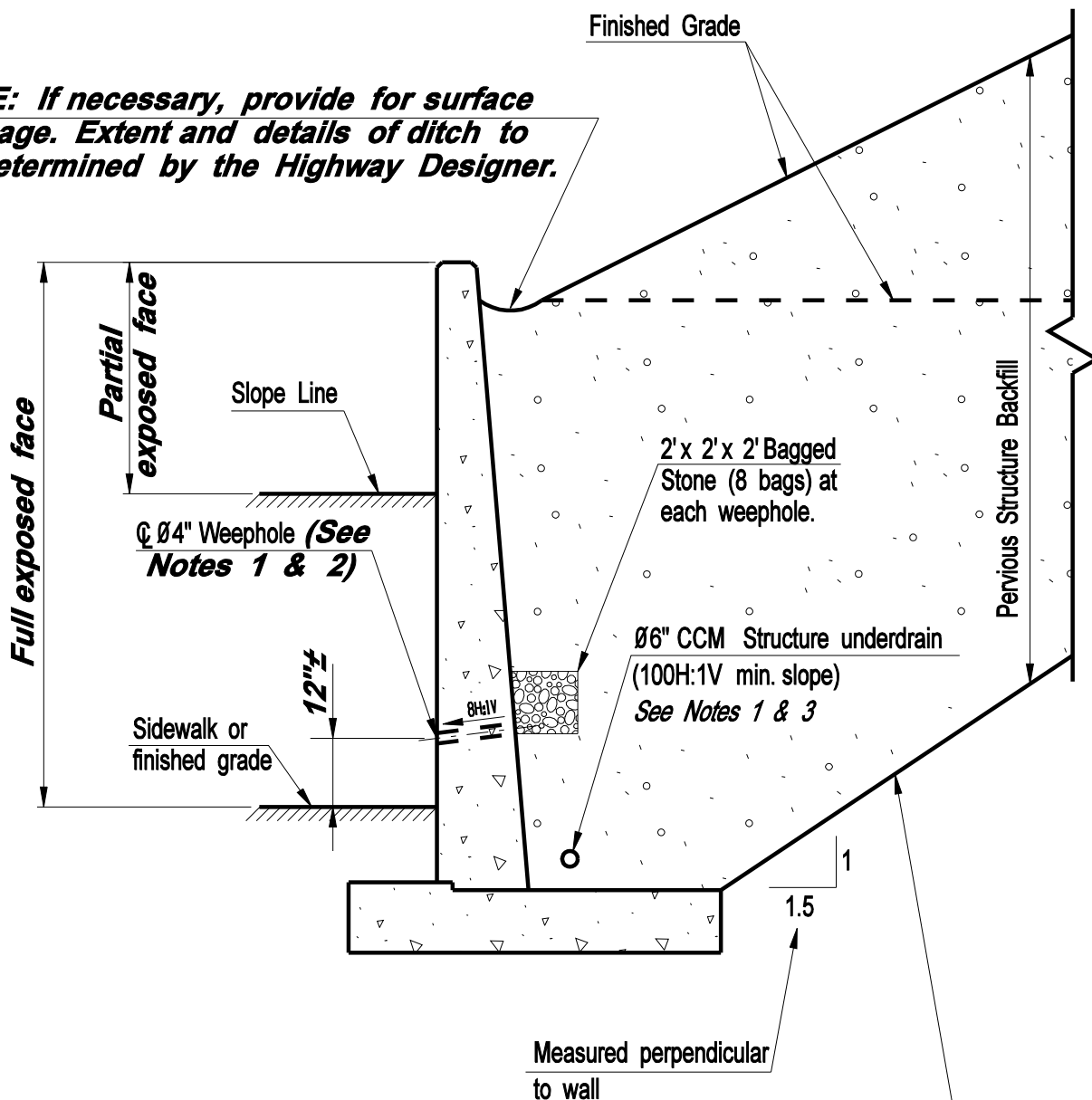
**PLAN NOTES
FOR EMBANKMENT WALLS**

Issue Date: 10/03

Revision Date: 3/09

Plate Number:
3.4.14

NOTE: If necessary, provide for surface drainage. Extent and details of ditch to be determined by the Highway Designer.



Slope line except where undisturbed material protrudes within this area.

DESIGN INFORMATION

1. Plan should show either 4" weephole or Ø6" structure underdrain. See Division 1.
2. Horizontal spacing and invert locations of weepholes shall be shown on the wingwall elevation views on the plans.
3. Ø6" CCM Structure Underdrain and Ø 6" CCM Outlet for Underdrain shall be included as Bridge Pay Items.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

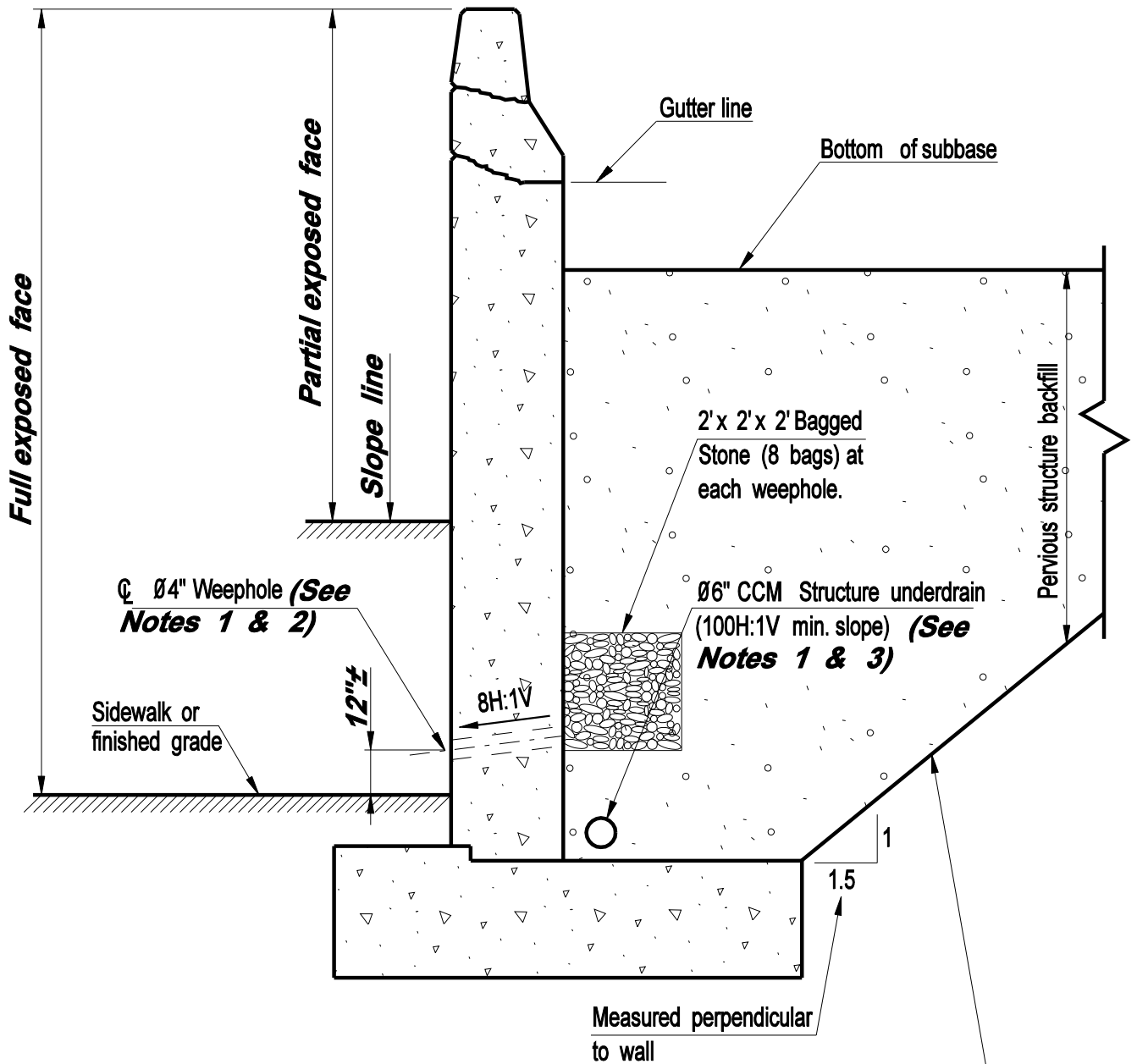
**FLARED WINGWALL OR RETAINING
WALL - DRAINAGE
AND BACKFILL REQUIREMENTS**

Issue Date: 10/03

Revision Date:

Plate Number:

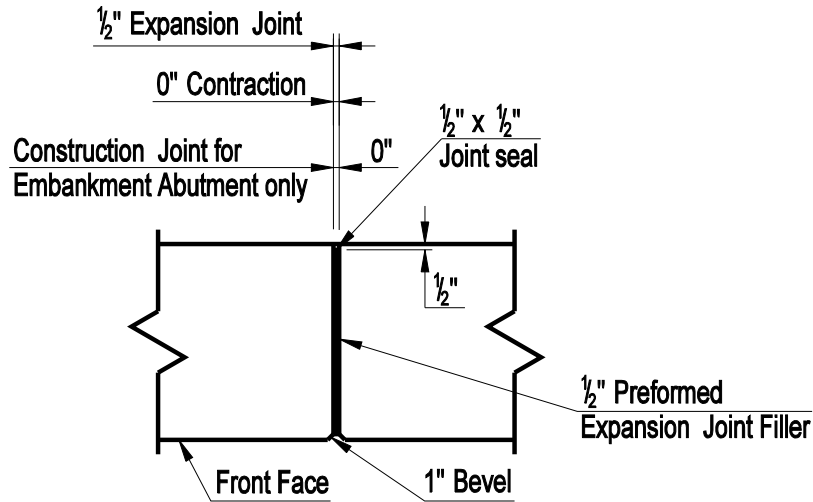
3.5.1



DESIGN INFORMATION

1. Plan should show either 4" weep hole or Ø6" structure underdrain. See Division I.
2. Horizontal spacing and invert locations of weep holes shall be shown on the wingwall elevation views on the plans.
3. Ø6" CCM Structure Underdrain and Ø 6" CCM Outlet for Underdrain shall be included as Bridge Pay Items.

Slope line except where undisturbed material obtrudes within this area



DESIGN INFORMATION:

1. Expansion joints shall be provided at intervals not exceeding 90'.
2. Contraction joints shall be provided at intervals not exceeding 30'.
3. All joints in abutments shall be located approximately midway between members.
4. At embankment abutments, contraction joints shall be changed to construction joints.

NOTES:

JOINTS: The Designer shall include the following notes as appropriate:

Joint seal to extend from top of footing to top of backwall and horizontally along top of backwall. (**Abutments**)

Joint seal to extend from top of footing to top of parapet and horizontally along this joint to outside face of parapet and horizontally along this joint to the outside face of wall. (**U - Type wings or Retaining walls with parapets**)

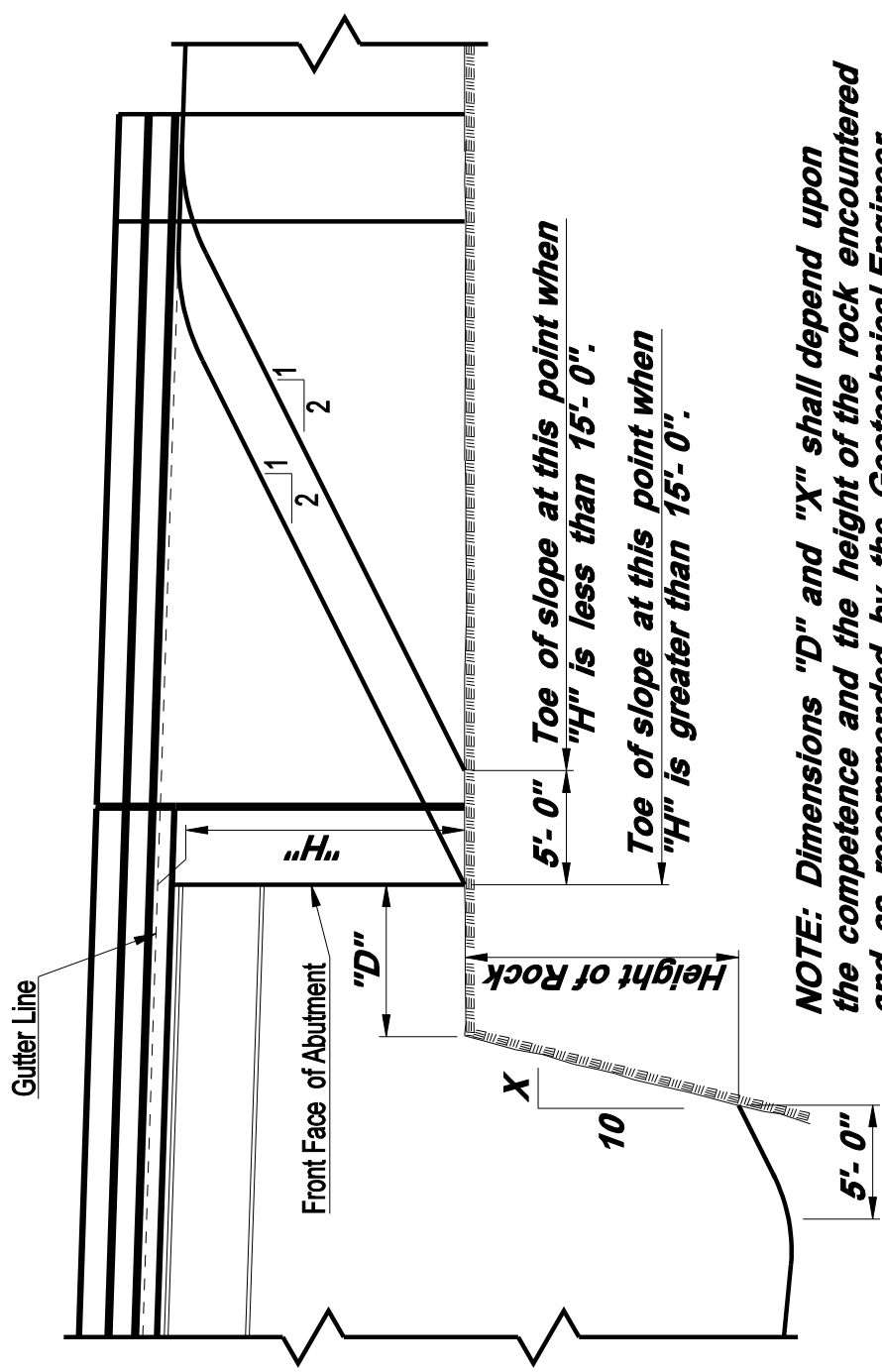
Joint seal to extend from top of footing to top of wall. (**Retaining Walls**)

Joint seal to extend from top of footing to top of wall. For the joints between the flared wings and superstructure, the joint seal shall extend from top of abutment backwall to top of wing. (**Flared wingwall**)

REINFORCEMENT:

No reinforcement shall pass through expansion or contraction joints.

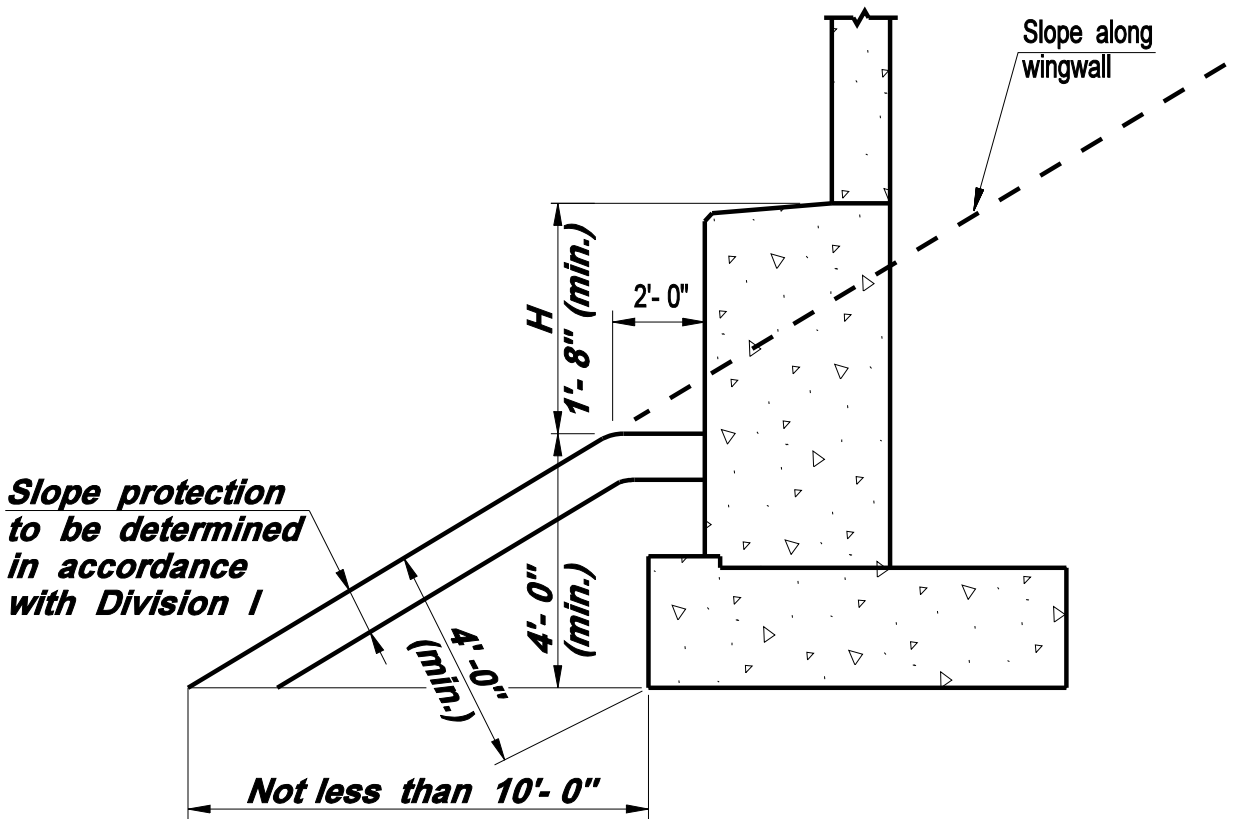
Reinforcement shall pass through construction joints.



5'-0" Toe of slope at this point when "H" is less than 15'-0".

Toe of slope at this point when "H" is greater than 15'-0".

NOTE: Dimensions "D" and "X" shall depend upon the competence and the height of the rock encountered and as recommended by the Geotechnical Engineer.



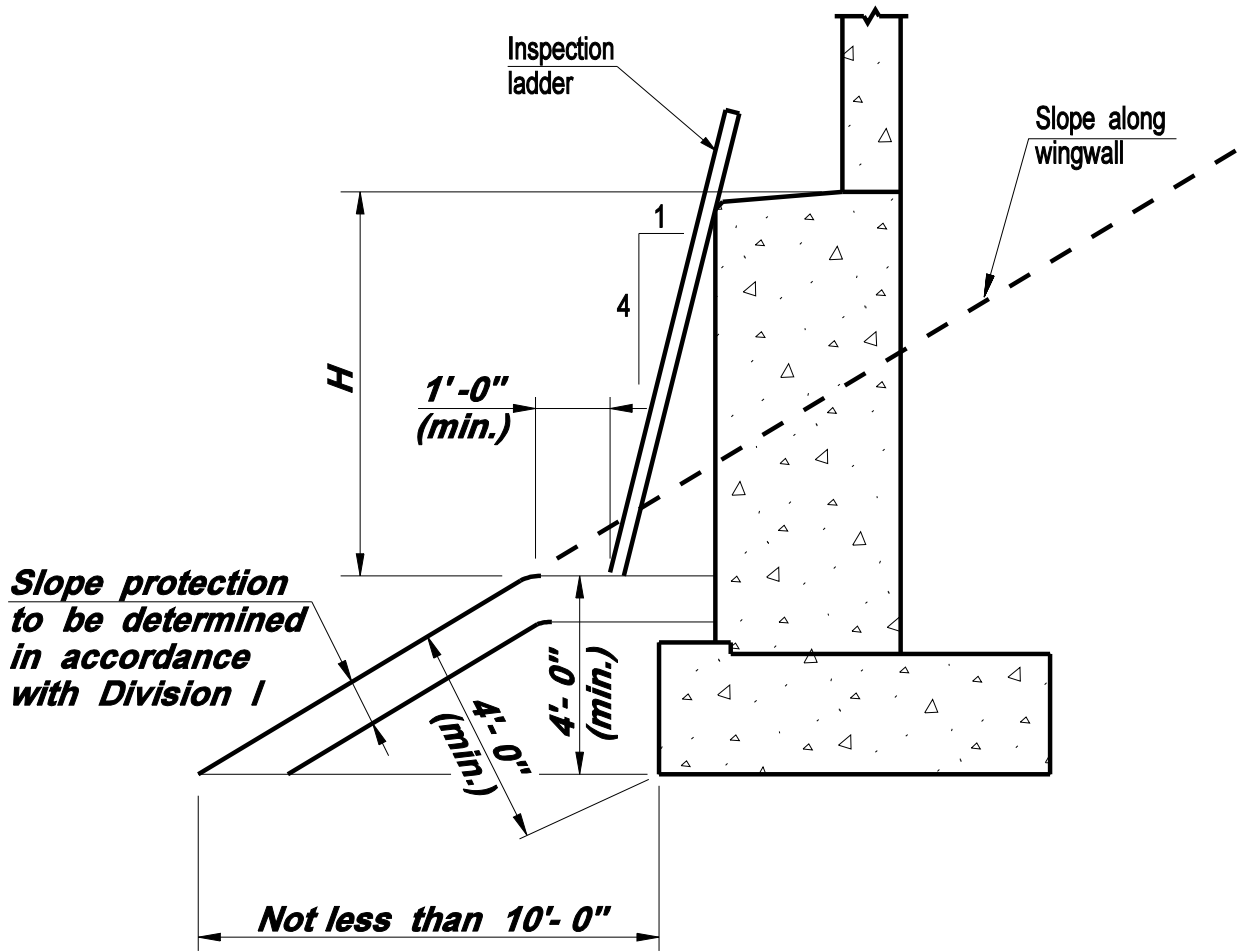
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

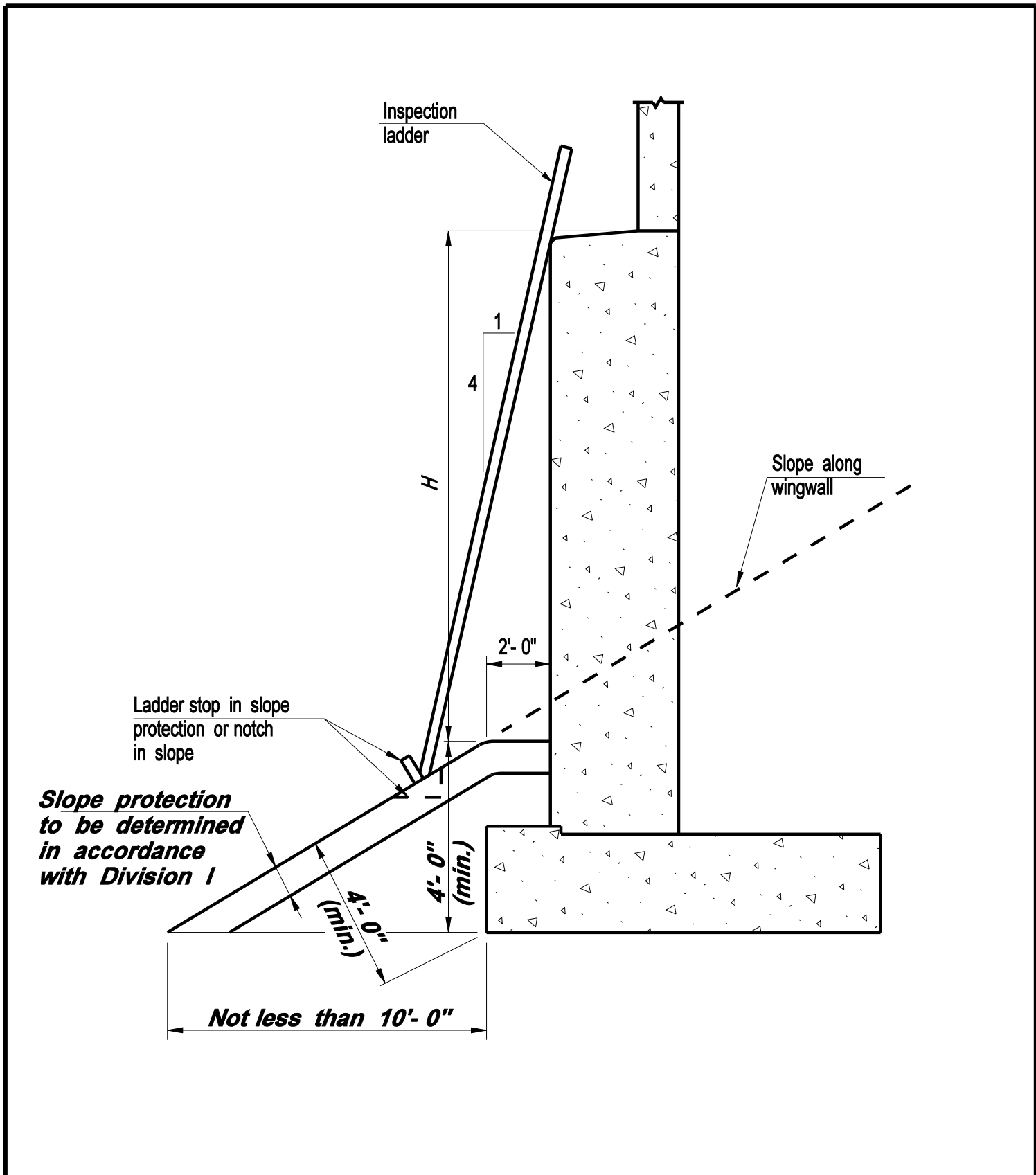
**TYPICAL EMBANKMENT
ABUTMENT NORMAL SECTION
($H \leq 5'-0''$)**

Issue Date: 10/03

Revision Date:

Plate Number:
3.6.3

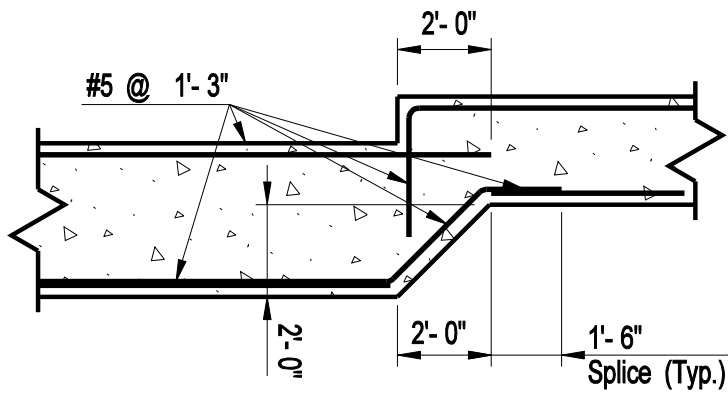




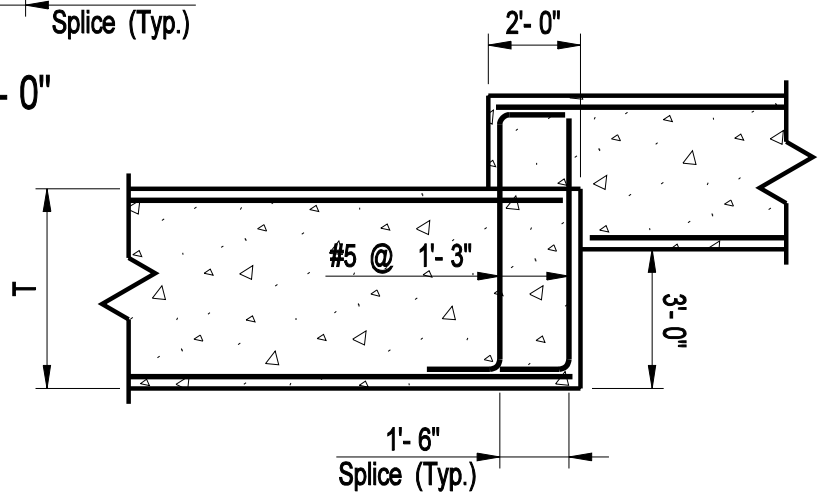
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**TYPICAL EMBANKMENT
ABUTMENT NORMAL SECTION
(H > 8'-0")**

Issue Date:	10/03
Revision Date:	
Plate Number:	3.6.5



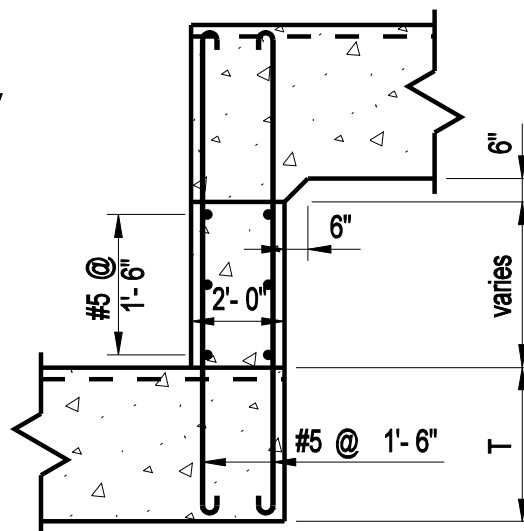
STEPPED FOOTING - 2'-0"



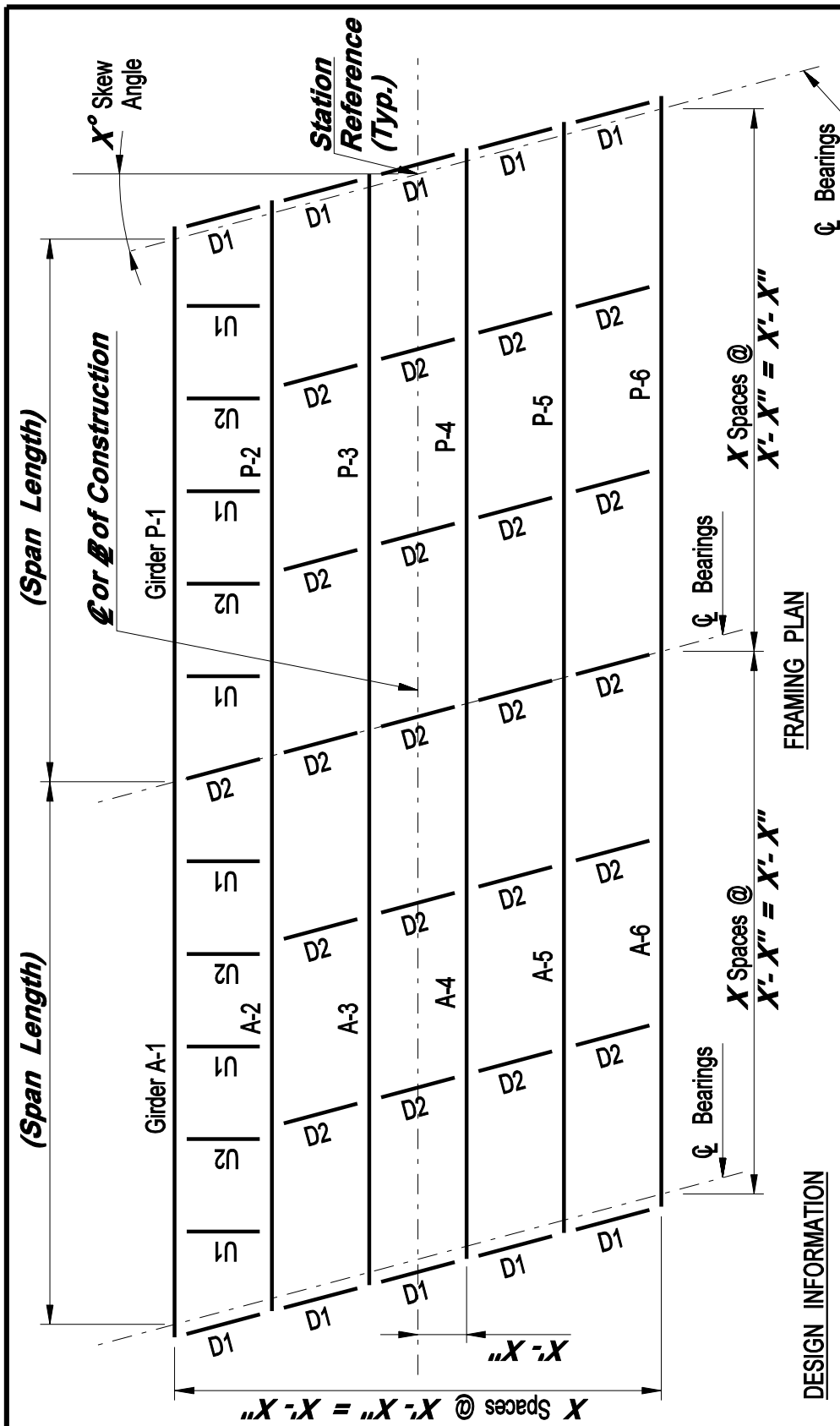
STEPPED FOOTING - 3'-0" to (T + 6")

DESIGN INFORMATION:

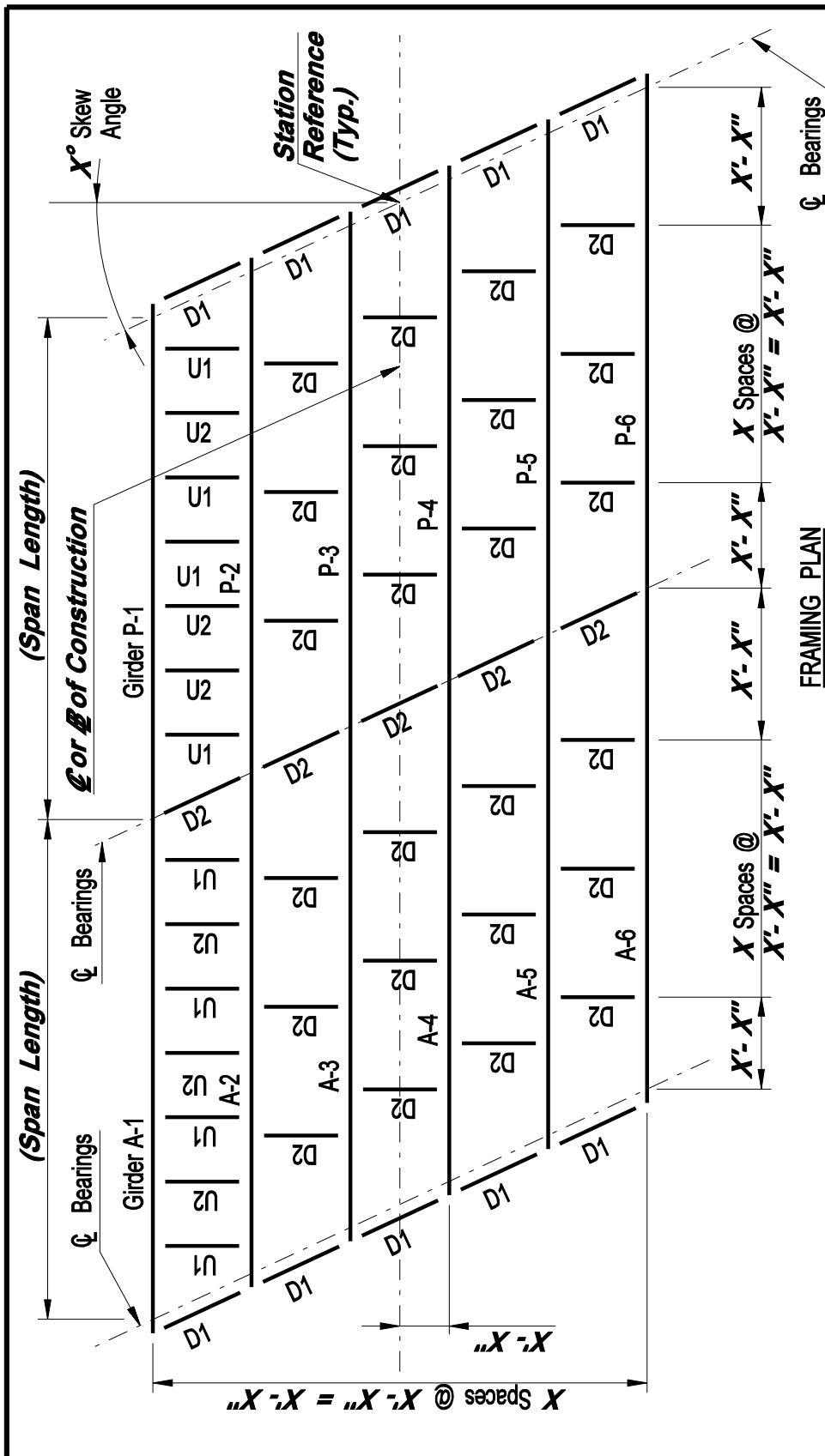
1. *The minimum step considered should be 2'-0".*
2. *Steps should be increased in 1'-0" increments.*



STEPPED FOOTING > (T + 6")



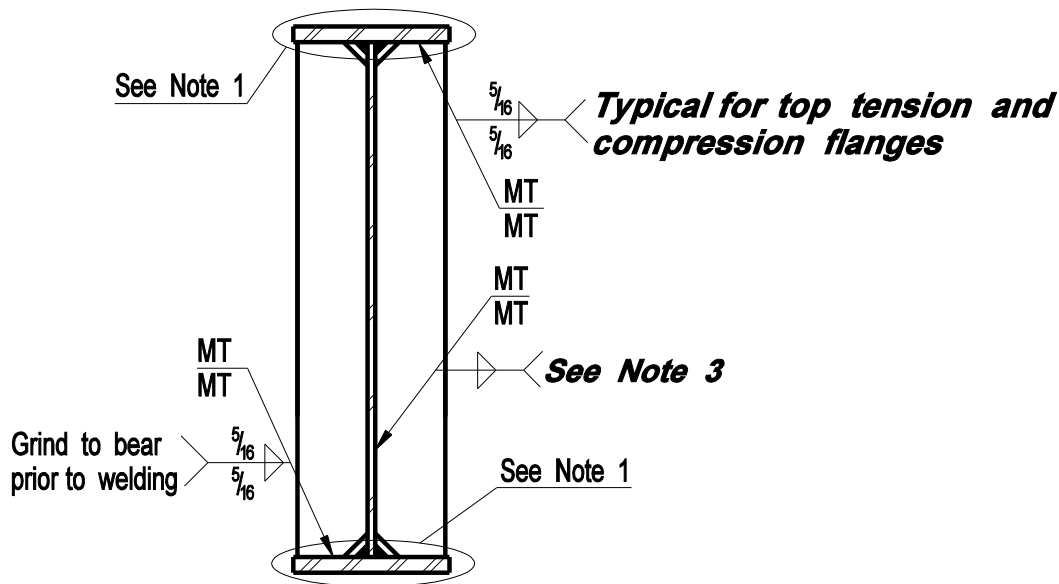
1. The framing plan shall be drawn full length without breaks and to scale on the plans. Include all relevant survey data and North arrow.
2. Continuous two-span bridge shown, simple and multiple continuous span bridges are similar.
3. Where utilities interfere with the typical end diaphragm, provide an alternative end diaphragm detail.



DESIGN INFORMATION

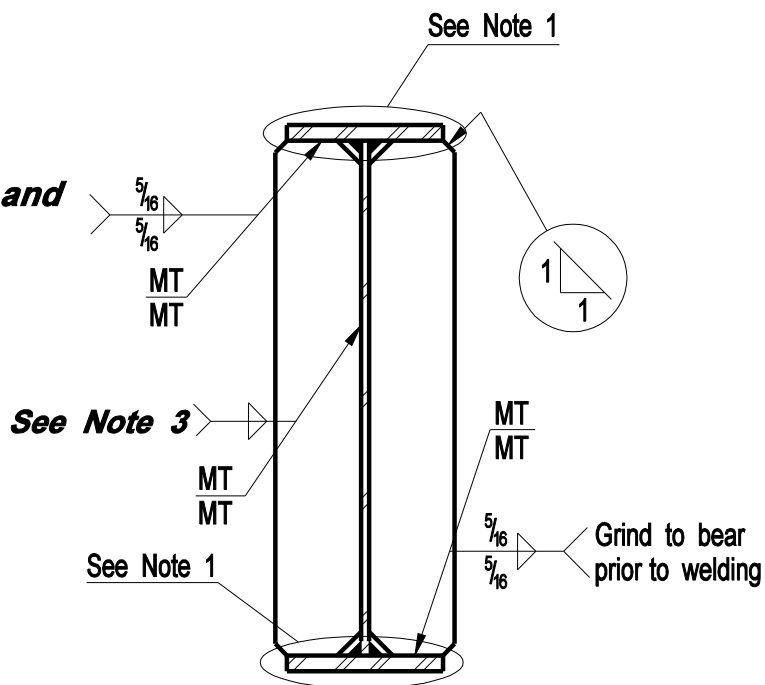
- D1 = End Bearing Diaphragm, see Plates 4.2.1 & 4.2.3
- D2 = Intermediate Diaphragm, see Plates 4.2.2 & 4.2.4
- U1 = Utility Support between diaphragms.
- U2 = Utility Support Diaphragm.

1. The framing plan shall be drawn full length without breaks and to scale on the plans. Include all relevant survey data and North arrow.
2. Continuous two-span bridge shown, simple and multiple continuous span bridges are similar.
3. Where utilities interfere with the typical end diaphragm, provide an alternative end diaphragm detail.



STIFFENERS NARROWER THAN FLANGE

Typical for top tension and compression flanges



STIFFENERS WIDER THAN FLANGE

NOTES:

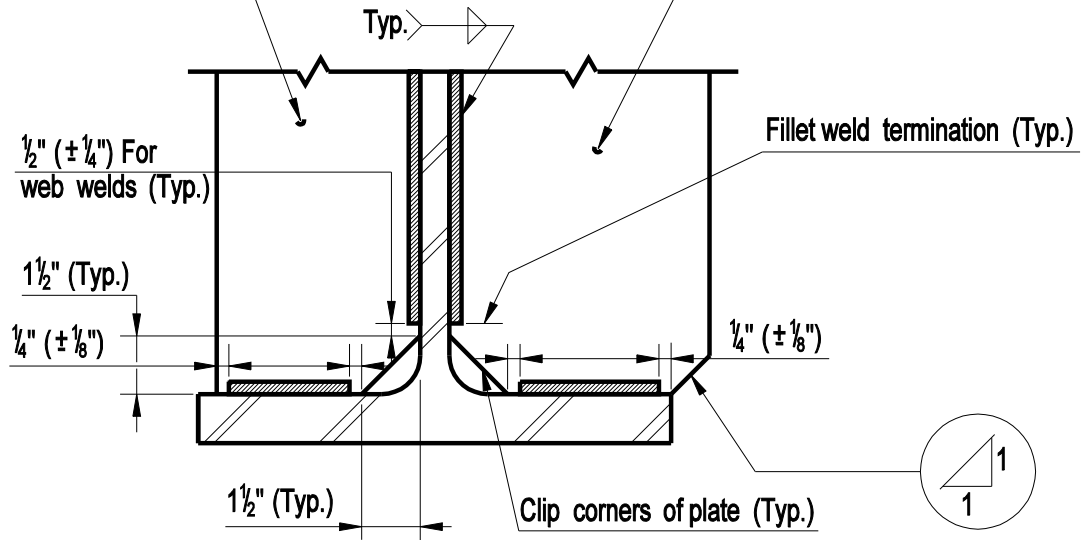
1. For clip and weld termination details, see Plate No. 4.2.2
2. For additional bearing stiffener details, see Plate No. 4.2.5

DESIGN INFORMATION

3. Weld shall be designed, see Division I, Section 7

Plate narrower than flange

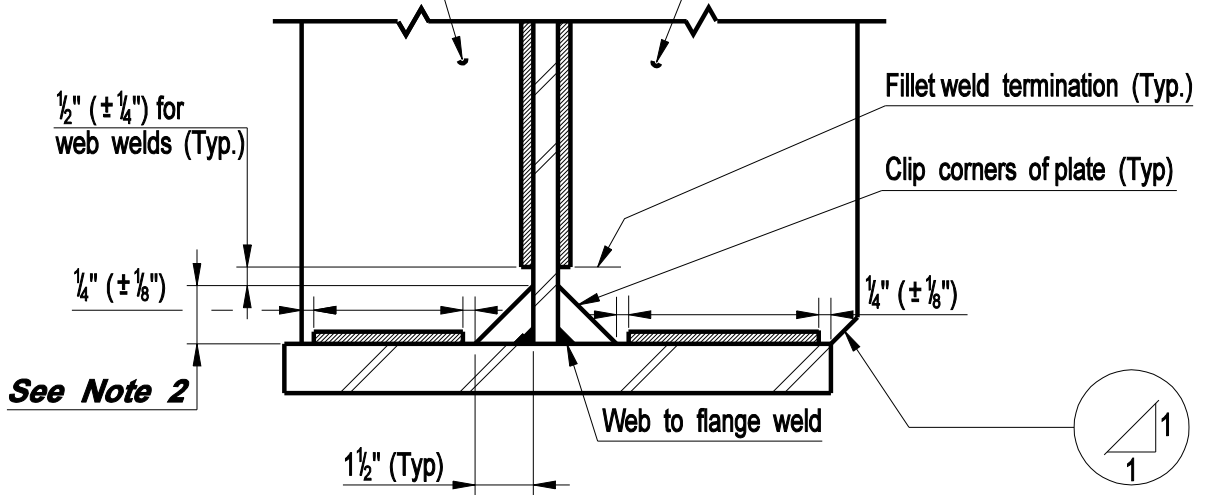
Plate wider than flange



TYPICAL SECTION - ROLLED BEAMS

Plate narrower than flange

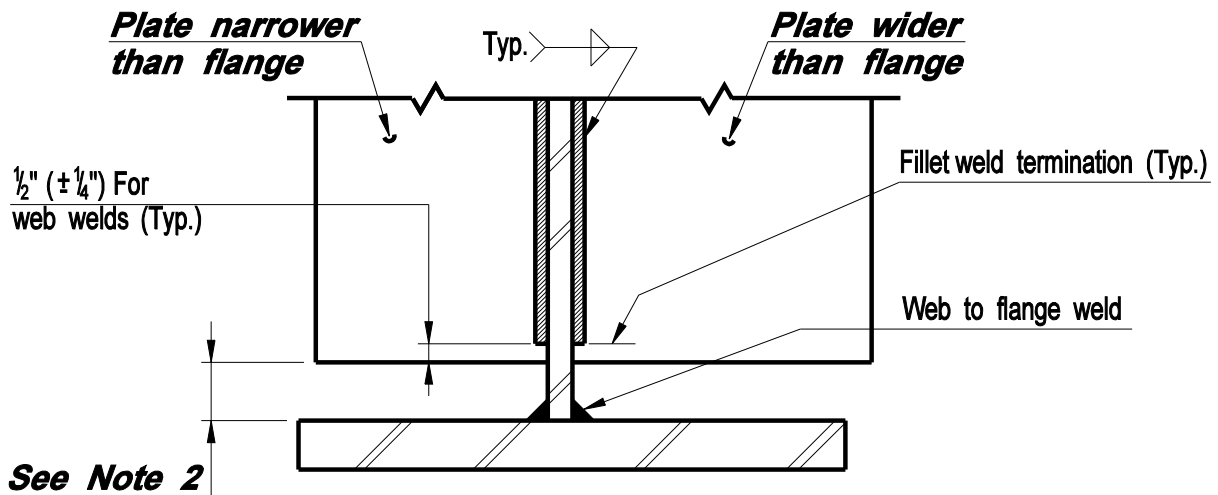
Plate wider than flange



TYPICAL SECTION - PLATE GIRDERS

NOTES:

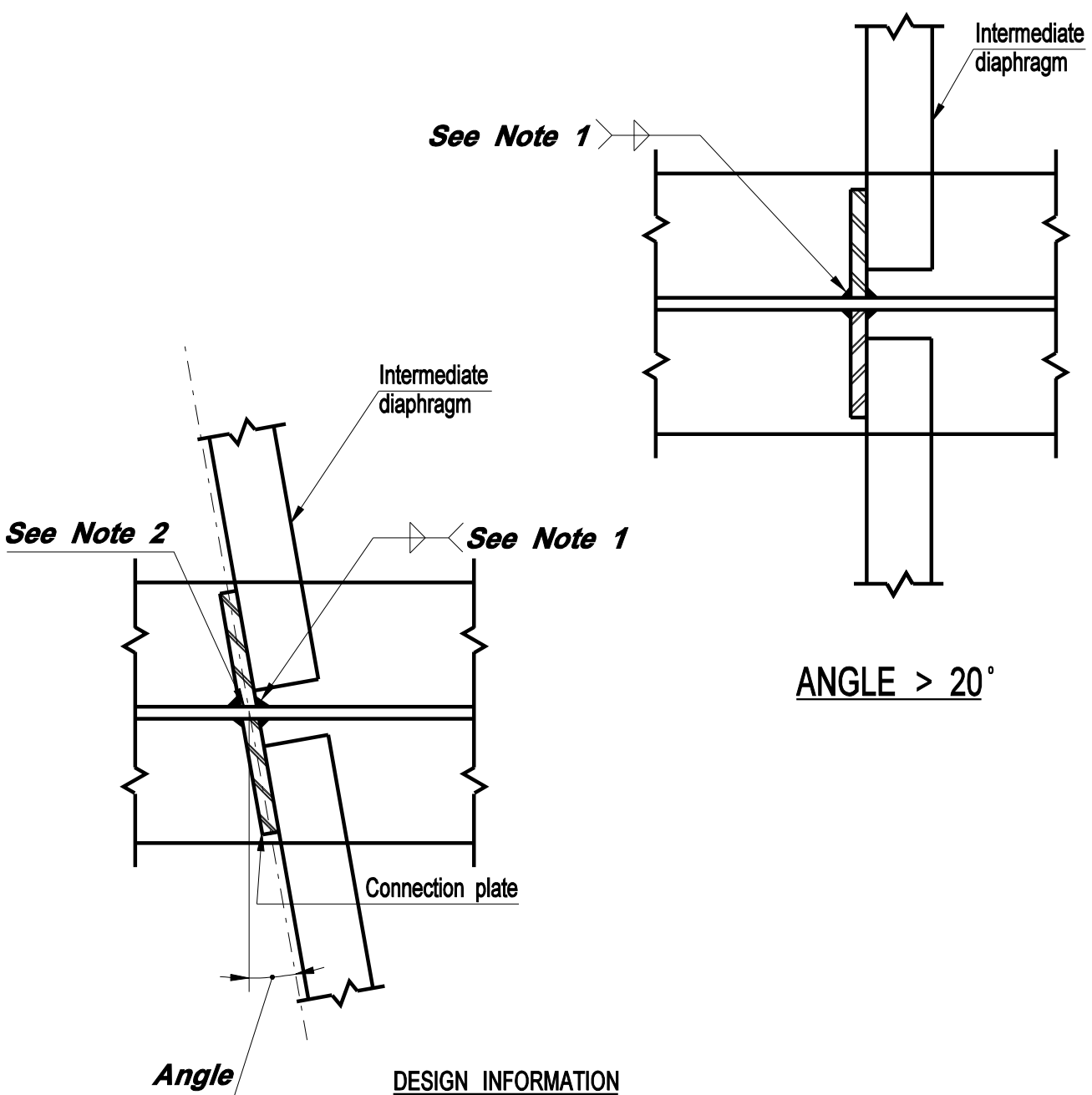
- 1. Details are shown for bottom flange, top flange is similar.
- 2. Designer shall determine this dimension.



TYPICAL SECTION - PLATE GIRDERS

DESIGN INFORMATION:

- 1. Details are shown for bottom flange, top flange is similar.**
- 2. Design shall determine this dimension.**

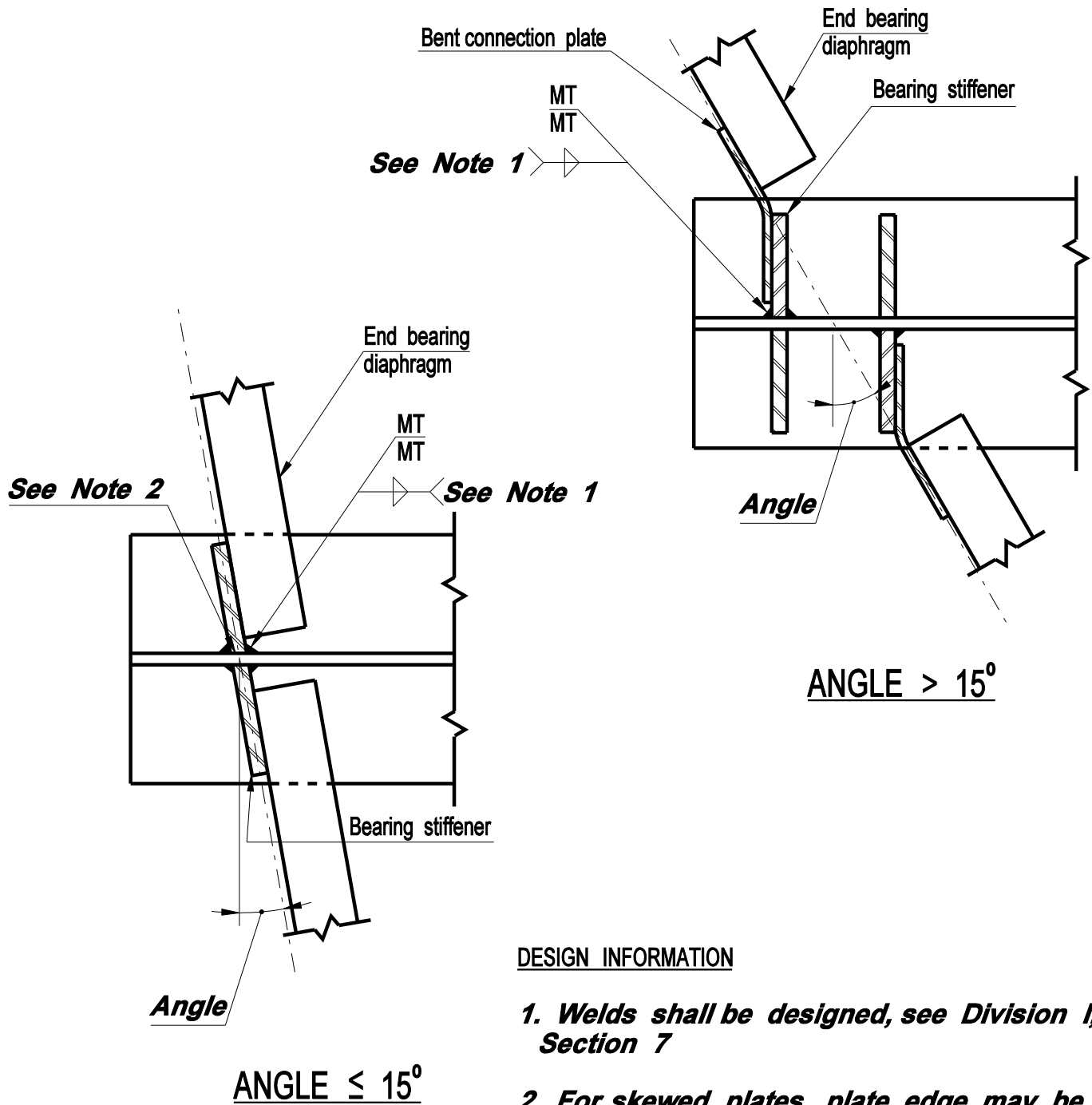


Angle

ANGLE ≤ 20°

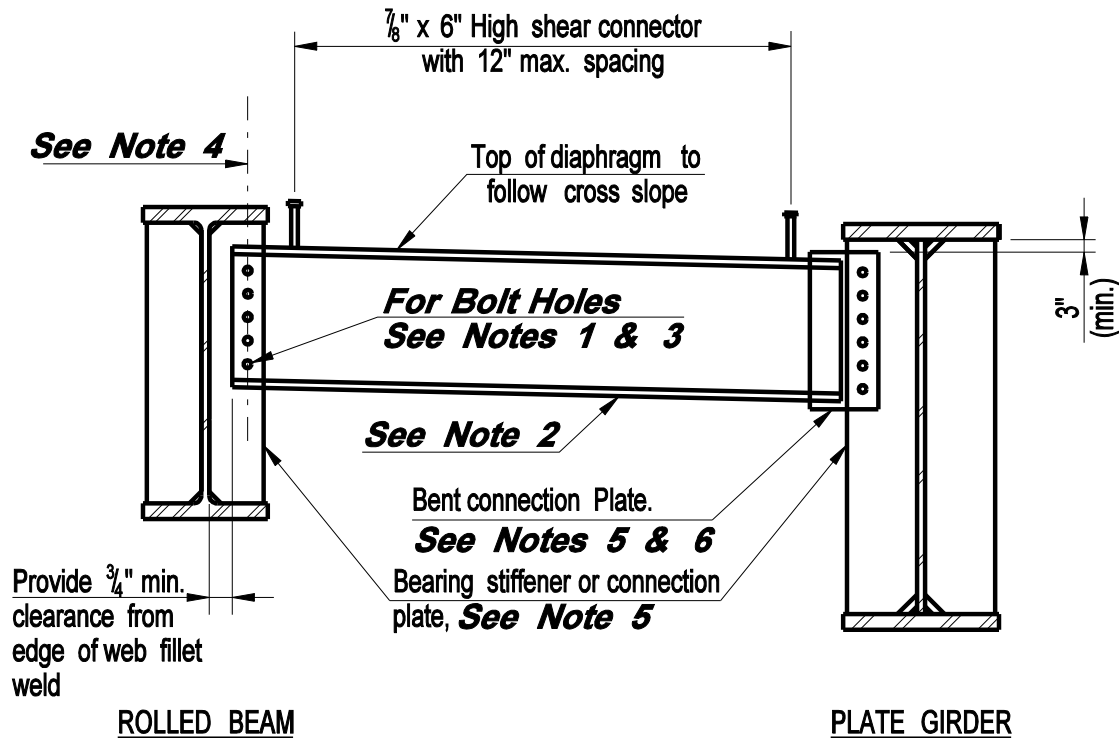
DESIGN INFORMATION

1. Welds shall be designed, see Division I, Section 7
2. For skewed plates, plate edge may be beveled or square.



DESIGN INFORMATION

1. Welds shall be designed, see Division I, Section 7
2. For skewed plates, plate edge may be beveled or square.

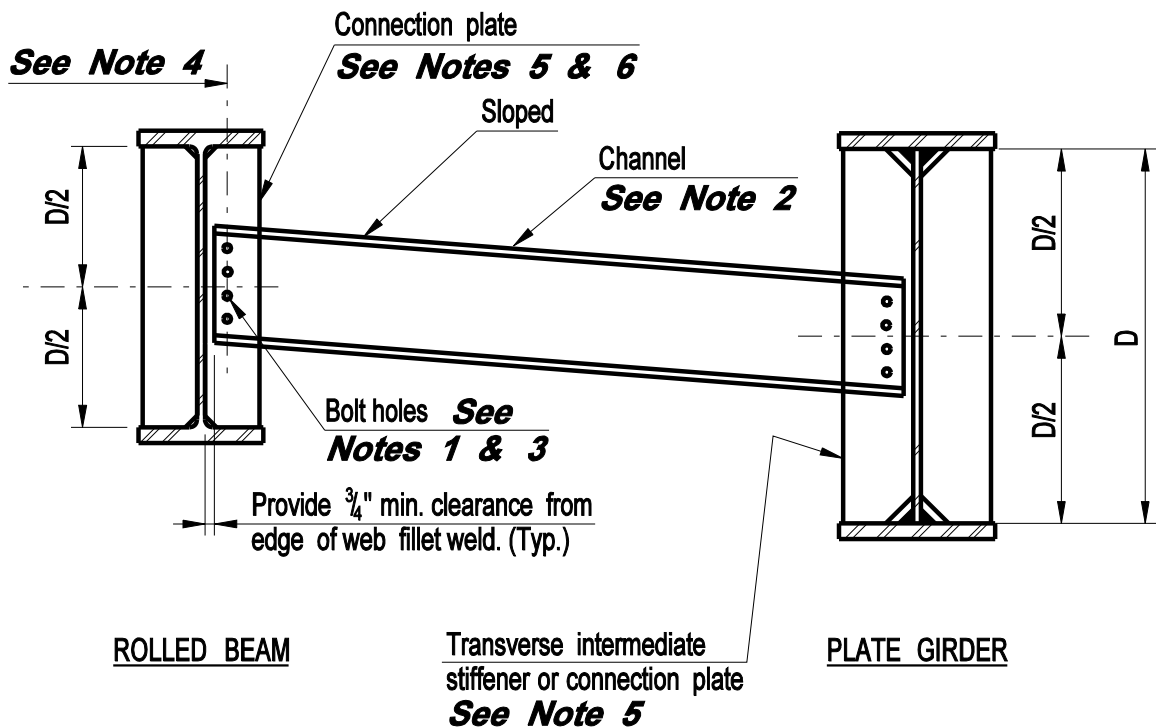


NOTES:

1. Bolt holes in channels shall be $\varnothing \frac{15}{16}$ " (standard) for $\varnothing \frac{7}{8}$ " bolts. Bolt holes in connection or stiffener plates shall be $\varnothing 1 \frac{1}{16}$ " (oversized).

DESIGN INFORMATION

2. Channel members shall be used for "I" shaped members. Size as determined by designer. C15 x 33.9 minimum.
3. Number of bolts shall be determined by the designer.
4. Centerline of bolt holes shall be vertical.
5. For connection and stiffener plate details, see Plate Nos. 4.2.1, 4.2.2 and 4.2.5.
6. Bent connection plate to be used for rolled beams or plate girders where skew angle $> 15^\circ$. See Plate 4.2.5.



Member Depth *	Diaphragm	H.S. Bolts
33" - 48"	MC18 x 42.7	10
27" - 30"	C15 x 33.9	8
21" - 24"	C12 x 20.7	6

* See Note 7

NOTES:

1. Bolt holes in channels shall be $\varnothing \frac{15}{16}$ " (standard) for $\varnothing \frac{7}{8}$ " bolts. Bolt holes in connection or stiffener plates shall be $\varnothing 1 \frac{1}{16}$ " (oversized).

DESIGN INFORMATION

2. Channel members shall be used for "I" shaped members.
3. Number of bolts shall be determined by the designer.
4. Centerline of bolt holes shall be vertical.
5. For connection and stiffener plate details, see Plates 4.2.2 - 4.2.4.
6. Connection plates shall be placed on skew for skew angle $< 20^\circ$.
7. Member depth is nominal depth for rolled beams, actual web depth for plate girders.

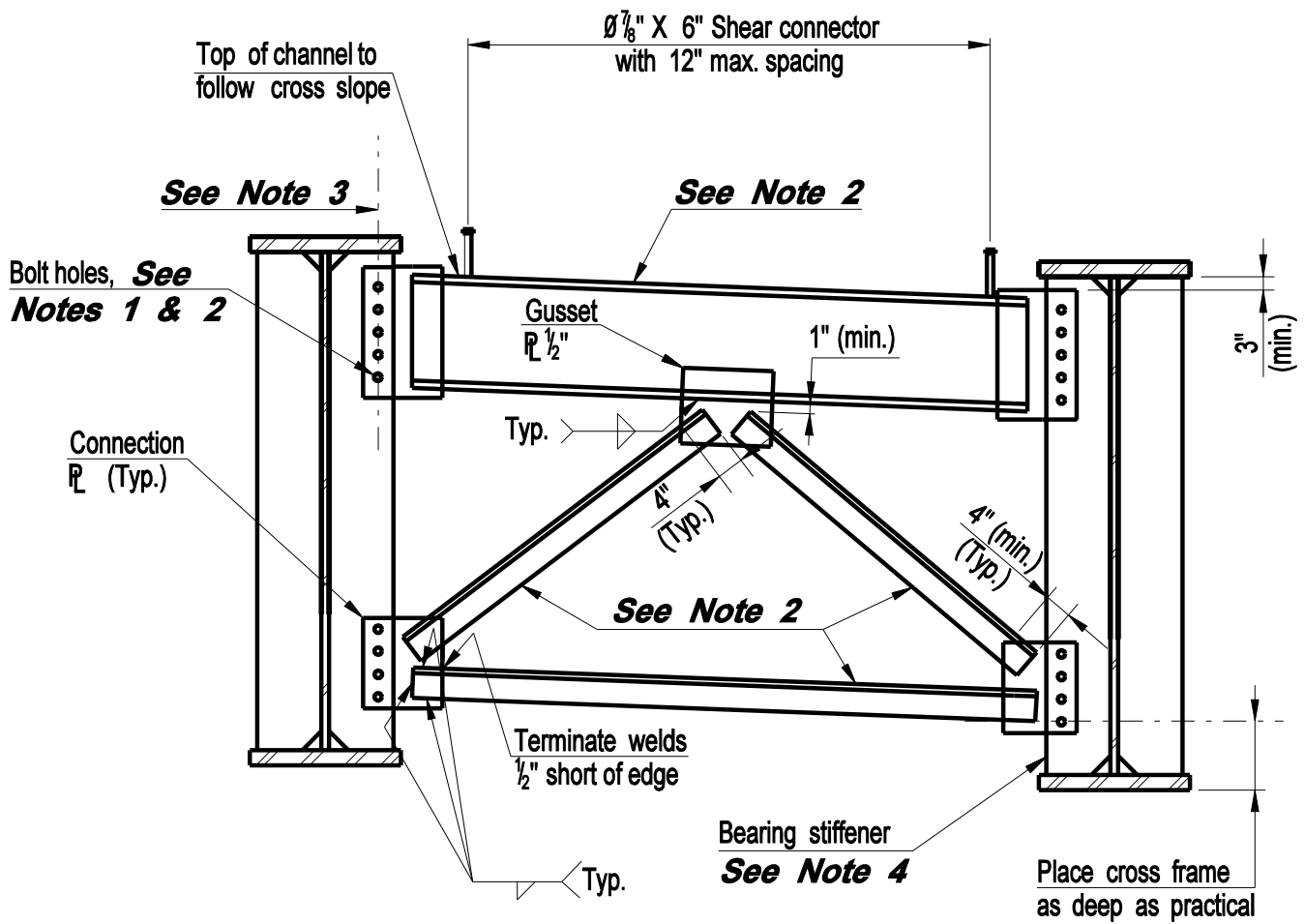
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

INTERMEDIATE DIAPHRAGM
WEB DEPTH $\leq 4'-0"$

Issue Date: 10/03

Revision Date: 01/05

Plate Number:
4.3.2

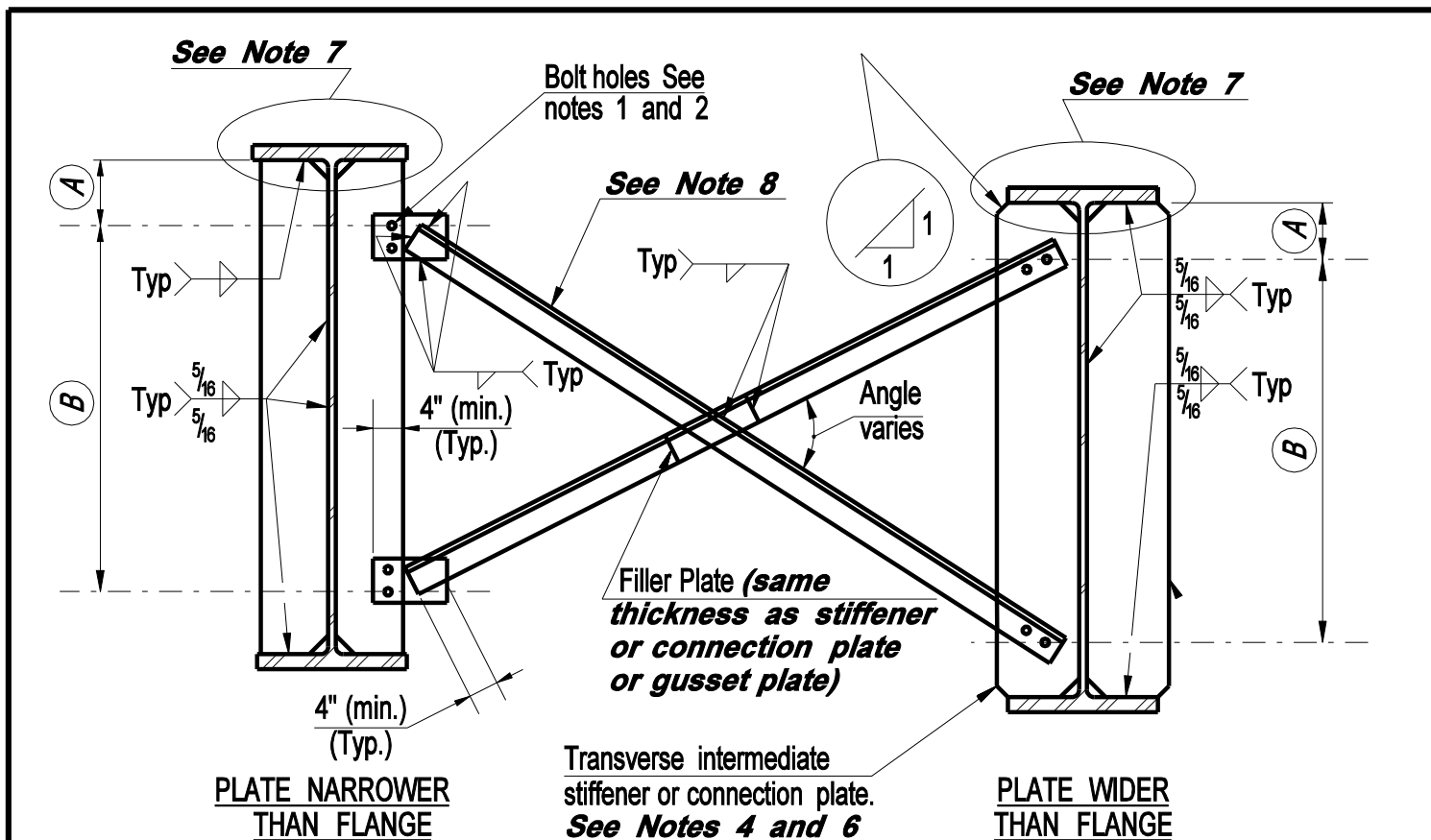


NOTES:

1. Bolt holes in channels shall be $\varnothing 15/16$ " (standard) for $\varnothing 7/8$ " bolts.
Bolt holes in bearing stiffener shall be $\varnothing 1 1/16$ " (oversized).

DESIGN INFORMATION

2. Channel and angle sizes along with the number of bolts shall be determined by the designer. Minimum angle size shall be L4" x 4" x 5/16".
3. Centerline of bolt holes shall be vertical.
4. For bearing stiffener details, see Plate Nos. 4.2.1, 4.2.2 and 4.2.5.



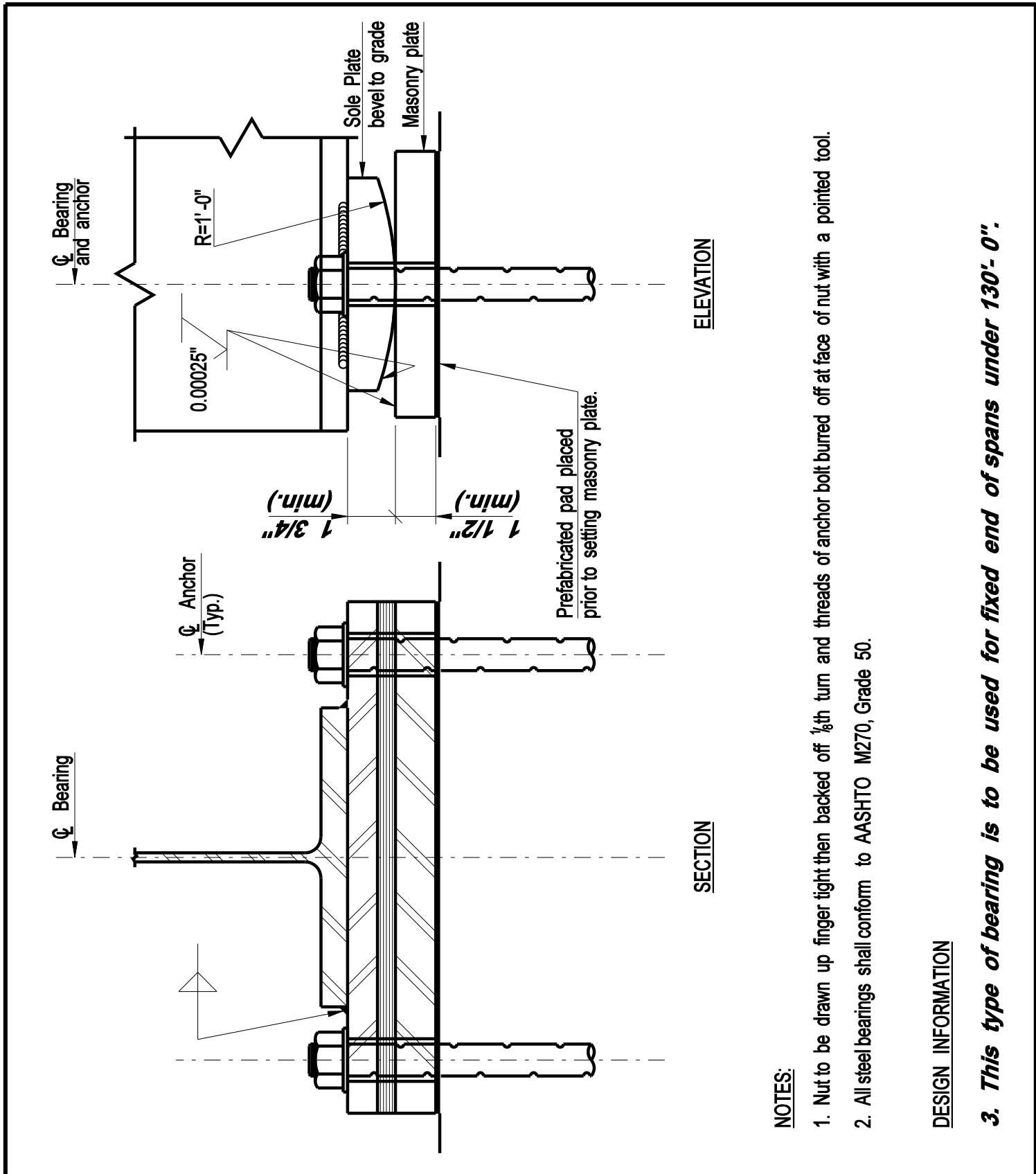
NOTES:

1. Bolt holes in angles and gusset plates shall be $\varnothing 1\frac{5}{16}$ " (standard) for $\varnothing 7/8$ " bolts. Bolt holes in transverse intermediate stiffener or connection plates shall be $\varnothing 1\frac{1}{16}$ " (oversized).
2. Two bolts per connection shall be used.
3. Gusset plates shall be square or rectangular.

DESIGN INFORMATION

4. Designer may detail narrower stiffeners or connection plates with gusset plates, wider stiffeners or connection plates with angles connected directly thereto.
5. Dimensions A and B shall be the same for each girder. Cross frames shall be as deep as practical
6. For connection and stiffener plate details, see Plate Nos. 4.2.2, and 4.2.4.
7. For clip and weld termination details, see Plate No. 4.2.2.
8. Angles to be sized by designer.

CONNECTICUT BRIDGE DESIGN MANUAL	INTERMEDIATE CROSS FRAME WEB DEPTH > 4'- 0"	Issue Date: 10/03
		Revision Date:
		Plate Number: 4.3.4



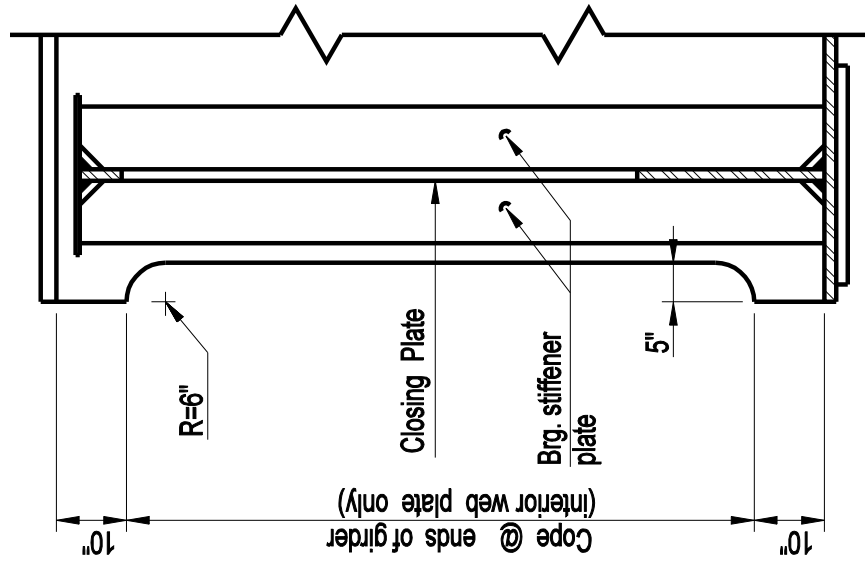
NOTES:

1. Nut to be drawn up finger tight then backed off $\frac{1}{8}$ th turn and threads of anchor bolt burred off at face of nut with a pointed tool.
2. All steel bearings shall conform to AASHTO M270, Grade 50.

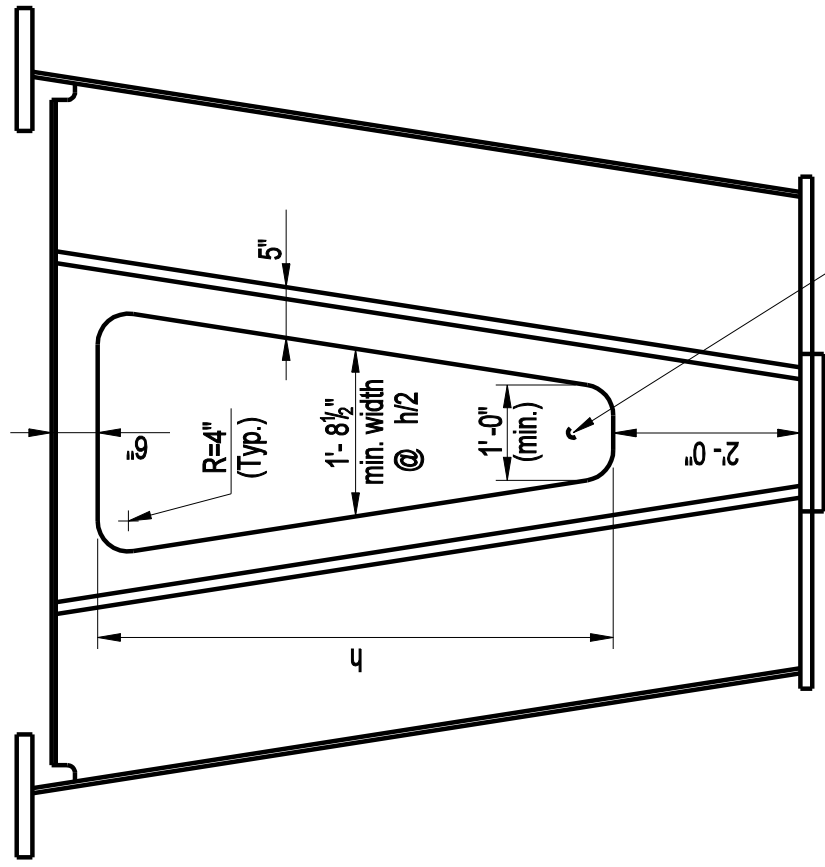
DESIGN INFORMATION

3. This type of bearing is to be used for fixed end of spans under 130'- 0".

Issue Date:	10/03
Revision Date:	
Plate Number:	4.4.1



SECTION A



Wire mesh closure,
see Plate 4.5.1b.

END ELEVATION

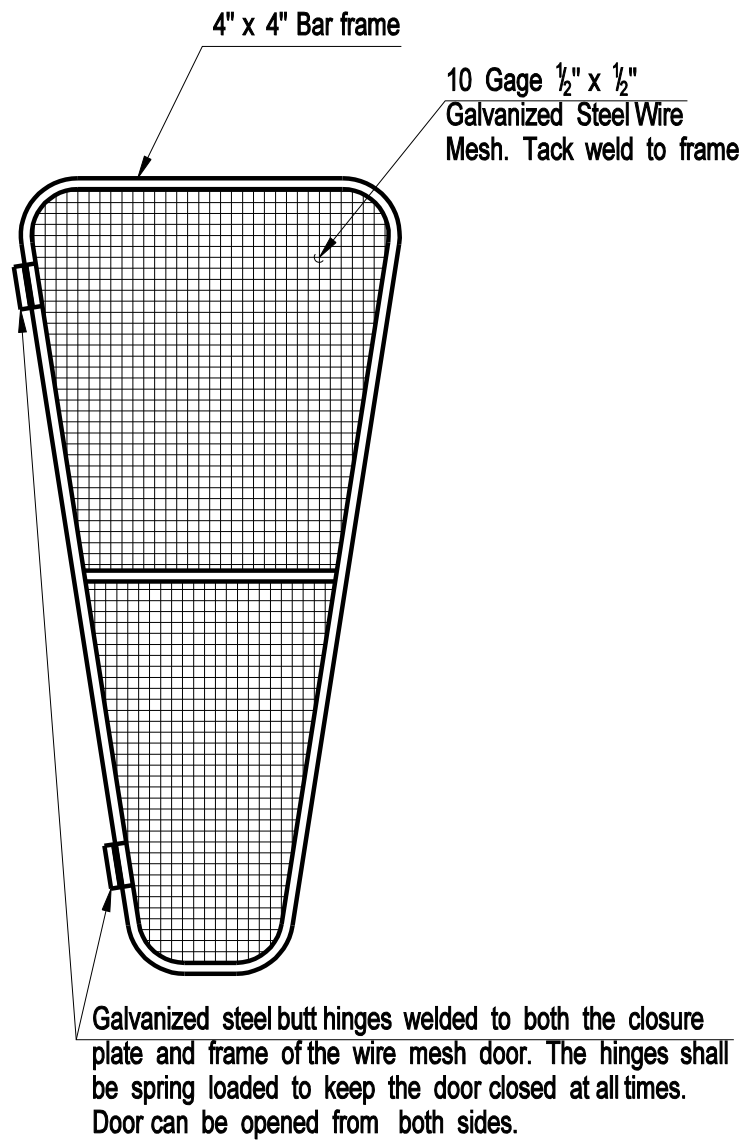
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

STEEL BOX GIRDER END DIAPHRAGM
ACCESS DETAILS

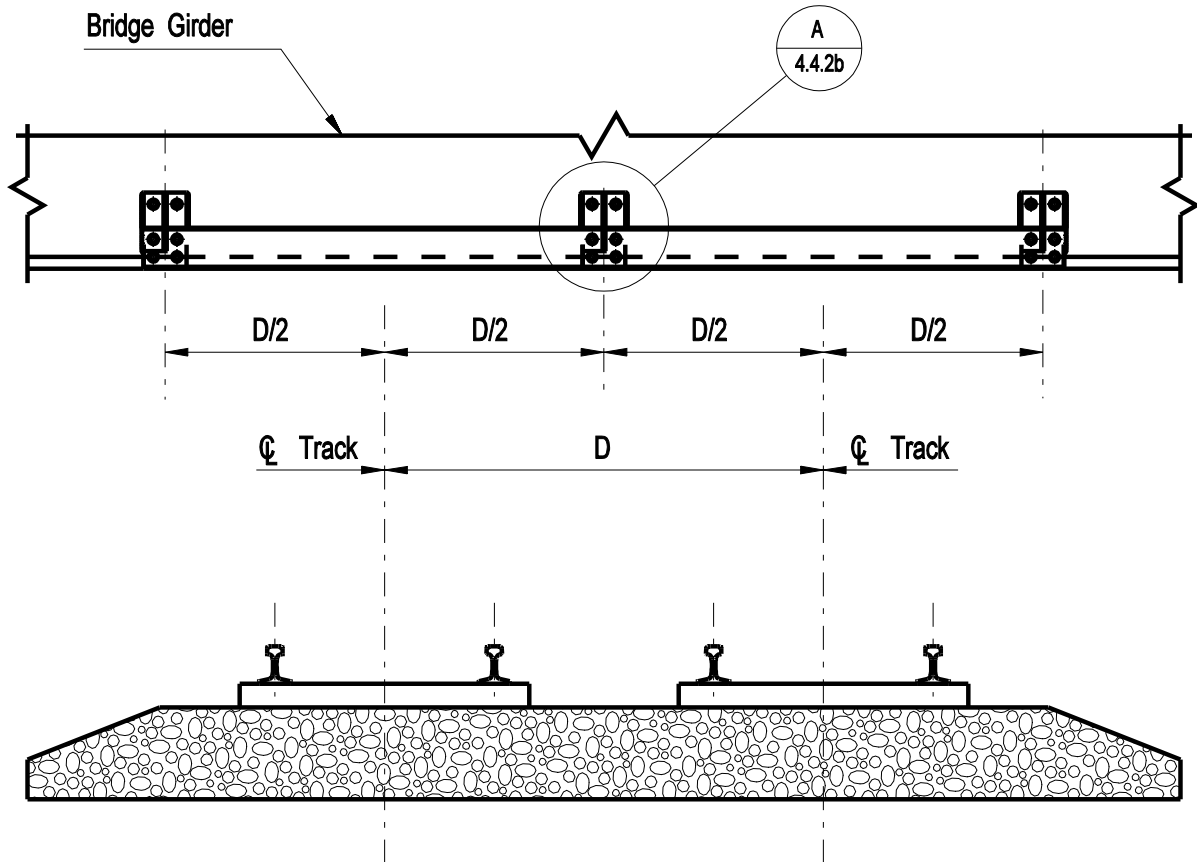
Issue Date: 10/03

Revision Date:

Plate Number:
4.5.1a



WIRE MESH CLOSURE



DESIGN INFORMATION

- 1. The information shown should be used only as a guide and must be reviewed by the Railroad prior to its use.**
- 2. The bottom elevation of the channel is to be at the same elevation as the bottom of the girder.**
- 3. All steel shall be ASTM A709 Grade 50 unless the bridge is to be made of weathering steel. In this case all steel shall be ASTM A709 Grade 50W.**
- 4. All bolts used with ASTM A709 Grade 50 steel shall be $\frac{7}{8}$ " ASTM A325. Bolts used with ASTM A709 Grade 50W steel shall be $\frac{7}{8}$ " ASTM A325 Type 3.**

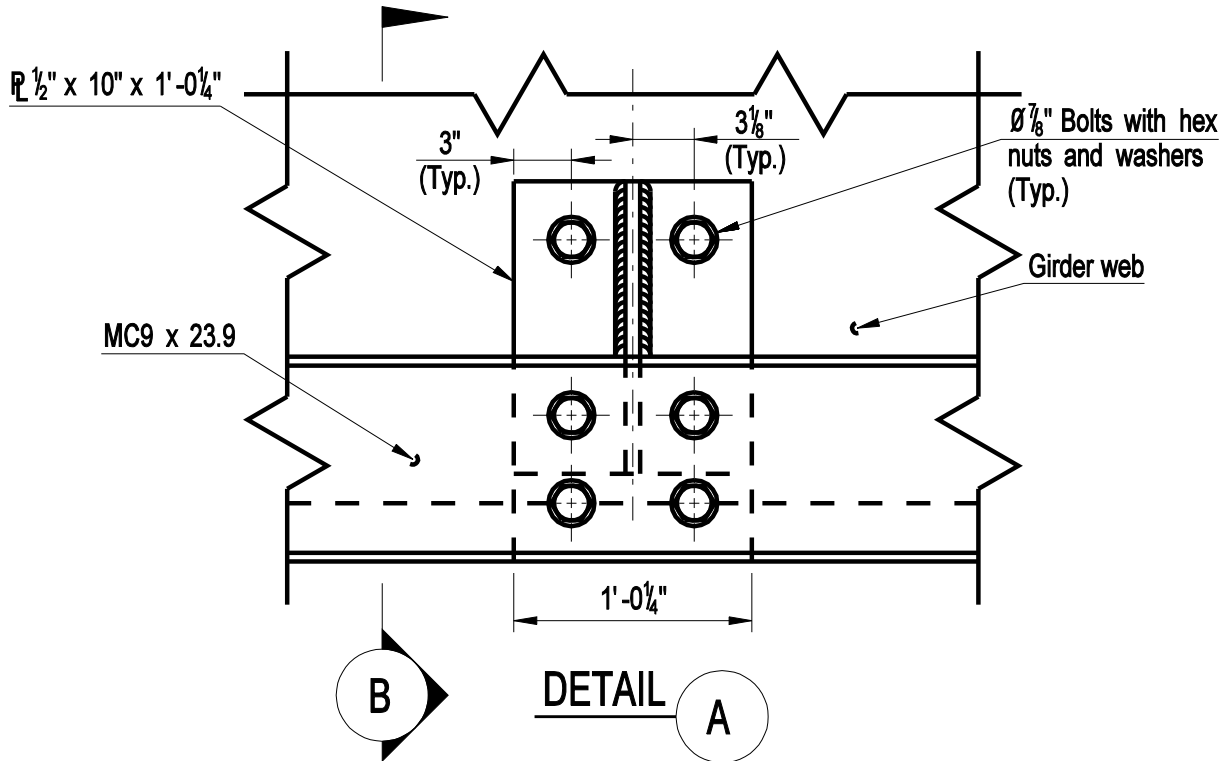
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**CATENARY CONNECTION
DETAIL FOR BRIDGES
OVER ELECTRIFIED RAILROADS**

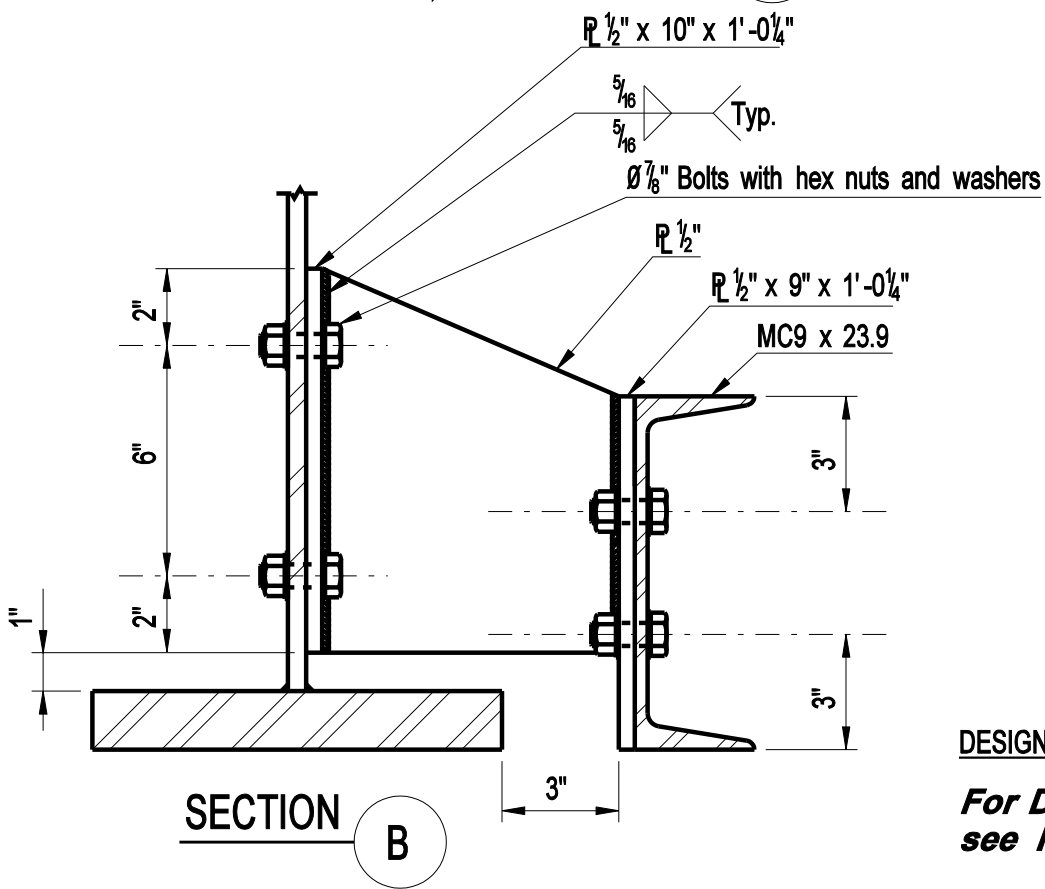
Issue Date: 10/03

Revision Date:

Plate Number:
4.5.2a



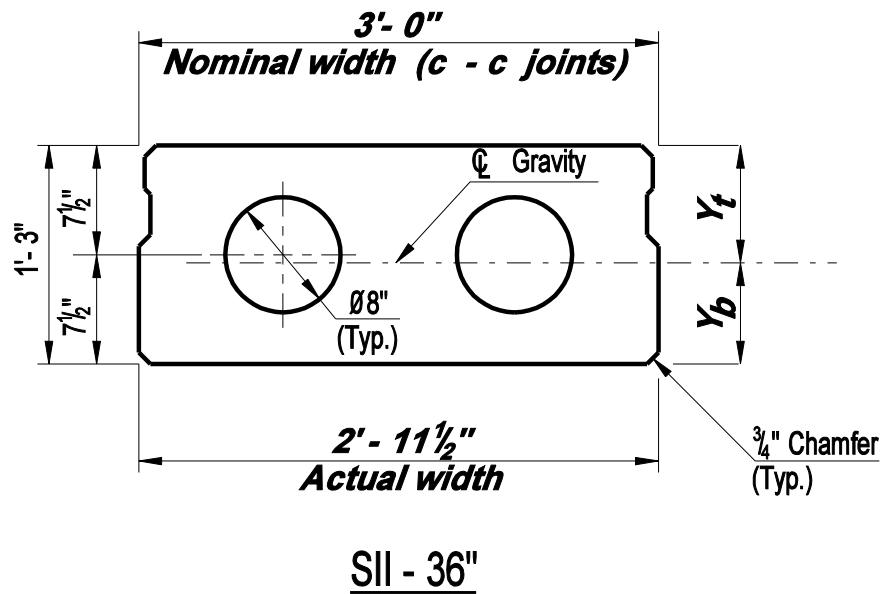
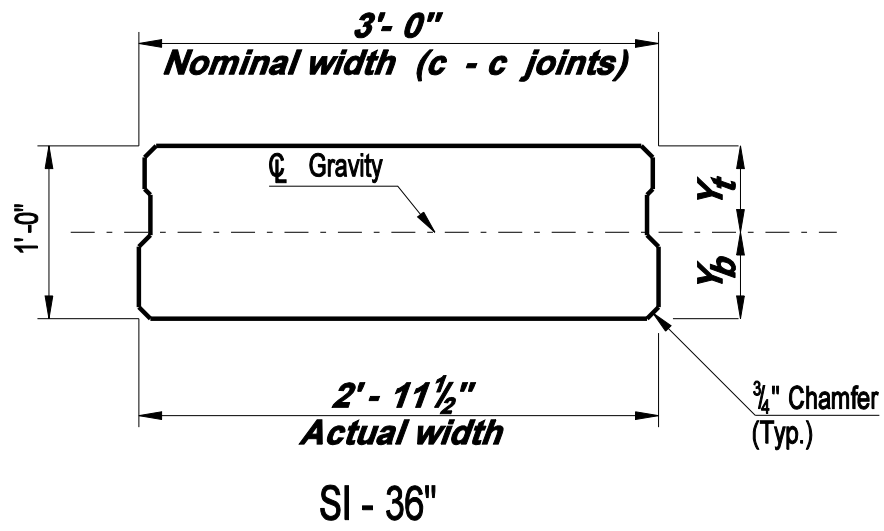
B
DETAIL
A



SECTION
B

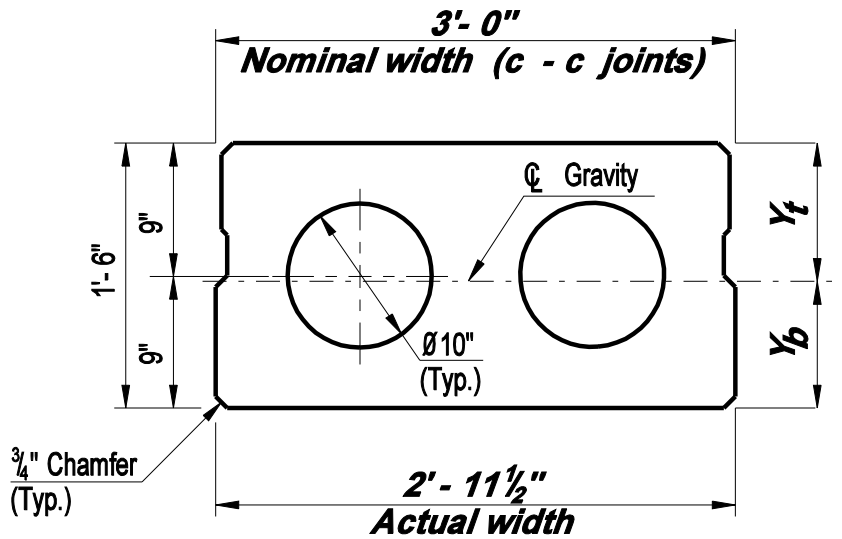
DESIGN INFORMATION

For Design information, see Plate 4.5.2a

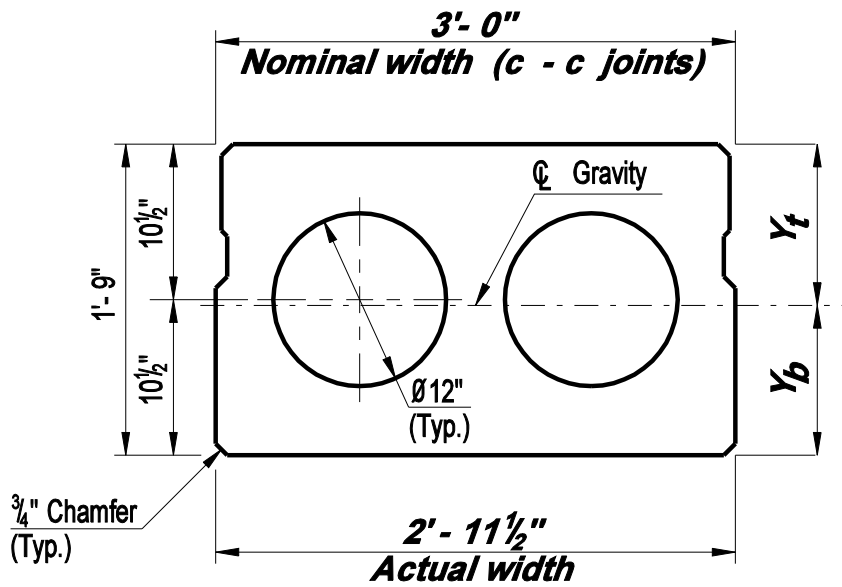


DESIGN INFORMATION

For Design information, see Plate 5.1.1c



SIII - 36"



SIV - 36"

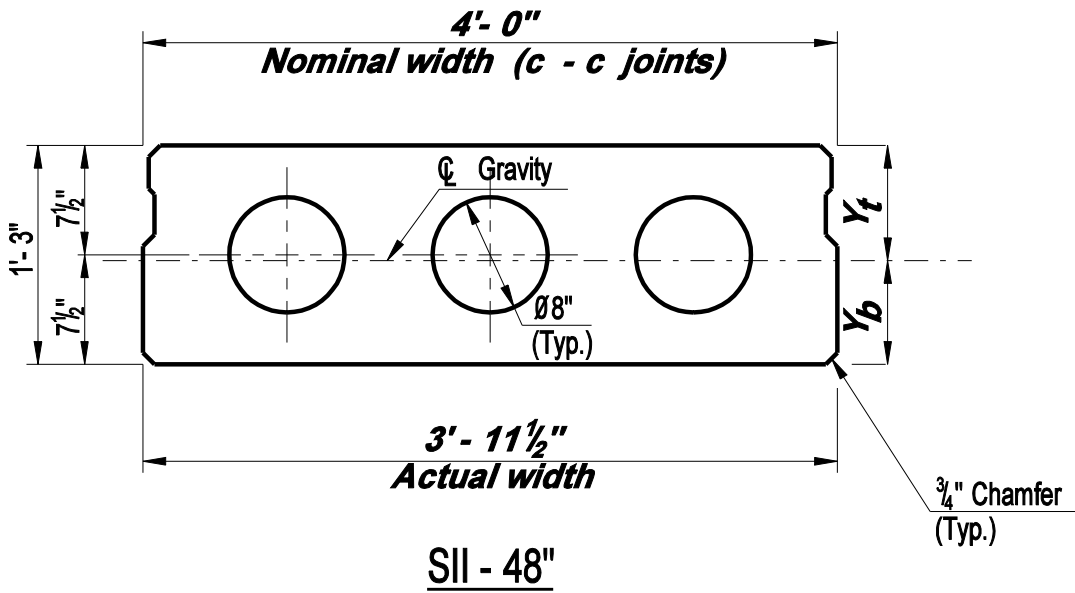
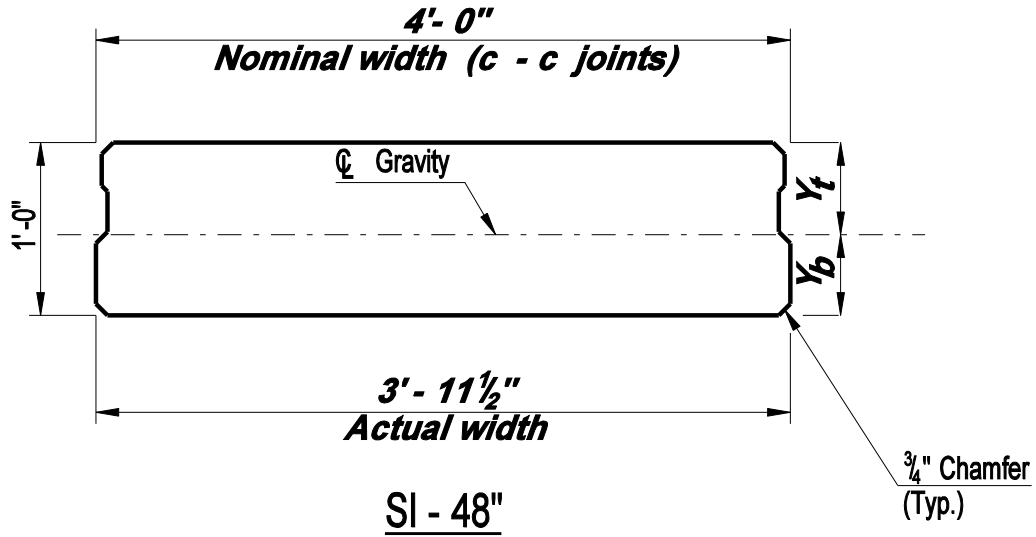
DESIGN INFORMATION

For Design information, see Plate 5.1.1c

BEAM TYPE	Width		Depth (inch)	A (inch ²)	I (inch ⁴)	Y _b (in.)	Y _t (in.)	S _b (inch ³)	S _t (inch ³)	Wt. (lb/ft)
	Nom. (inch)	Act. (inch)								
	SI-36	36.0								
SII-36	36.0	35.5	15.0	438	9728	7.44	7.56	1309	1287	457
SIII-36	36.0	35.5	18.0	473	16034	8.92	9.08	1798	1766	493
SIV-36	36.0	35.5	21.0	511	24987	10.40	10.60	2403	2358	532

DESIGN INFORMATION

1. *Weight of beam does not include weight of solid sections at transverse ties. Use the total weight (including solid sections) for design.*
2. *Voids may be eliminated to develop sidewalk/parapet reinforcement. See Section 5.6. The designer shall calculate and use the Modified Properties in this case.*
3. *For design details, see Plate 5.1.1a & 5.1.1b*
4. *If anchors must be drilled-in directly above a void for the purpose of anchoring Temporary Precast Concrete Barrier Curb, the size of the void should be adjusted to provide at least eight inches of thickness at the anchor locations.*



DESIGN INFORMATION

For design information, see Plate 5.1.2c

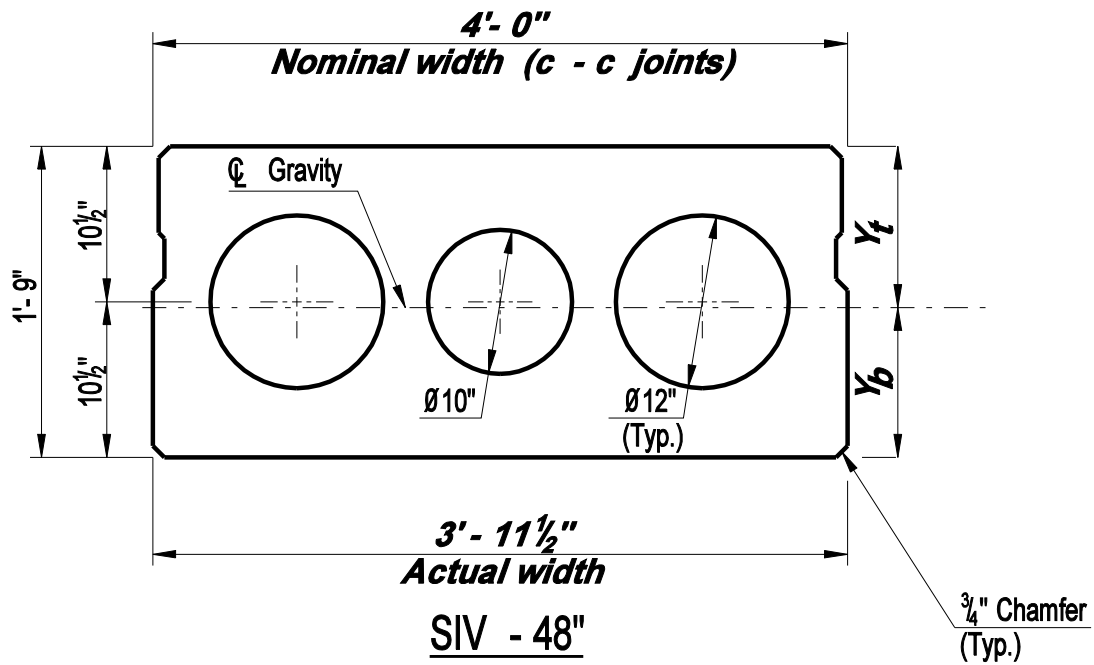
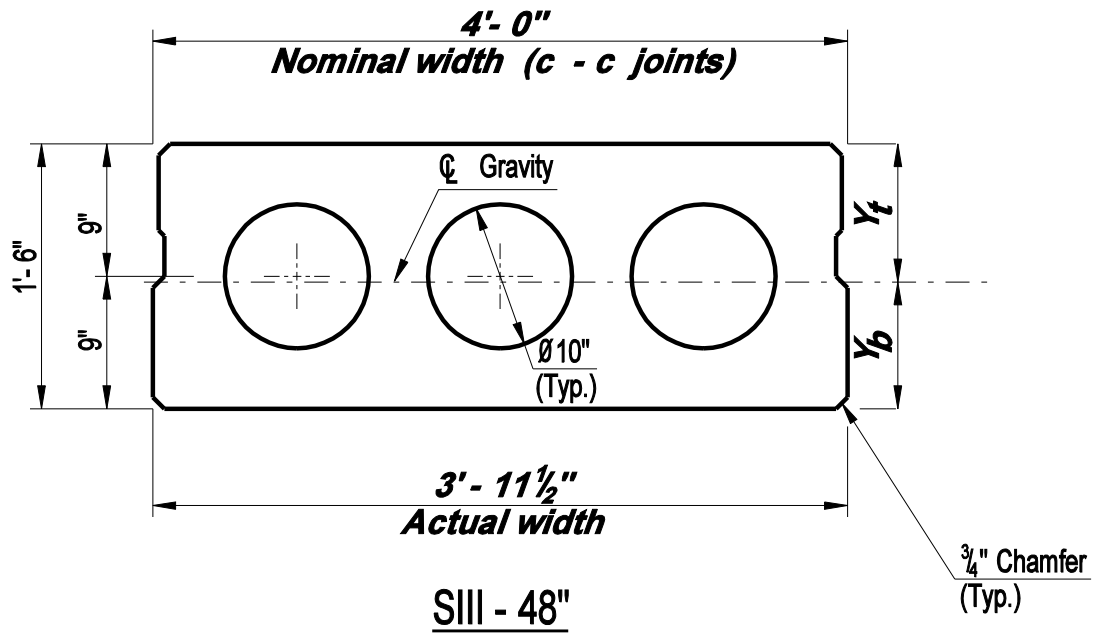
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SECTION PROPERTIES
AASHTO CONCRETE
SLABS - 4'- 0" WIDE**

Issue Date: 10/03

Revision Date: 01/05

Plate Number:
5.1.2a



DESIGN INFORMATION

For design information, see Plate 5.1.2c

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

SECTION PROPERTIES
AASHTO CONCRETE
SLABS - 4'- 0" WIDE

Issue Date: 10/03

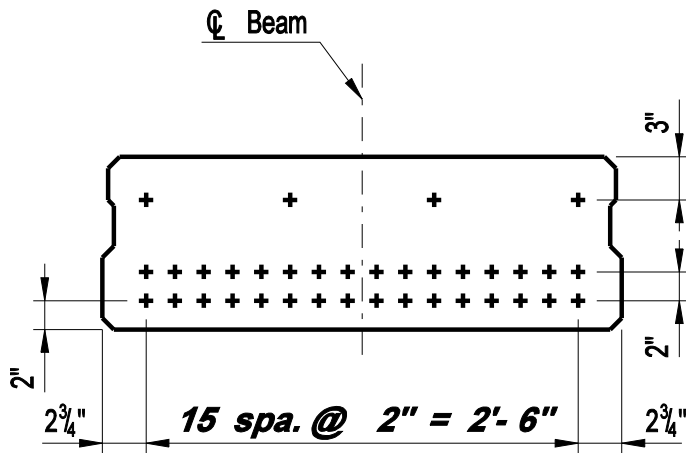
Revision Date:

Plate Number:
5.1.2b

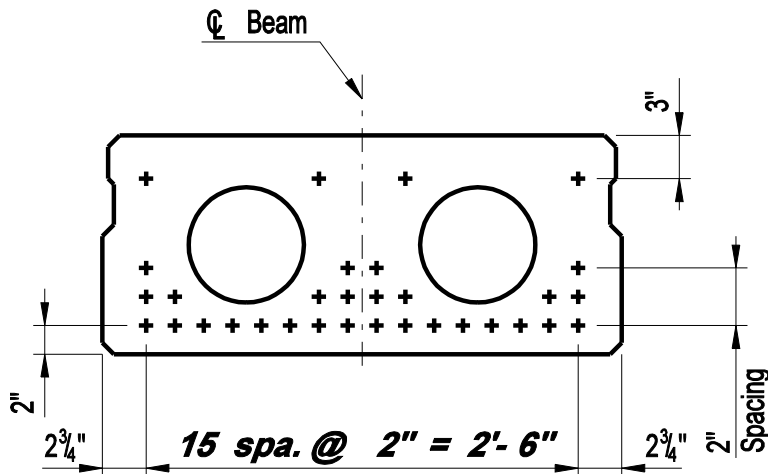
BEAM TYPE	Width		Depth	A	I	Y _b	Y _t	S _b	S _t	Wt.
	Nom. (inch)	Act. (inch)								
SI-48	48.0	47.5	12.0	561	6773	5.97	6.03	1135	1124	585
SII-48	48.0	47.5	15.0	553	12622	7.45	7.55	1695	1672	576
SIII-48	48.0	47.5	18.0	611	21376	8.94	9.06	2393	2359	636
SIV-48	48.0	47.5	21.0	684	33759	10.43	10.57	3238	3193	713

DESIGN INFORMATION

1. Weight of beam does not include weight of solid sections at transverse ties. Use the total weight (including solid sections) for design.
2. Voids may be eliminated to develop sidewalk/parapet reinforcement. See Section 5.6. The designer shall calculate and use the Modified Properties in this case.
3. For design details, see Plates 5.1.2a & 5.1.2b



SI - 36"



SII - 36"

DESIGN INFORMATION

For Design Information, see Plate 5.1.7

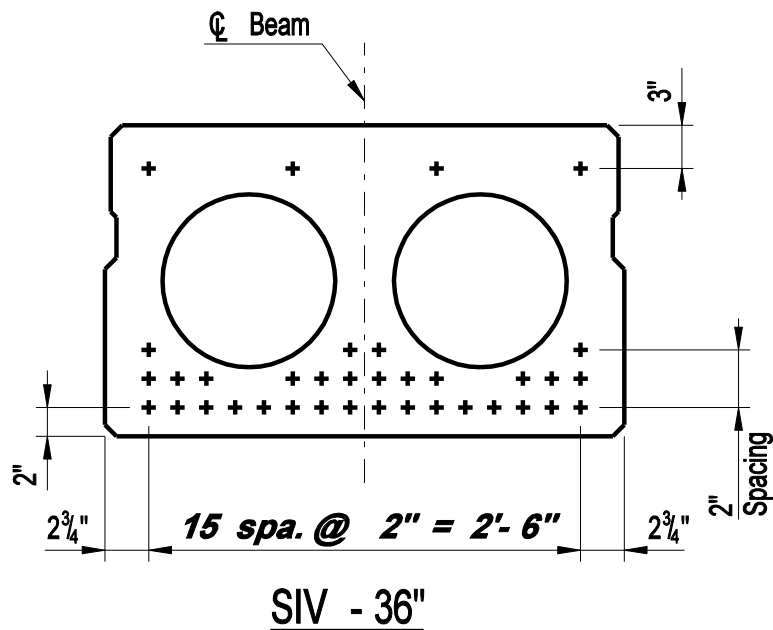
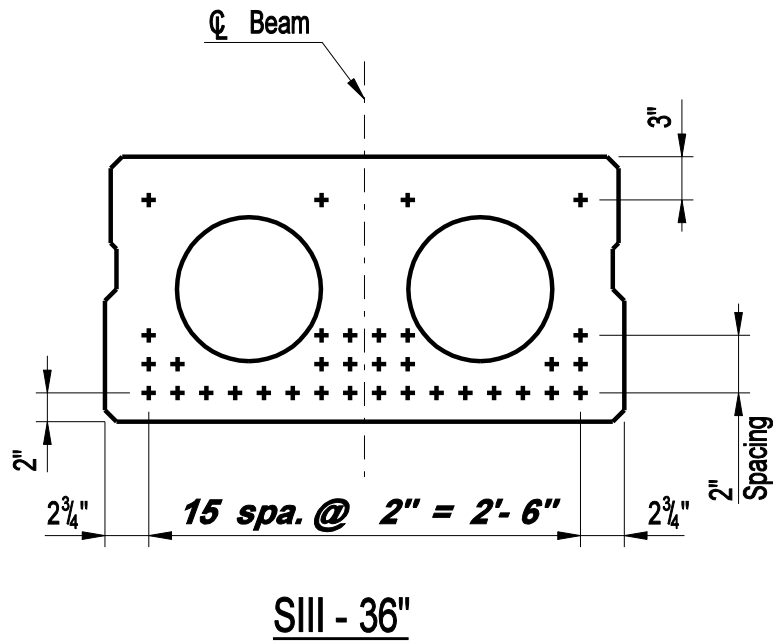
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

STRAND LOCATIONS
AASHTO CONCRETE SLABS
(S I & S II - 3'- 0" WIDE)

Issue Date: 10/03

Revision Date:

Plate Number:
5.1.3



DESIGN INFORMATION

Design Information, see Plate 5.1.7

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

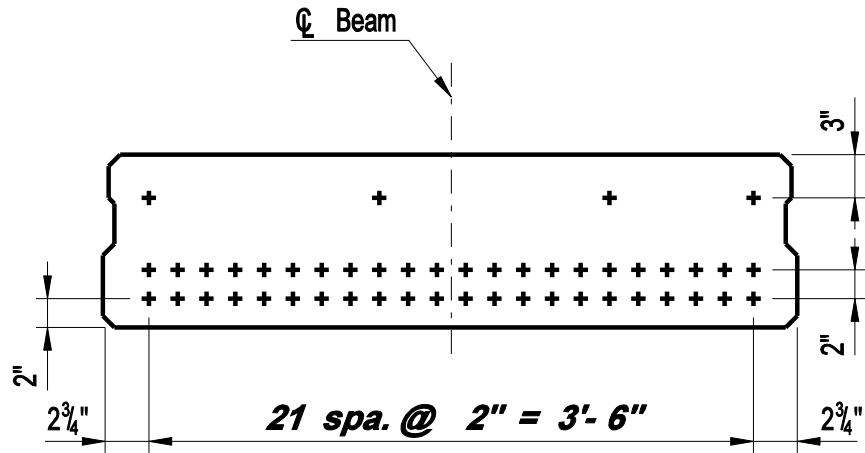
STRAND LOCATIONS
AASHTO CONCRETE SLABS
(S III & S IV - 3'-0" WIDE)

Issue Date: 10/03

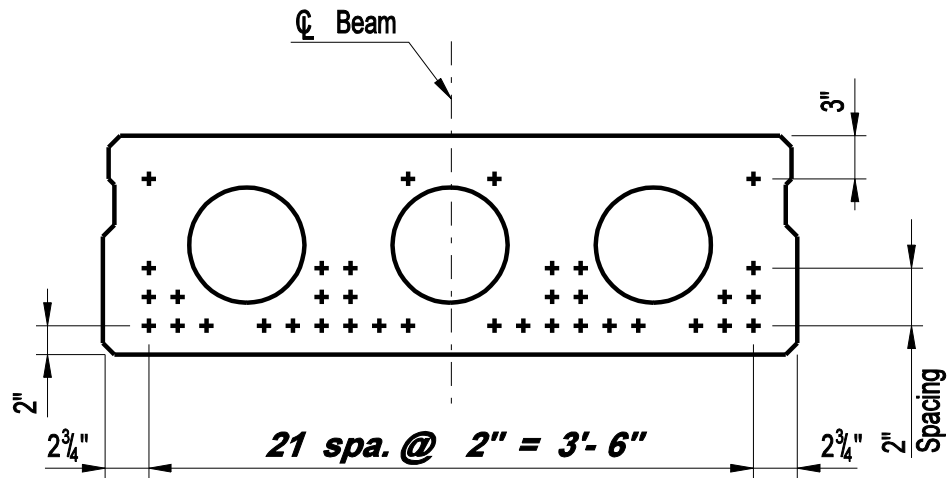
Revision Date:

Plate Number:

5.1.4



SI - 48"



SII - 48"

DESIGN INFORMATION

Design Information, see Plate 5.1.7

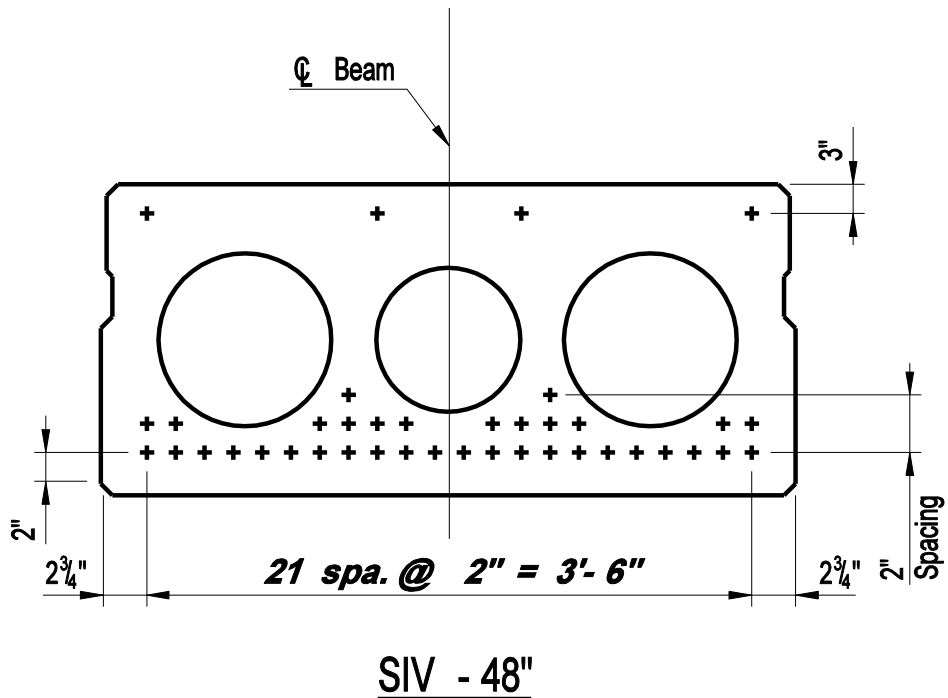
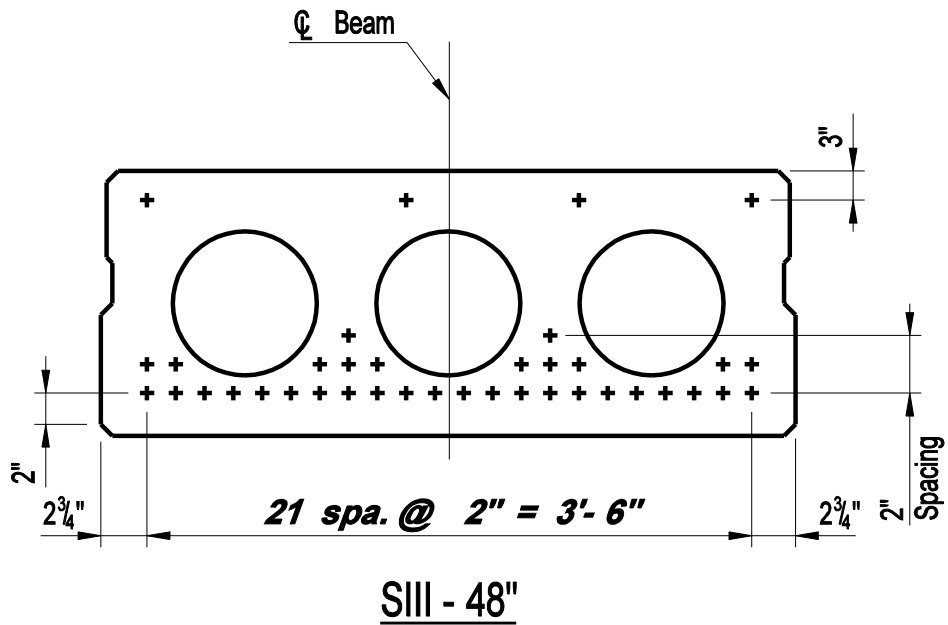
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

STRAND LOCATIONS
AASHTO CONCRETE SLABS
(S I & S II - 4'- 0" WIDE)

Issue Date: 10/03

Revision Date:

Plate Number:
5.1.5



DESIGN INFORMATION

For Design Information, see Plate 5.1.7

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

STRAND LOCATIONS
AASHTO CONCRETE SLABS
(S III & S IV - 4'- 0" WIDE)

Issue Date: 10/03

Revision Date:

Plate Number:

5.1.6

DESIGN INFORMATION

- 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 and tolerances. For most beam designs, strands shall be placed in as many locations within the pattern as required.**
- 2. + Denotes Prestressing strands**
- 3. Strand locations shown for design purposes only. Final plans shall only show number of strands and center of gravity.**
- 4. For design details, see Plates 5.1.3 - 5.1.6**

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**STRAND LOCATIONS
AASHTO CONCRETE SLABS
(DESIGN INFORMATION)**

Issue Date: 10/03

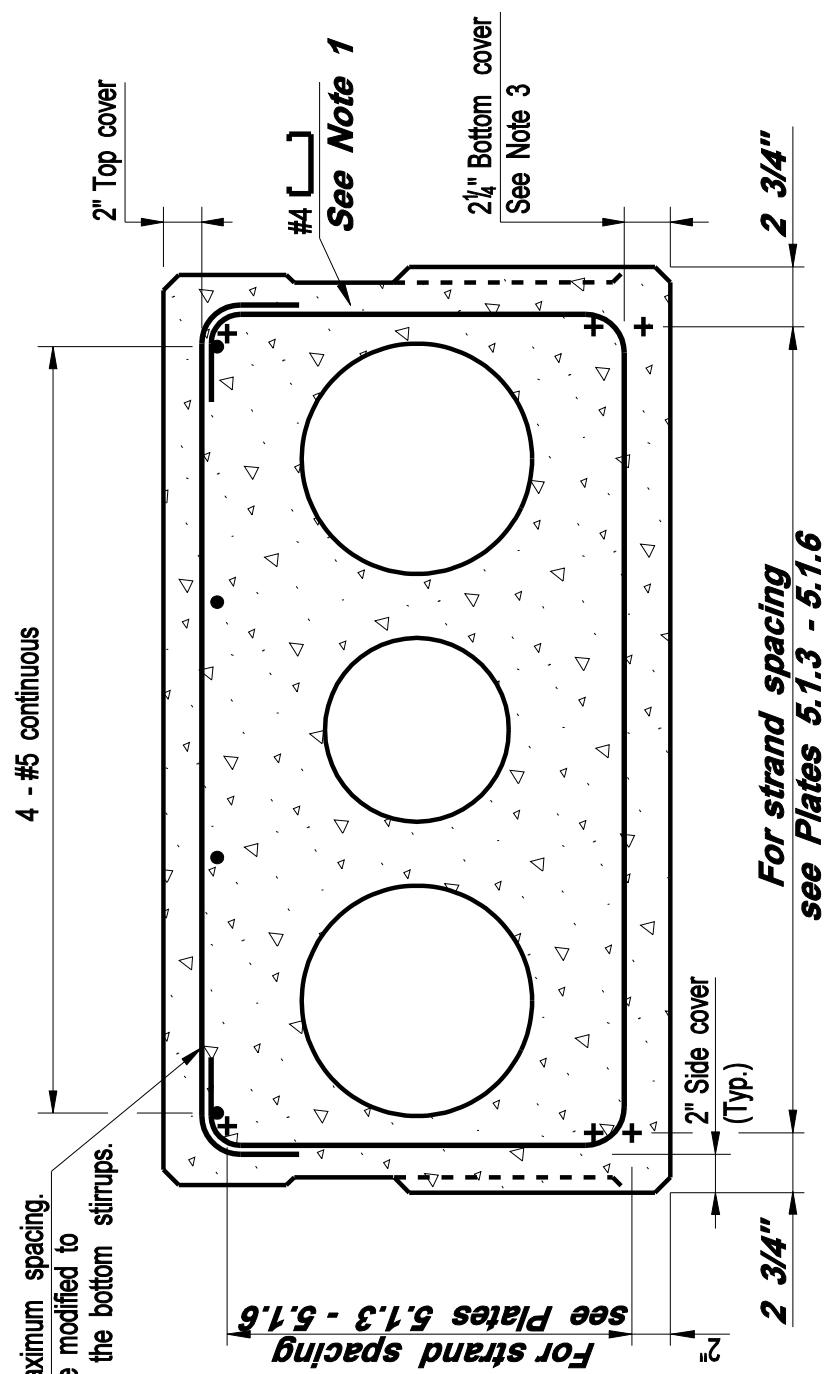
Revision Date:

Plate Number:
5.1.7

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**TYPICAL MIDSPAN SECTION
AASHTO CONCRETE SLABS**

Issue Date:	10/03
Revision Date:	
Plate Number:	5.1.8



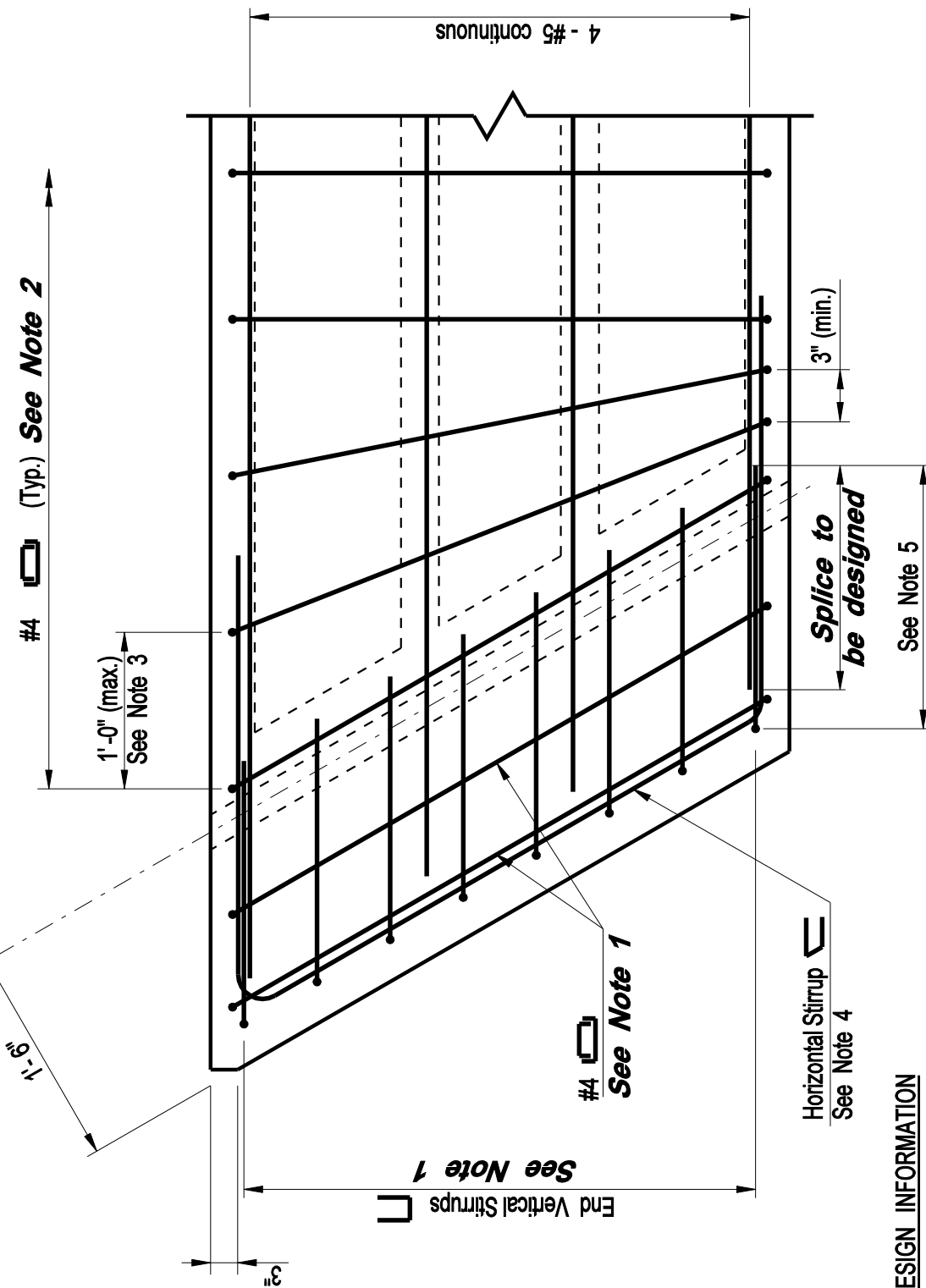
NOTES:

1. This cover is required to facilitate the placement of the bottom prestressing strands. The fabricator may modify cover (1 1/2" min.) if no conflicts exist with the prestressing strands.

DESIGN INFORMATION

1. *Stirrups shall be designed to conform to the requirements of AASHTO. The stirrups shall be #4 bars with a maximum spacing of 12".*
2. *+ Denotes prestressing strands*

∅ 02½" Transverse tie strand hole



DESIGN INFORMATION

For Notes 1 - 5, See Plate 5.1.9b

PLAN

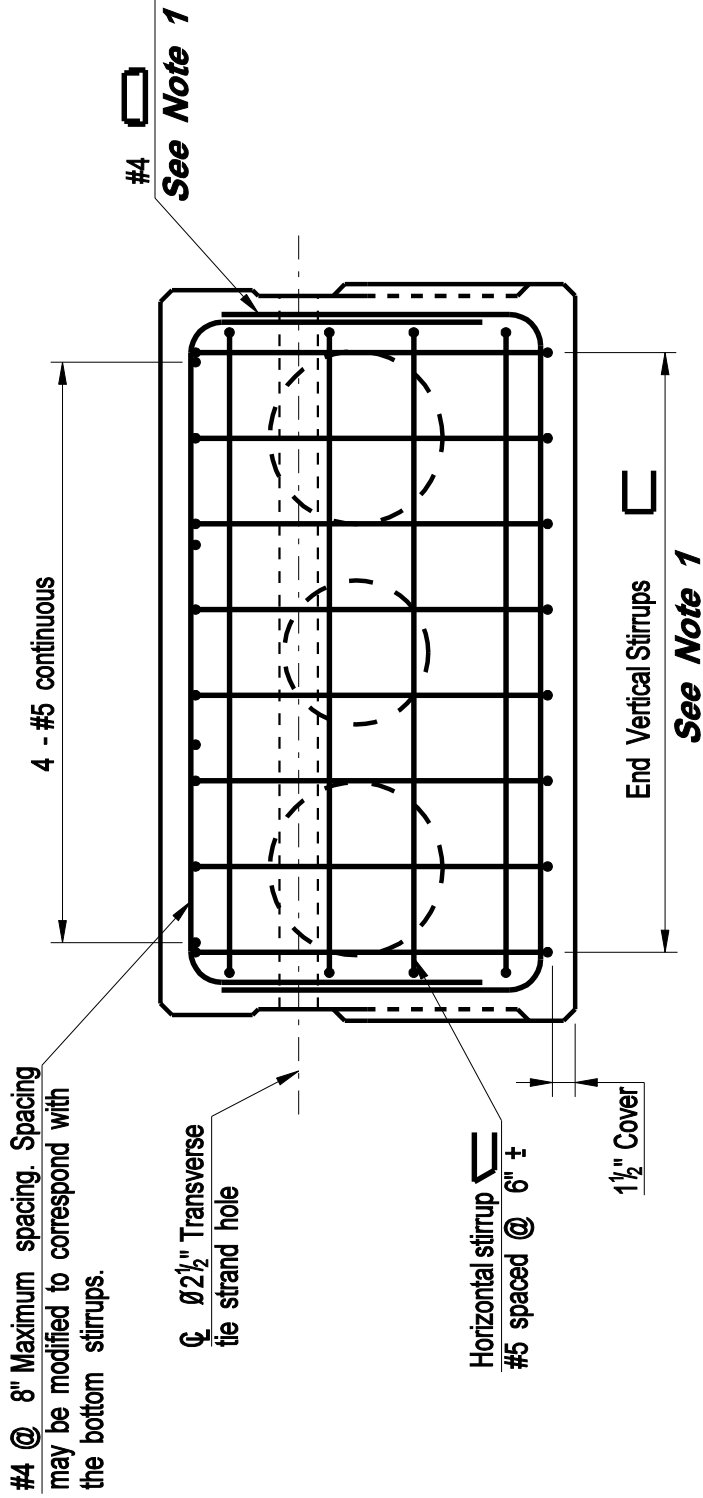
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

END BLOCK REINFORCING
AASHTO CONCRETE SLABS

Issue Date: 10/03

Revision Date:

Plate Number:
5.1.9a

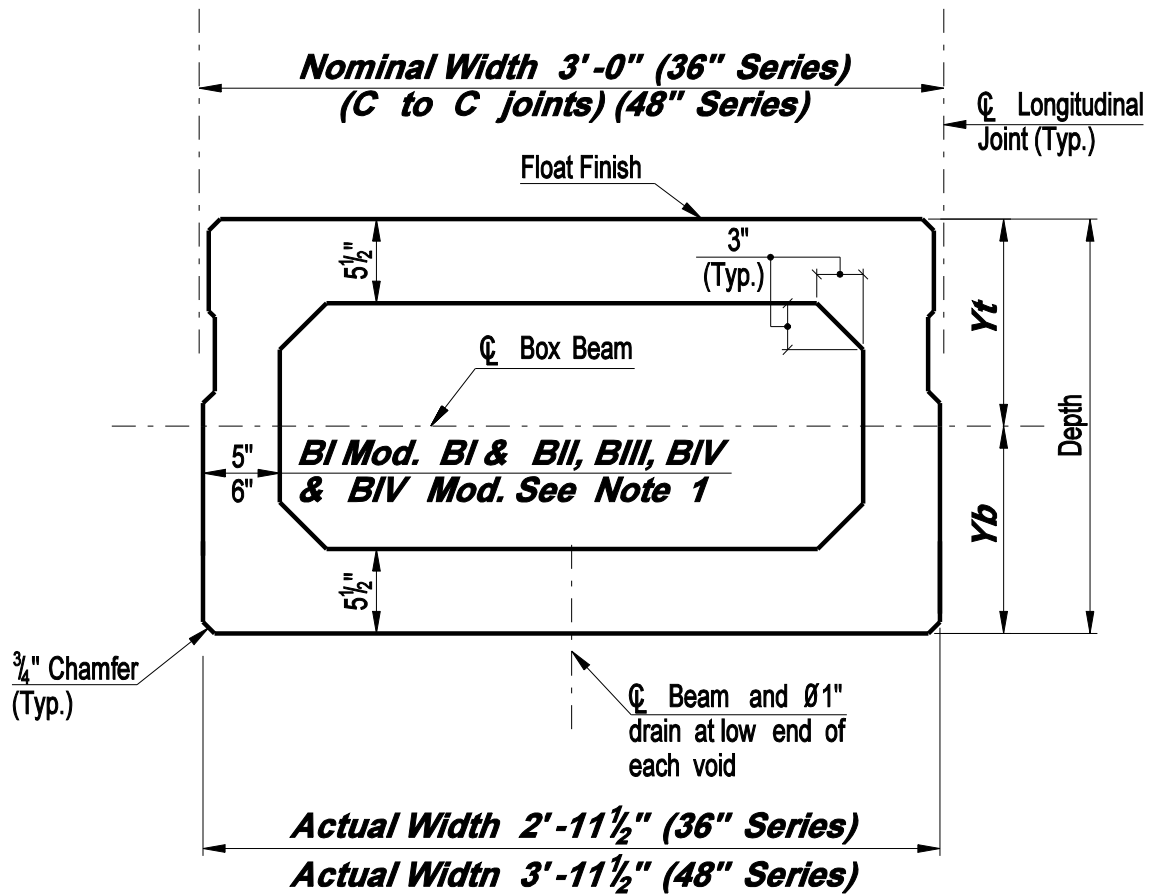


DESIGN INFORMATION

1. *The Engineer shall design the vertical legs of the last transverse stirrup and the end vertical stirrups to satisfy the requirements of AASHTO.*
2. *Stirrups shall be designed to conform to the requirements of AASHTO. The stirrups shall be #4 bars.*

NOTES:

3. Splay stirrups to avoid conflicts with transverse tie strand holes.
4. Extend longitudinal legs a minimum distance equal to the depth of the beam or 12" into the web of the voided section, whichever is larger.
5. Horizontal legs of the vertical stirrups are equal to the depth of the beam.



DESIGN INFORMATION

- 5" Web is to accommodate 1 column of draped strands.**
- 6" Web is to accommodate 2 columns of draped strands. For typical strand locations, see Plates 5.2.2 & 5.2.3.**
- 7. Top slab thickness shall be increased to eight inches where necessary to accommodate drilled-in anchors for Temporary Precast Concrete Barrier Curb.**

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SECTION PROPERTIES
AASHTO CONCRETE
BOX BEAMS**

Issue Date: 10/03

Revision Date:

Plate Number:

5.2.1a

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SECTION PROPERTIES
AASHTO CONCRETE
BOX BEAMS**

BEAM TYPE	Width		Depth	A (<i>inch</i> ²)	I (<i>inch</i> ⁴)	Y _b (<i>in.</i>)	Y _t (<i>in.</i>)	S _b (<i>inch</i> ³)	S _t (<i>inch</i> ³)	Wt. (<i>lb/ft</i>)
	Nom. (<i>inch</i>)	Act. (<i>inch</i>)								
BI-36 Mod.	36.0	35.5	24.0	524.6	36136	11.87	12.13	3043	2980	546
BI-48 Mod.	48.0	47.5	24.0	656.6	47764	11.90	12.10	4014	3947	684
BI-36	36.0	35.5	27.0	554.6	49495	13.35	13.65	3709	3625	578
BI-48	48.0	47.5	27.0	686.6	65085	13.38	13.62	4886	4777	715
BI-36	36.0	35.5	33.0	614.6	83834	16.30	16.70	5144	5019	640
BI-48	48.0	47.5	33.0	746.6	109127	16.33	16.67	6681	6548	778
BI-36	36.0	35.5	39.0	730.6	132895	19.28	19.72	6894	6738	761
BI-48	48.0	47.5	39.0	862.6	170267	19.31	19.69	8817	8648	899
BIV-36	36.0	35.5	42.0	766.6	161387	20.76	21.24	7773	7599	799
BIV-48	48.0	47.5	42.0	898.6	205690	20.80	21.20	9890	9701	936
BIV-36 Mod.	36.0	35.5	45.0	802.6	193328	22.25	22.75	8689	8498	836
BIV-48 Mod.	48.0	47.5	45.0	834.6	245156	22.29	22.72	11001	10793	974

DESIGN INFORMATION

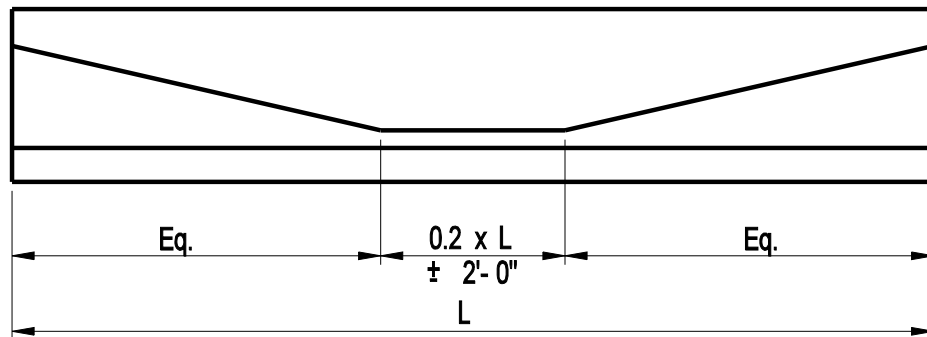
1. Weight of beam does not include weight of solid sections at transverse ties. Use the total weight (including solid sections) for design.
2. Thickness of top flange may have to be increased to develop sidewalk/parapet reinforcement. See Section 5.6. The designer shall calculate and use the Modified Properties in this case.

Issue Date: 10/03

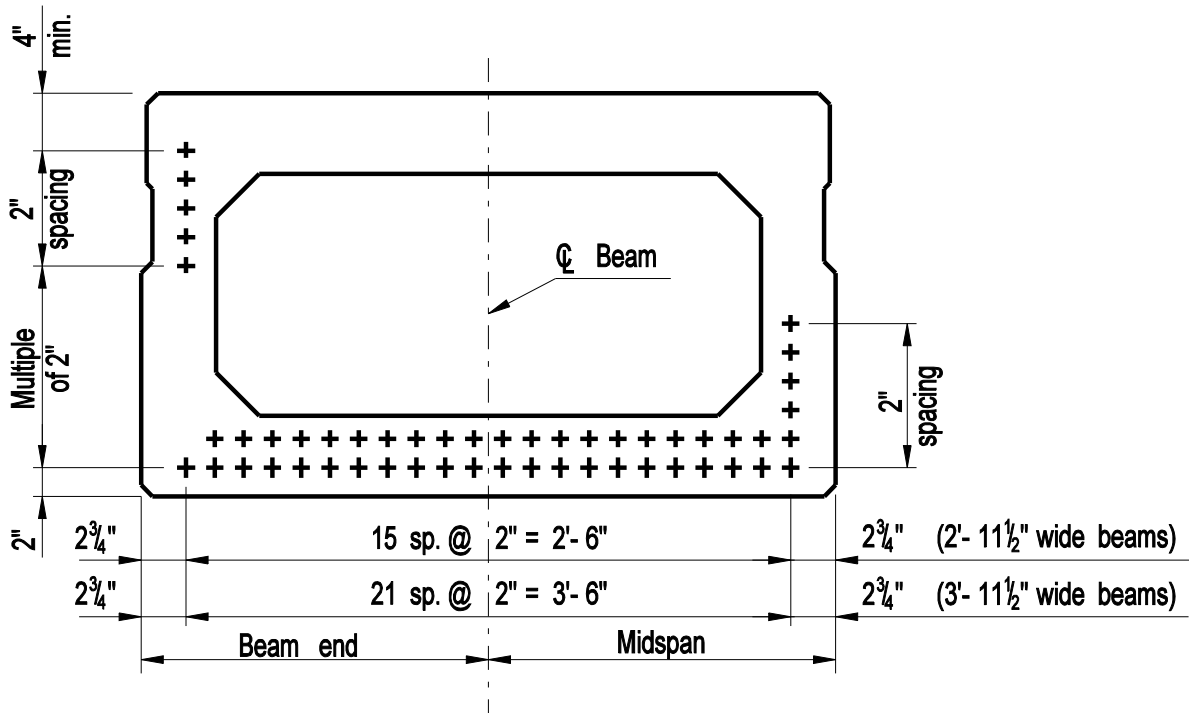
Revision Date:

Plate Number:

5.2.1b



HOLD DOWN POINTS FOR DRAPED STRANDS



STRAND LOCATIONS

DESIGN INFORMATION

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 and tolerances. For most beam designs, strands shall be placed in as many locations within the pattern as required.*
2. *+ Denotes Prestressing strands*
3. *Strand locations shown for design purposes only. Final plans shall only show number of strands and center of gravity.*

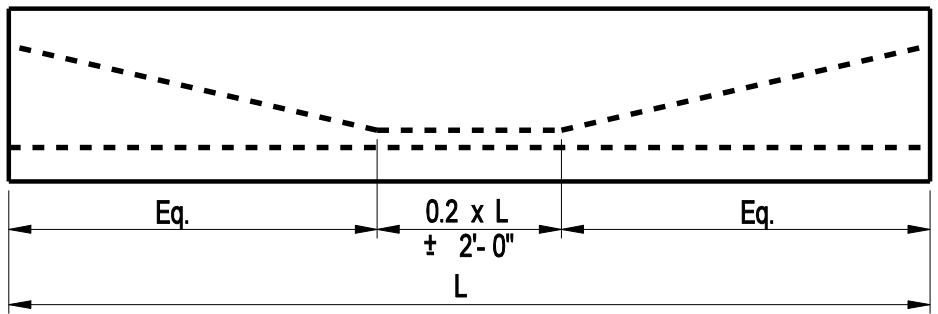
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**STRAND LOCATIONS
AASHTO BOX BEAMS
(TYPE B I, B I MODIFIED & B II)**

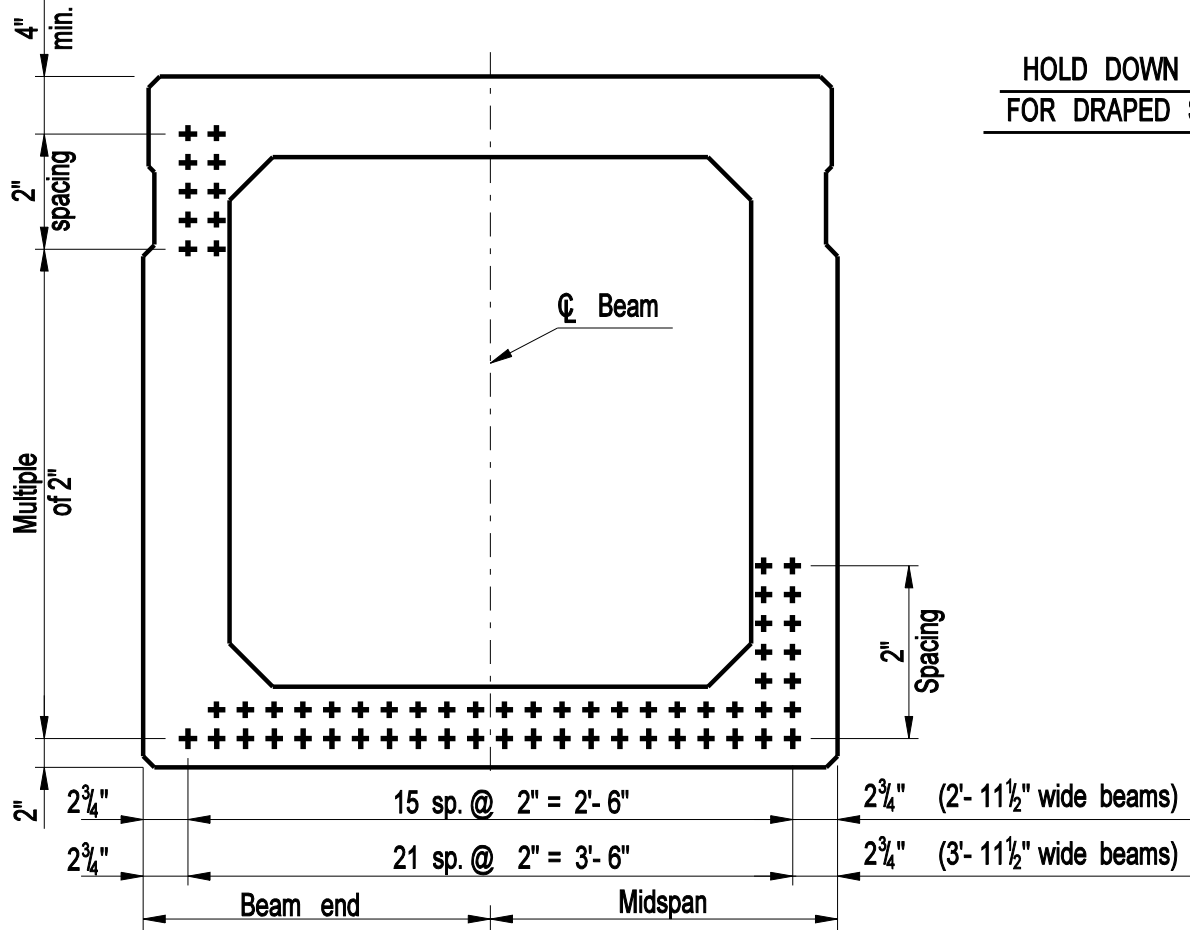
Issue Date: 10/03

Revision Date:

Plate Number:
5.2.2



HOLD DOWN POINTS
FOR DRAPED STRANDS



STRAND LOCATION

DESIGN INFORMATION

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 and tolerances. For most beam designs, strands shall be placed in as many locations within the pattern as required.*
2. *+ Denotes Prestressing strands*
3. *Strand locations shown for design purposes only. Final plans shall only show number of strands and center of gravity.*

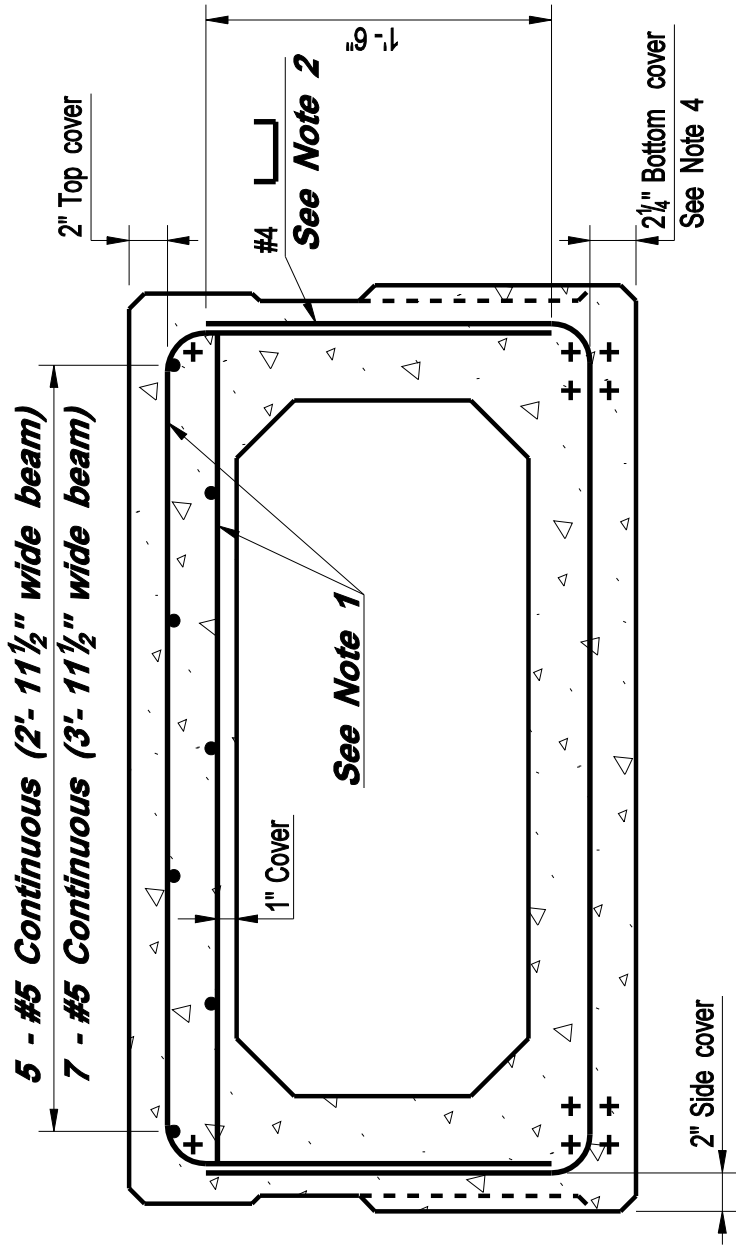
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**STRAND LOCATIONS
AASHTO BOX BEAMS
(TYPE B III, B IV & B IV MODIFIED)**

Issue Date: 10/03

Revision Date:

Plate Number:
5.23

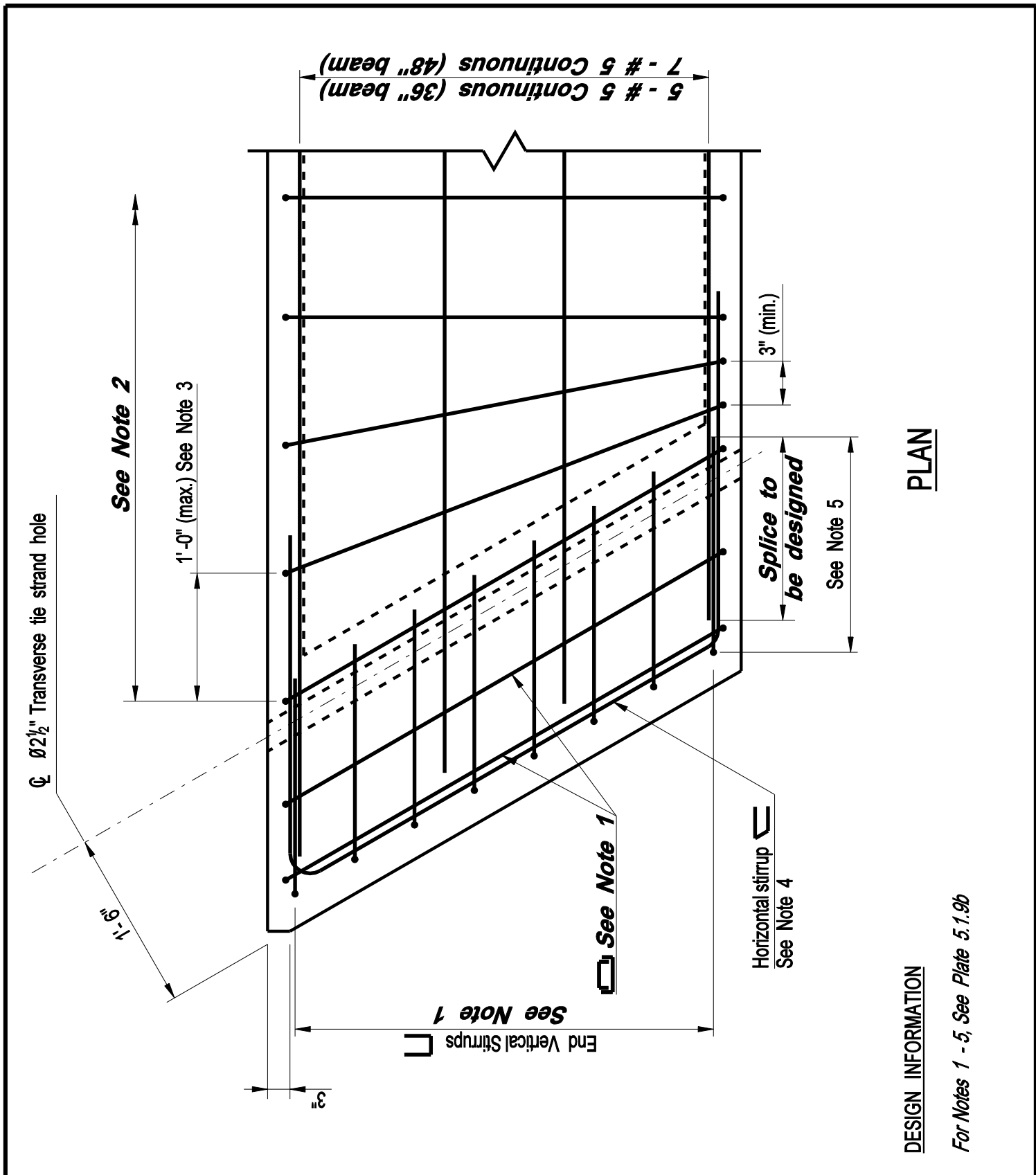


DESIGN INFORMATION

1. Use #4 or #5 bars only for the top transverse stirrups and slab reinforcement. Spacing shall not exceed 8".
2. Bottom transverse stirrups shall be placed at a multiple of the top bar spacing with a maximum spacing of 1'-4".
3. + Denotes prestressed strand.

NOTES:

4. This cover is required to facilitate the placement of the bottom prestressing strands. The fabricator may modify cover (1 1/2" min.) if no conflicts exist with the prestressing strands.



PLAN

DESIGN INFORMATION

For Notes 1 - 5, See Plate 5.1.9b

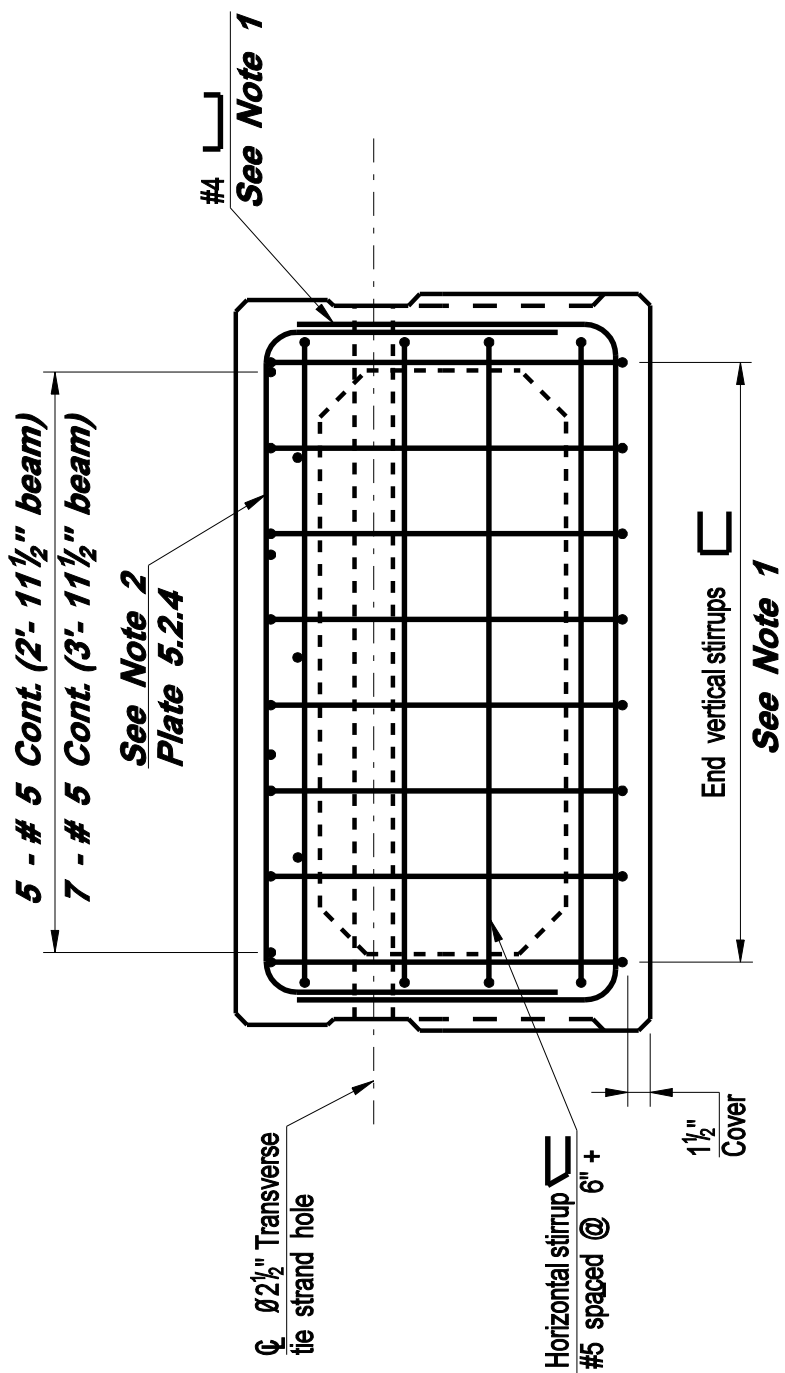
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**END BLOCK REINFORCING
AASHTO BOX BEAMS**

Issue Date: 10/03

Revision Date:

Plate Number:
5.2.5a



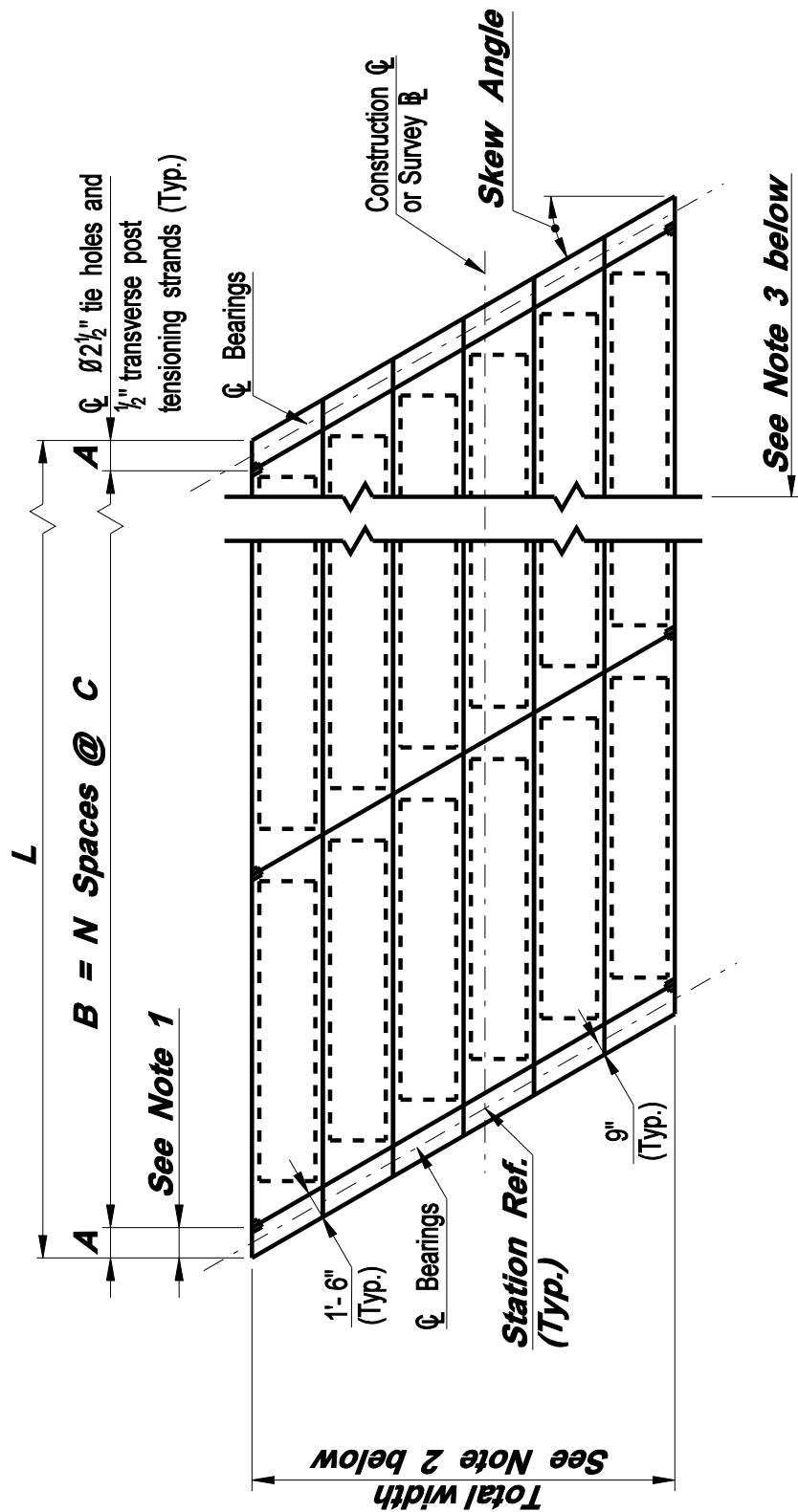
END VIEW

DESIGN INFORMATION

1. *The Engineer shall design the vertical legs of the last transverse stirrup and the end vertical stirrups to satisfy the requirements of AASHTO.*
2. *Stirrups shall be designed to conform to the requirements of AASHTO.*

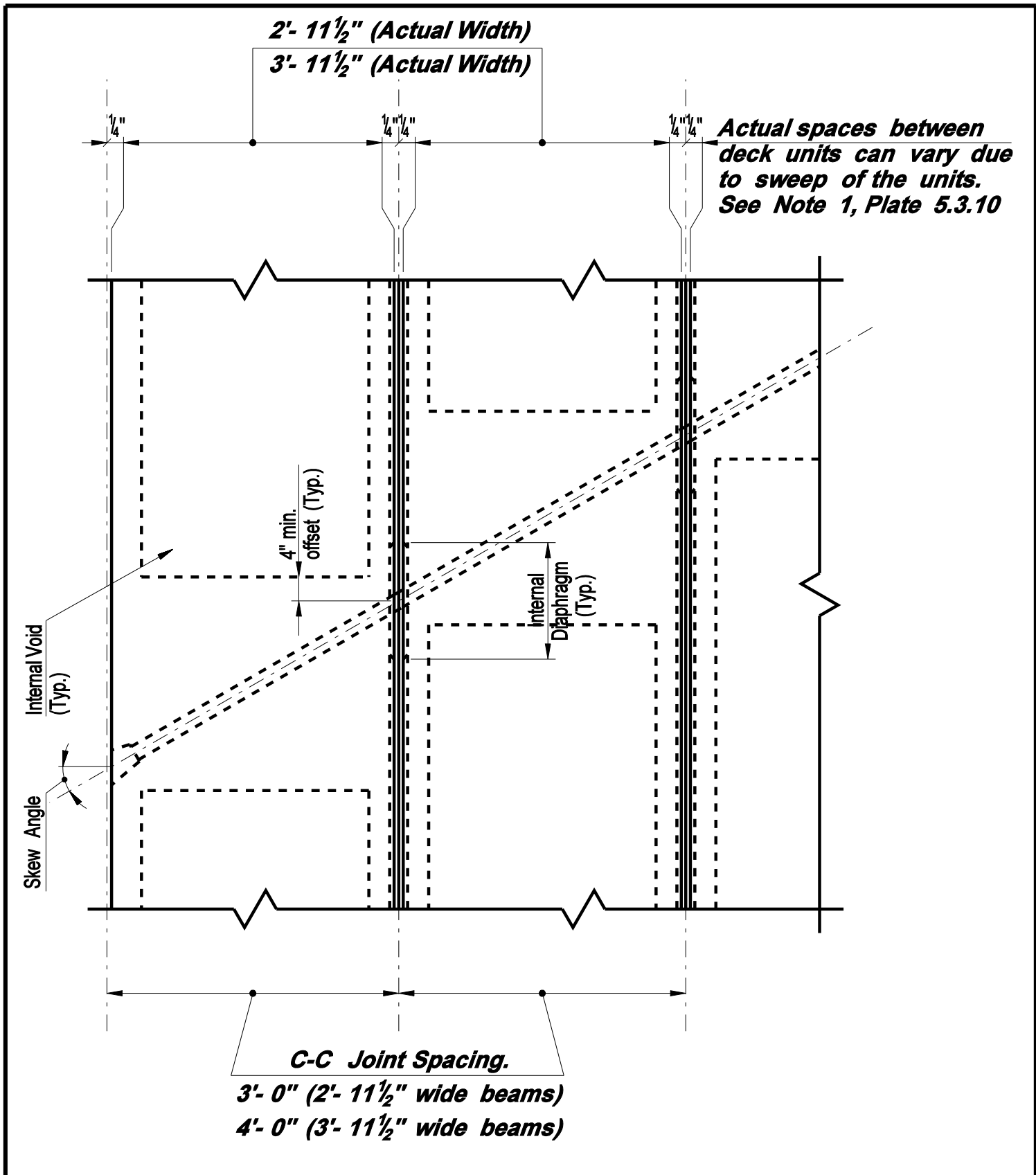
NOTES:

3. Splay stirrups to avoid conflicts with transverse tie strand holes.
4. Extend longitudinal legs a minimum distance equal to the depth of the beam or 12" into the web of the voided section, whichever is larger.
5. Horizontal legs of the vertical stirrups are equal to the depth of the beam.



DESIGN INFORMATION

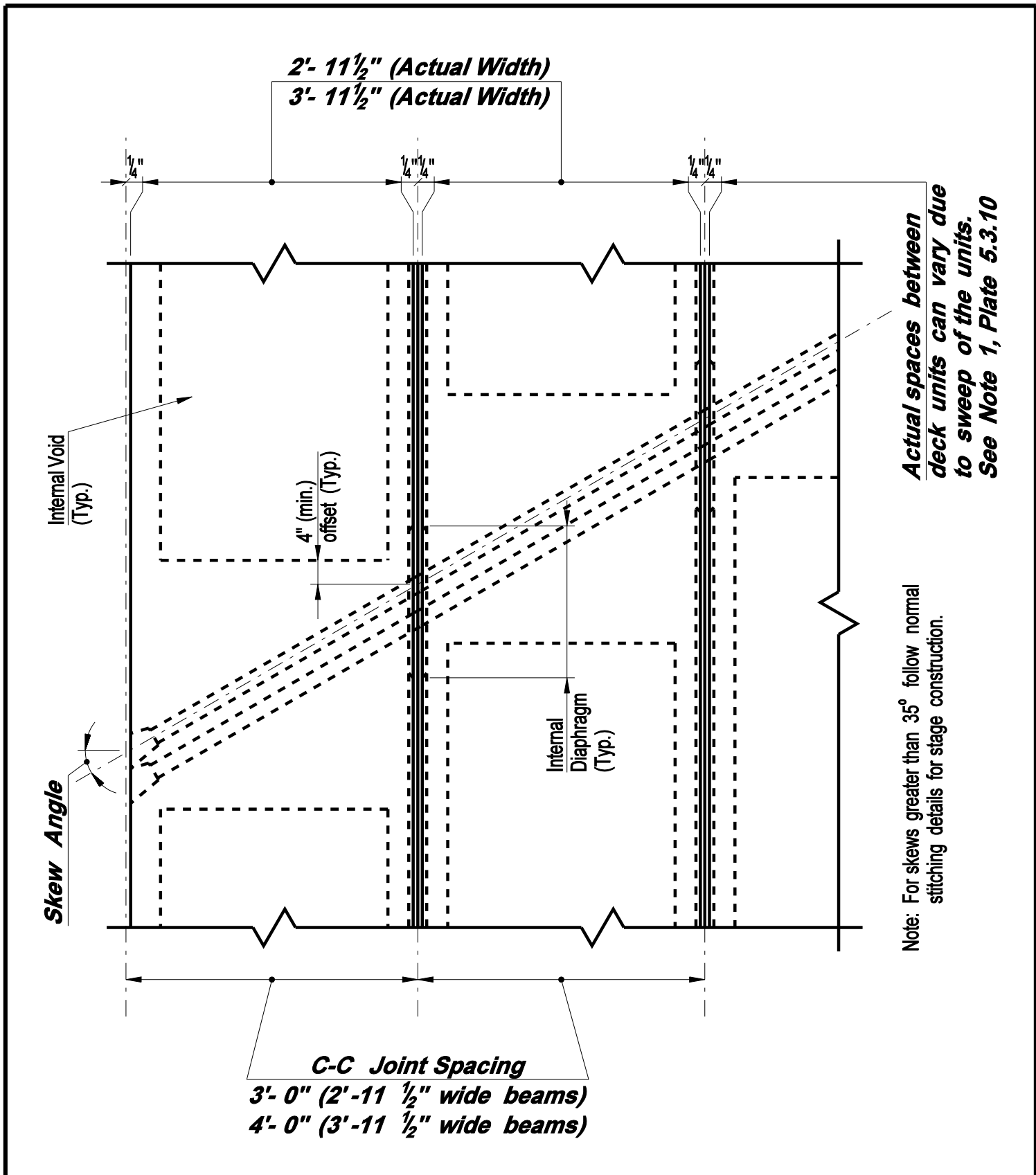
1. $A = 18" / \cos(\text{Skew angle})$
 $B = L - (2xA)$
 $C = B/N$ where $N = \text{Number of Internal voids. (See Plate No. 5.3.7 for the required number of transverse ties.)}$
2. Total width shall be calculated using 4'-0" for 48" series nominal units and 3'-0" for 36" series nominal units.
3. Framing plan shall be drawn full length without breaks and to scale on the construction plans. Show all internal voids, transverse ties and include North arrow.



**CONNECTICUT
BRIDGE DESIGN
MANUAL**

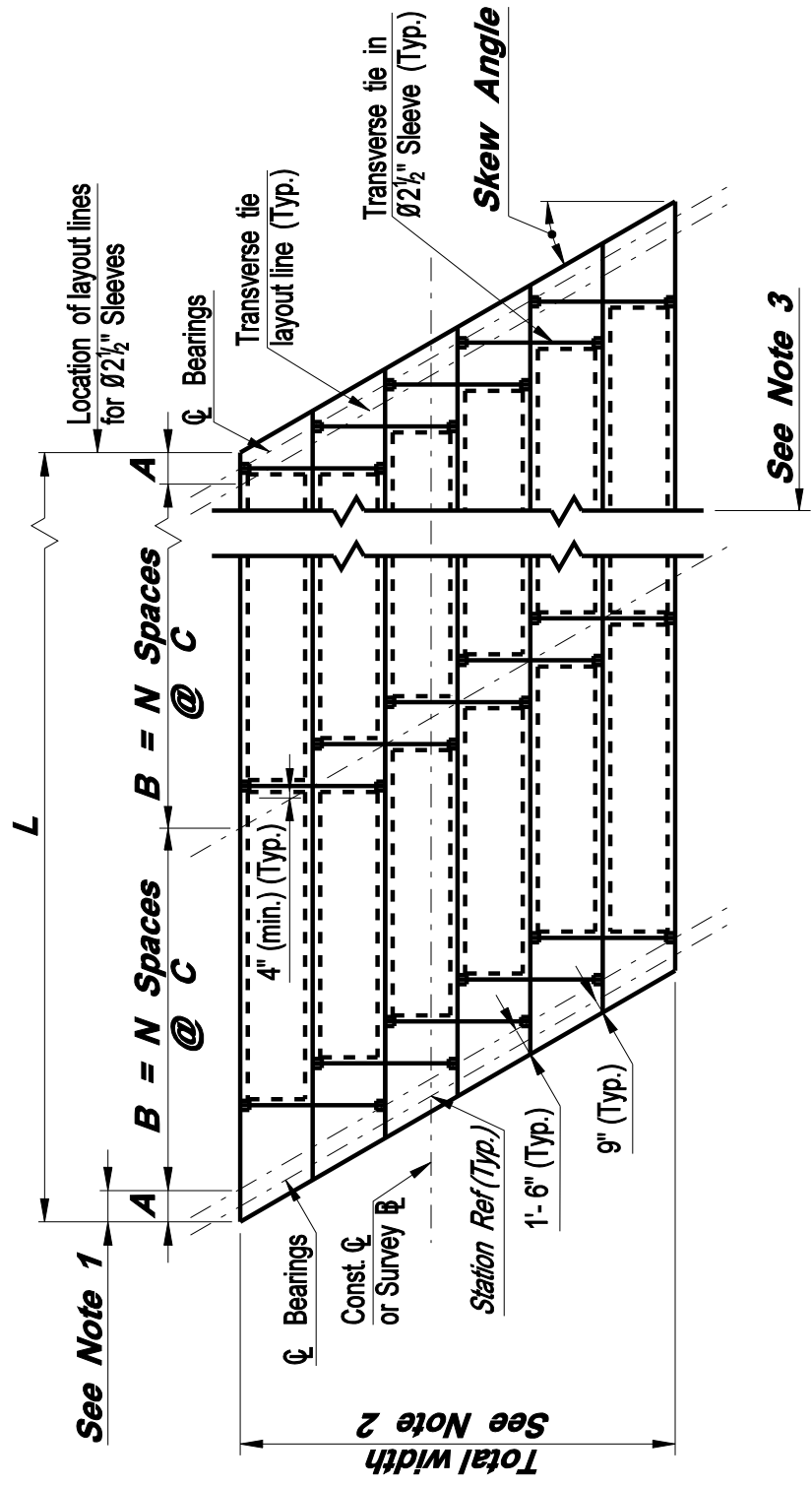
TRANSVERSE TIE STRAND
ARRANGEMENT FOR PRECAST
CONCRETE DECK UNITS
(SKEW ≤ 35°)

Issue Date:	10/03
Revision Date:	
Plate Number:	5.3.2



**FRAMING PLAN - PRECAST
CONCRETE DECK UNITS
(SKEW > 35°)**

Issue Date:	10/03
Revision Date:	
Plate Number:	5.3.5

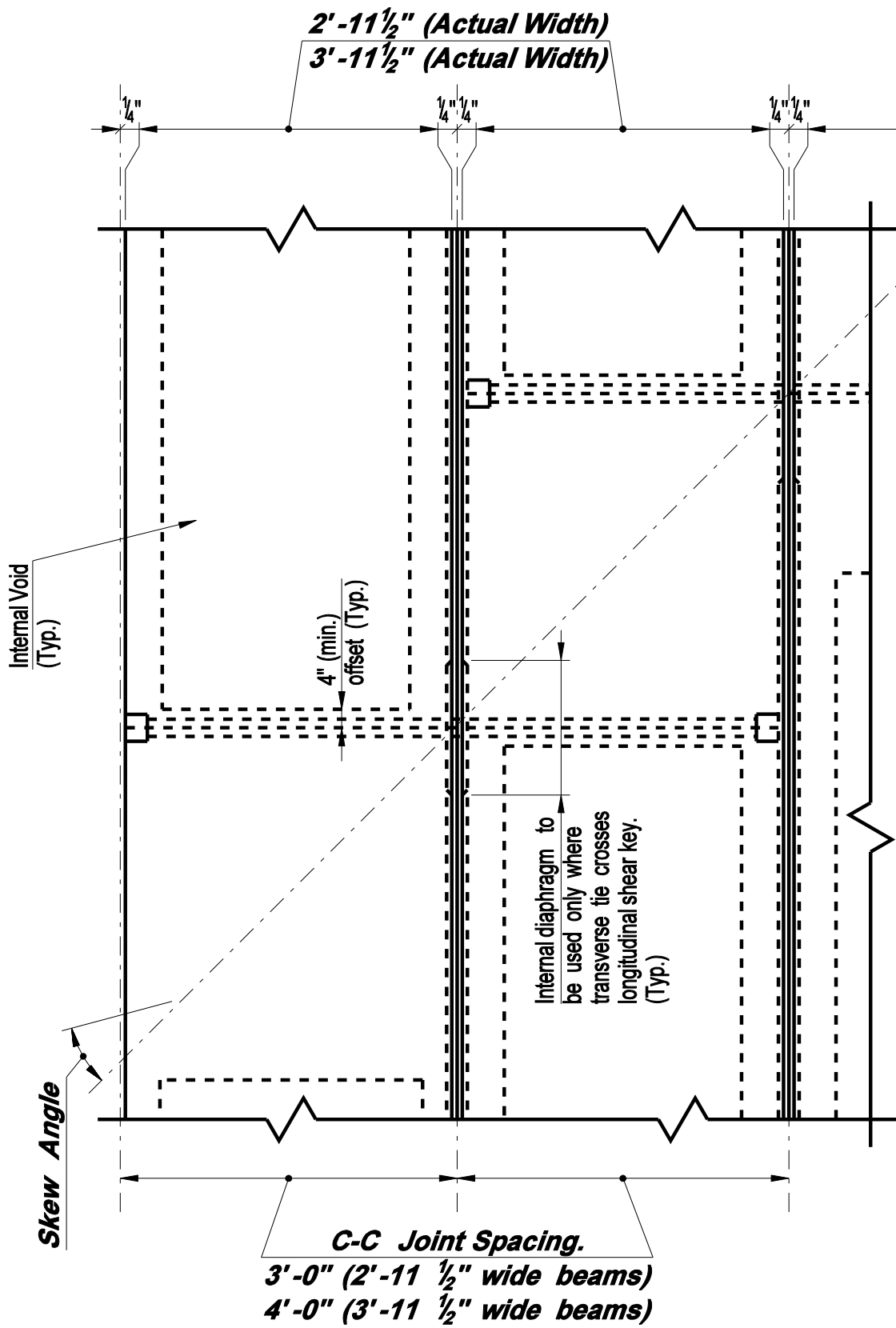


DESIGN INFORMATION

1. $A = 18'' / \cos \text{skew angle}$
 $B = L - (2xA)$
 $C = B/N$ where $N = \text{Number of Internal Voids.}$ (See Plate No. 5.3.7 for the required number of transverse ties.)
 $L = \text{Span Length} + A$

2. Total width shall be calculated using 4'-0" for 48" series nominal units and 3'-0" for 36" series nominal units.

3. Framing plan shall be drawn full length without breaks and to scale on the construction plans. Show all internal voids, transverse ties and include North arrow.



Actual spaces between deck units can vary due to sweep of the units. See Note 1, Plate 5.3.10

NOTES:
For skews greater than 35° follow normal stitching details for stage construction.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**TRANSVERSE TIE STRAND
ARRANGEMENT FOR PRECAST
CONCRETE DECK UNITS
(SKEW > 35°)**

Issue Date: 10/03

Revision Date:

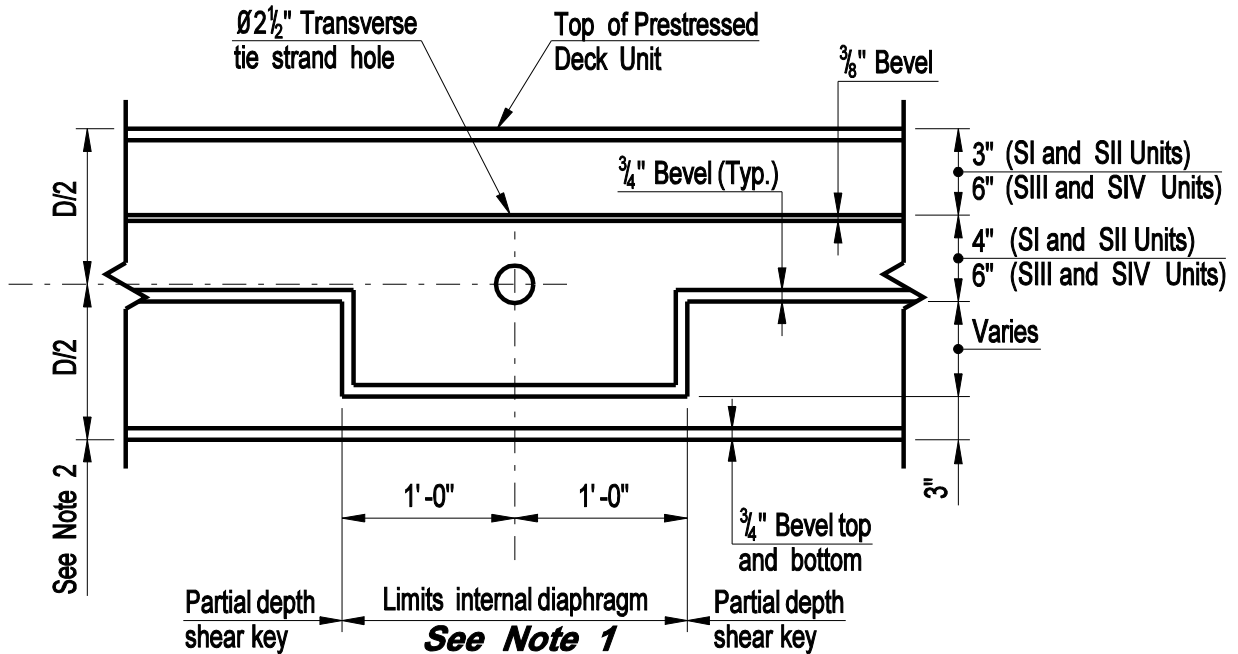
Plate Number:
5.3.6

PRECAST CONCRETE VOIDED SLABS							
BEAM	SPANS	TIE LOCATIONS			TOP	BOTTOM	
		ENDS	1/3 POINTS	MIDSPAN		SKEW $\geq 25^\circ$ or STITCHED BEAMS	SKEW $\geq 25^\circ$
<i>SI Thru SIV</i>	$\leq 40'-0''$	X		X	X		X
	$> 40'-0''$	X	X		X		X

PRECAST CONCRETE BOX BEAMS								
BEAM	SPANS	TIE LOCATIONS				TOP	BOTTOM	
		ENDS	1/4 POINTS	1/3 POINTS	MIDSPAN		SKEW $\leq 25^\circ$ or STITCHED BEAMS	SKEW $\geq 25^\circ$
<i>BI & BI Mod.</i>	$\leq 50'-0''$	X			X	X		X
	$> 50'-0''$	X		X		X		X
<i>BII</i>	$\leq 75'-0''$	X		X		X		X
	$> 75'-0''$	X	X			X		X
<i>BIII</i>	$\leq 75'-0''$	X				X	X	X
	$> 75'-0''$	X	X			X	X	X
<i>BIV & BIV Mod.</i>	ALL	X	X		X	X	X	X

NOTE:

The designer shall investigate the fascia beam for torsional load due to parapet overhang or utilities. Consideration shall be given to increasing the number of lateral tie strands, the amount of post-tensioning and/or providing additional internal diaphragms.

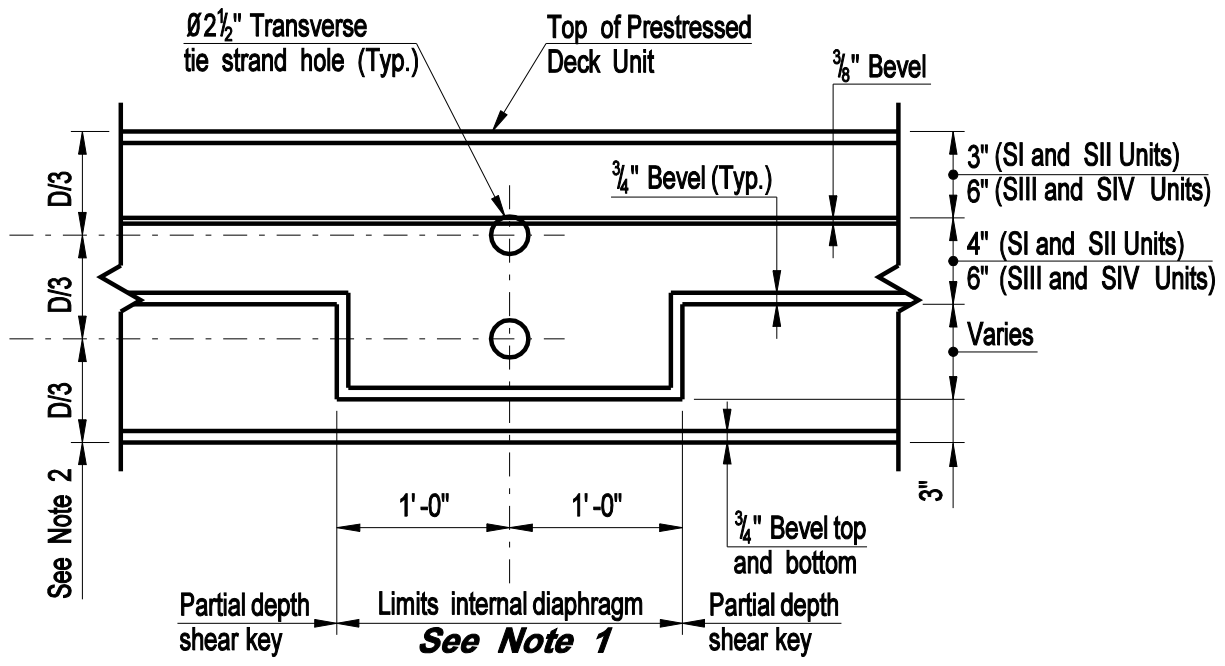


DESIGN INFORMATION

1. If two sets of post-tensioning strands are used for stage construction, the width of the internal diaphragm shall be increased to 2'- 0" plus the longitudinal spacing of the two tie strand holes.

NOTES:

2. The vertical location of the transverse tie strands must be coordinated with the location of the prestressed strands and adjusted as necessary by the fabricator.

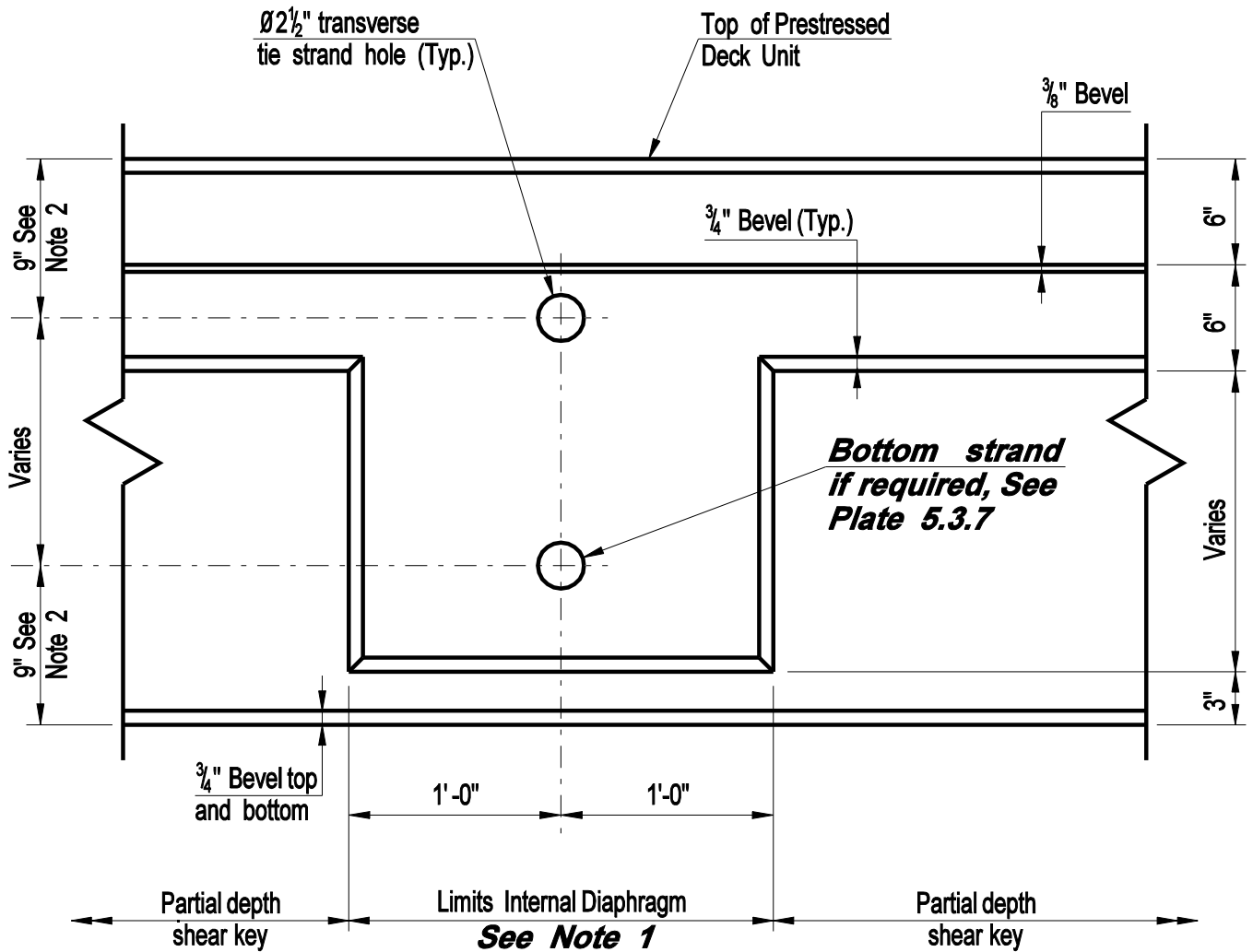


DESIGN INFORMATION

1. If two sets of post-tensioning strands are used for stage construction, the width of the internal diaphragm shall be increased to 2'-0" plus the longitudinal spacing of the two tie strand holes.

NOTES:

2. The vertical location of the transverse tie strands must be coordinated with the location of the prestressed strands and adjusted as necessary by the fabricator.

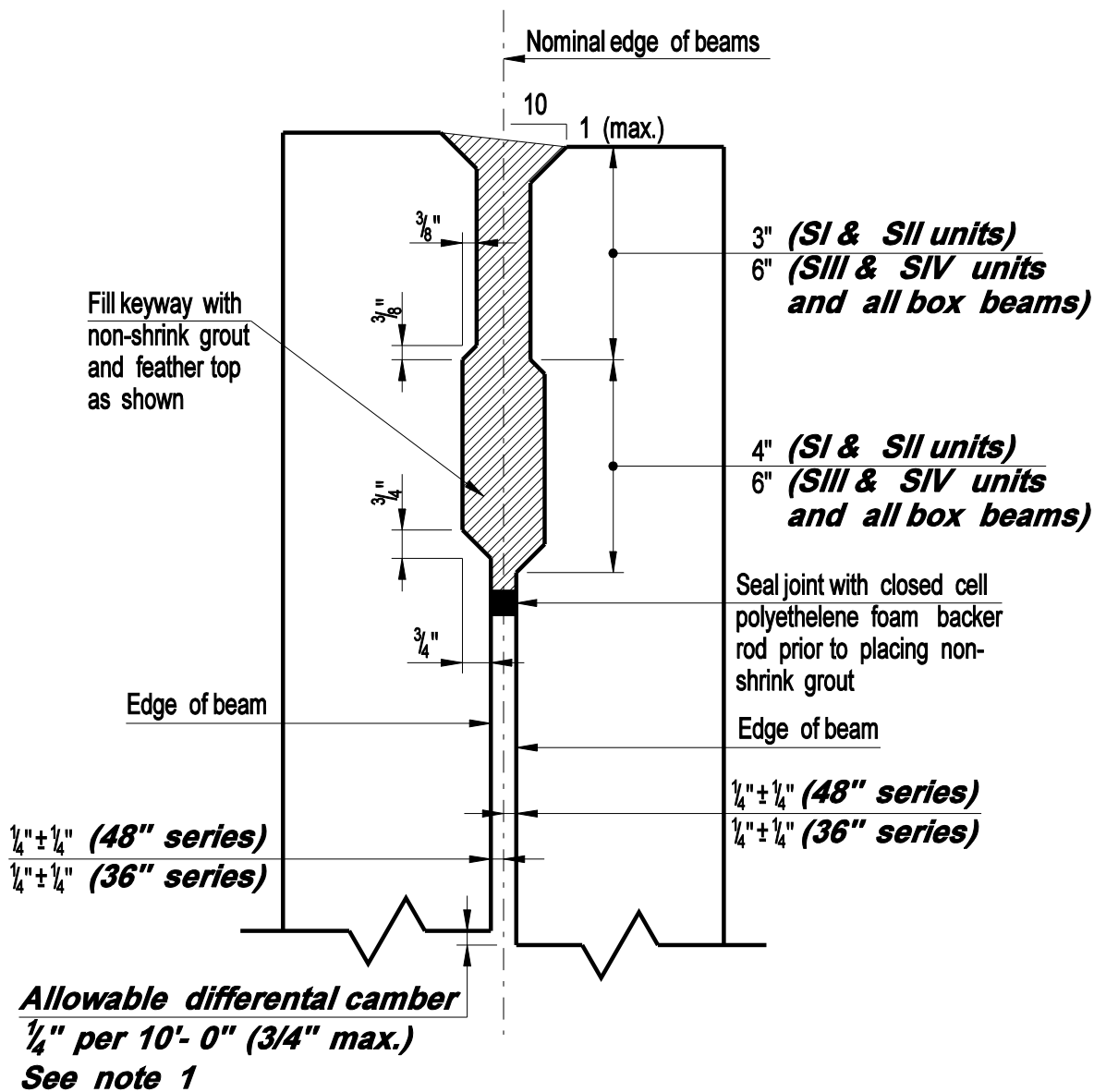


DESIGN INFORMATION

- 1. If two sets of post-tensioning strands are used for stage construction, the width of the internal diaphragm shall be increased to 2'- 0" plus the longitudinal spacing of the two tie strand holes.***

NOTES:

- 2. The vertical location of the transverse tie strands must be co-ordinated with the location of the prestressed strands and adjusted as necessary by the fabricator.**



DESIGN INFORMATION

1. The variation indicated is due to fabrication tolerances for sweeps and camber of the deck units.

NOTES:

2. The deck units shall be placed at the nominal spacing shown on the plan with a gap between the units. The width of the gaps will vary due to the sweep of the units.
3. Grout for shear keys shall be rodded or vibrated to ensure that all voids in the shear keys are filled.

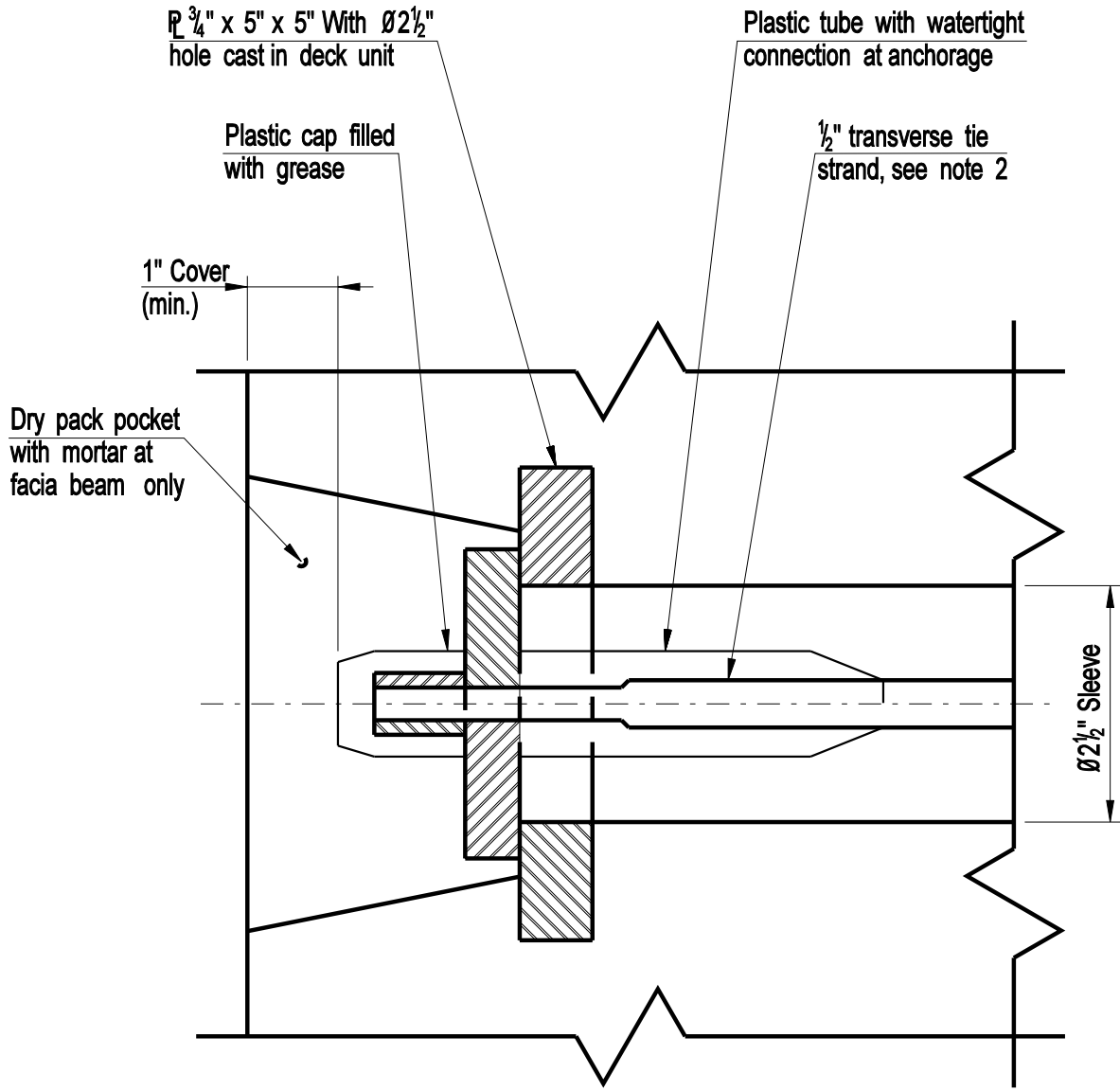
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

VACANT

Issue Date: 10/03

Revision Date:

Plate Number:
5.3.12



TRANSVERSE TIE POCKET DETAIL

NOTES:

1. Other anchorage systems may be substituted with the approval of the Engineer. Alternate anchorage systems shall be watertight and corrosion proof.
2. 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.

CONNECTICUT BRIDGE DESIGN MANUAL	TRANSVERSE TIE ANCHORAGE PRECAST CONCRETE DECK UNITS	Issue Date: 10/03
		Revision Date:
		Plate Number: 5.3.13

FOR SKEWS $\leq 35^\circ$:

TRANSVERSE TIE TENSIONING NOTES:

1. After all beams have been erected, tension each transverse tie to 5 kips.
2. Fill all keyways with non-shrink grout. The contractor shall cover and protect the keyways from the weather and debris until they are filled.
3. After the grout has attained a strength of 1500 psi (based on the manufacturers directions) tension each transverse tie to 30 kips. No traffic or heavy equipment will be permitted on the beams until all ties have been fully tensioned.

(The above note applies to units with single transverse ties. See Plate 5.3.7)

After the grout has attained a strength of 1500 psi (based on the manufacturers directions) at each transverse tie location, tension the bottom tie to 15 kips, then the top tie to 15 kips. Repeat the sequence once more so that each strand has 30 kips of tension. No traffic or heavy equipment will be permitted on the beams until all ties have been fully tensioned.

(The above note applies to units with double transverse ties. See Plate 5.3.7)

4. Concrete for sidewalk, curb and/or barrier sections shall not be placed until the transverse ties have been fully tensioned.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

TRANSVERSE TIE TENSIONING
NOTES - PRECAST CONCRETE
BOX BEAMS (SKEWS $\leq 35^\circ$)

Issue Date: 10/03

Revision Date:

Plate Number:
5.3.14

FOR SKEWS > 35°:

TRANSVERSE TIE TENSIONING NOTES:

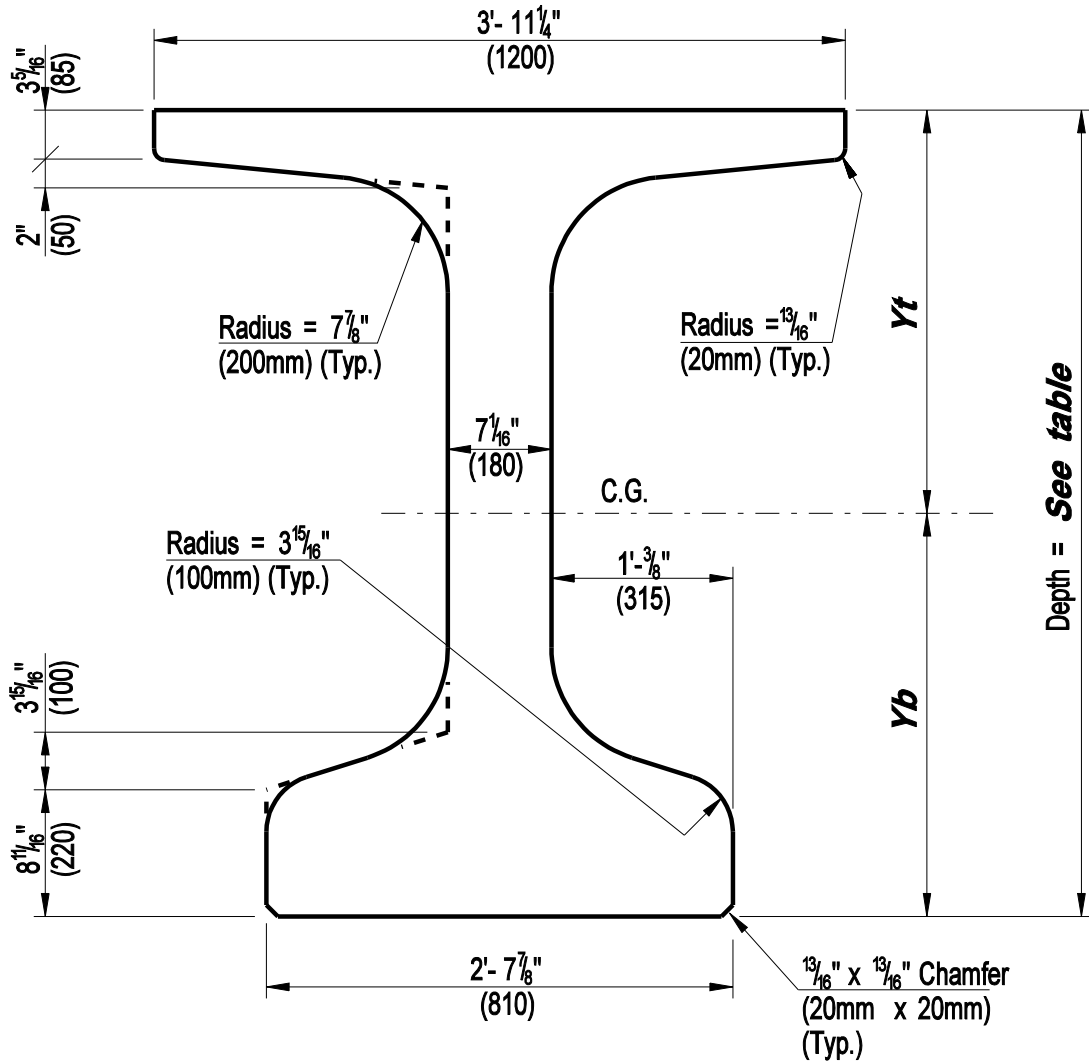
1. As each beam is being erected, install the transverse ties with hardwood wedges between the beams at each transverse tie location at the top and bottom of the beam.
2. Secure each beam to the preceding beam by tensioning each transverse tie to 30 kips before erecting the next beam.

***(The above note applies to units with single transverse ties.
See Plate 5.3.7)***

Secure each beam to the preceding beam by first tensioning the bottom tie at each transverse tie location to 15 kips, then the top tie to 15 kips. Repeat the sequence once more so that each tie has 30 kips of tension before erecting the next beam.

***(The above note applies to units with double transverse ties.
See Plate 5.3.7)***

3. Fill all keyways with non-shrinking grout after transverse ties have been tensioned. The contractor shall cover and protect the keyways from the weather and debris until they are filled. No traffic or heavy equipment will be permitted on the beams until all keyways have been filled and the grout has cured.
4. When the grout has attained a strength of 1500 psi (based on grout manufacturers directions) the wedges shall be removed and voids left by the top wedges shall be filled with grout.
5. Concrete for sidewalk, curb and/or barrier sections shall not be placed until grout has attained a strength of 1500 psi.



Beam Type	Depth (in)	Weight (lbs/ft)	Area (in ²)	I _x c.g. (in ⁴)	I _y c.g. (in ⁴)	Y _t (in)	Y _b (in)	S _t (in ³)	S _b (in ³)
NEBT 1000	39.37	777.47	745.55	149,196	61,744	20.35	19.02	7323	7872
NEBT 1200	47.24	835.26	801.35	238,089	61,985	24.61	22.64	9703	10,496
NEBT 1400	55.12	893.72	857.15	353,169	62,225	28.86	26.26	12,205	13,425
NEBT 1600	62.99	951.51	912.95	492,514	62,465	33.03	29.96	14,890	16,415
NEBT 1800	70.87	1009.97	968.75	666,690	62,706	37.20	33.66	17,758	19,589

DESIGN INFORMATION

- $f'_c = 6500$ psi (precast)
 $f'_c = 4500$ psi (deck)
 Max. Beam spacing = 6'- 6"
 Allowable Tension = 0.0

2. Metric dimensions are given () for correlation to standard NEBT metric forms.

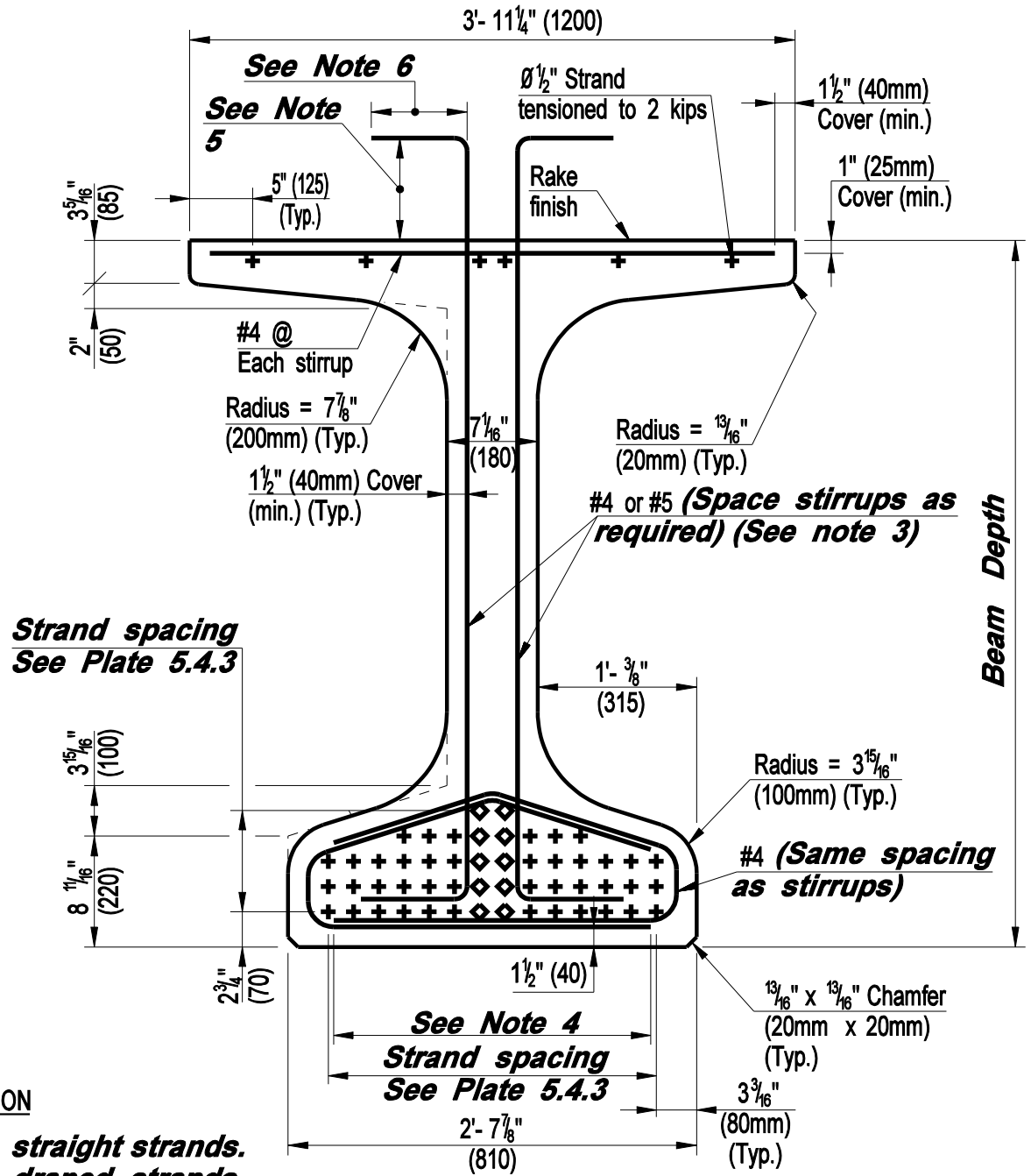
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

SECTION PROPERTIES
NEW ENGLAND BULB TEES
(TYPE NEBT 40 - 72)

Issue Date: 10/03

Revision Date:

Plate Number:
5.4.1



DESIGN INFORMATION

1. + Denotes straight strands.
2. ◇ Denotes draped strands.
3. Stirrups to be designed in accordance with AASHTO shear reinforcement requirements.
4. Lap splices in accordance with AASHTO requirements
5. Stirrups shall be checked for horizontal shear at the interface with the deck. Provide 6" (150mm) minimum embedment and 2" (50mm) minimum cover at top of deck.
6. Top of stirrups to constitute a standard hook in accordance with AASHTO.
7. Metric dimensions are given () for correlation to standard NEBT metric forms.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

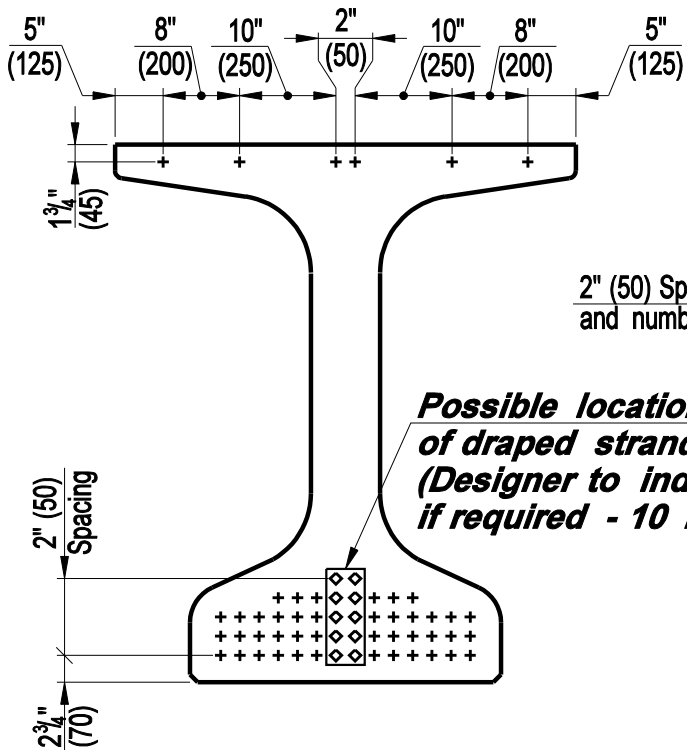
**TYPICAL MIDSPAN SECTION
NEW ENGLAND
BULB TEE BEAMS**

Issue Date: 10/03

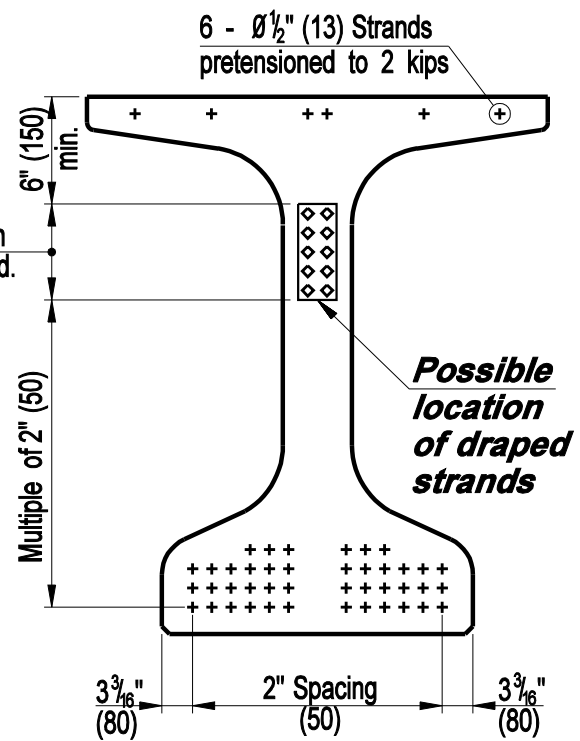
Revision Date:

Plate Number:

5.4.2



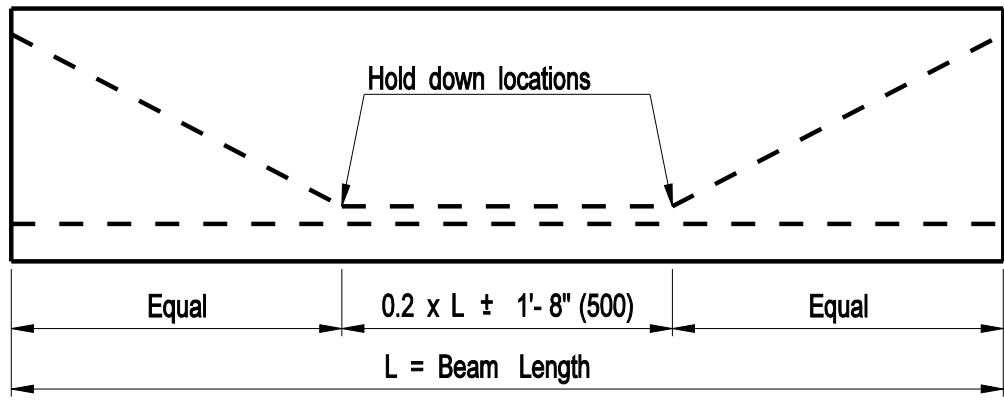
STRAND LOCATION MIDSPAN



STRAND LOCATION BEAM END

DESIGN INFORMATION

1. + Denotes straight strands.
2. ◇ Denotes draped strands.
3. Strands in top flange are for fabrication purposes only and are not considered in the design.
4. Strands shall be placed within a 2" x 2" (50mm x 50mm) grid. The number and location of the strands shall be as required by design.
5. Metric dimensions are given () for correlation to standard NEBT metric forms.



HOLD DOWN POINTS FOR DRAPED STRANDS

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

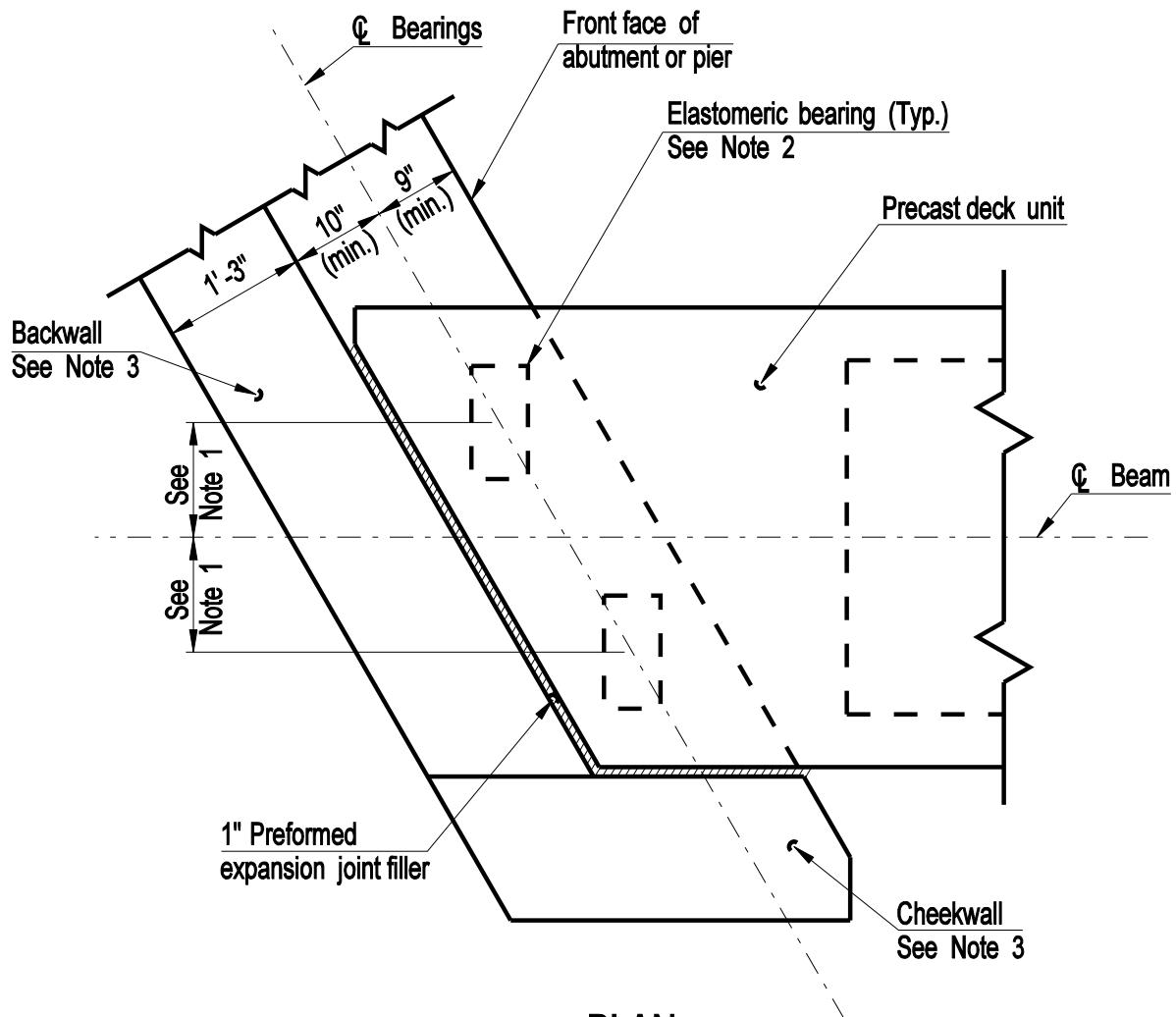
**STRAND LOCATIONS AND
HOLD DOWN DETAIL NEW
ENGLAND BULB TEE BEAMS**

Issue Date: 10/03

Revision Date:

Plate Number:

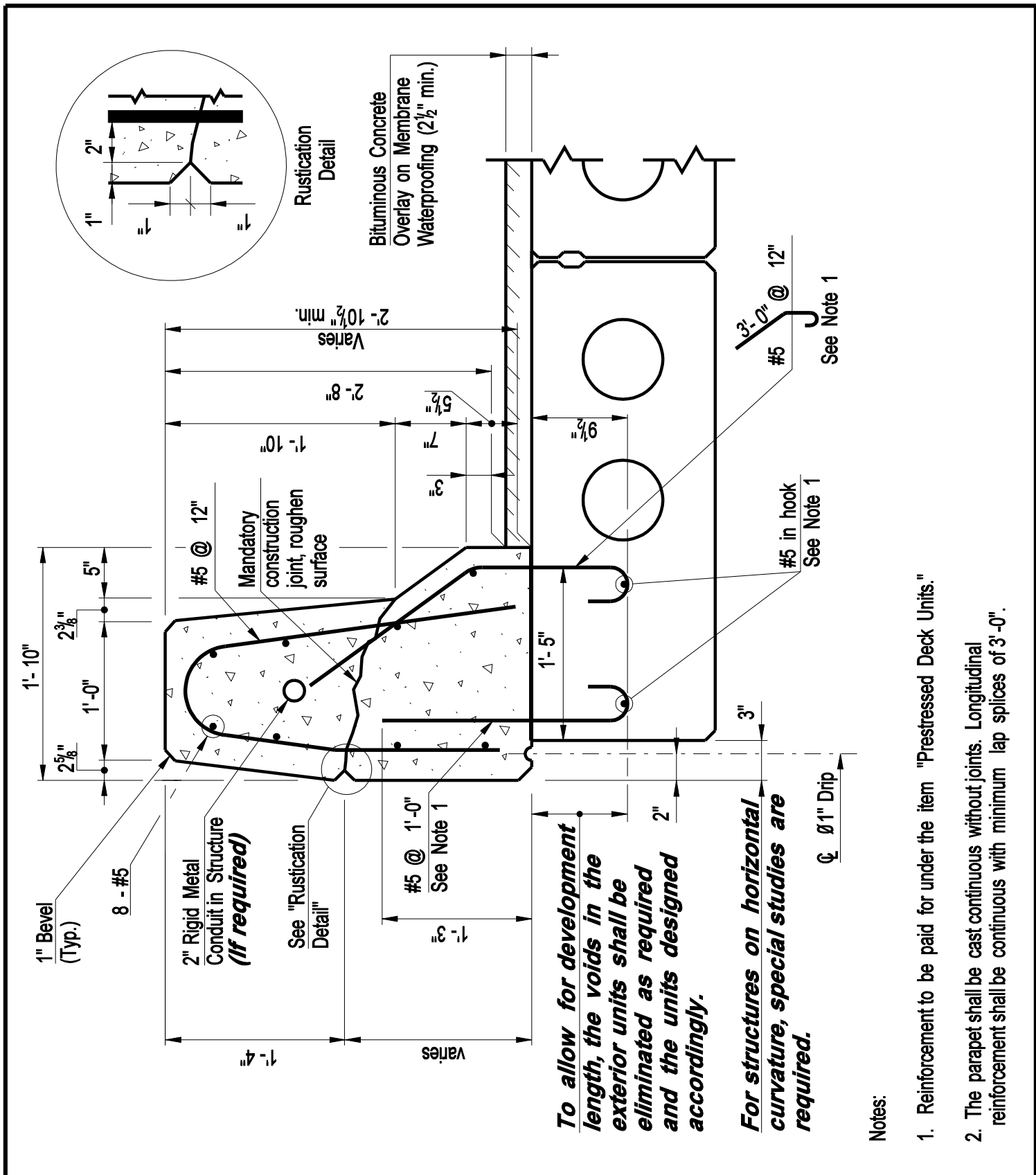
5.4.3



PLAN
ELASTOMERIC BEARING LAYOUT

NOTES:

1. This dimension shall be the nominal beam spacing divided by four.
2. Elastomeric bearing shall be designed according to Section 14 of the AASHTO specifications. Neoprene shims may be used to provide uniform bearing on pads offset by beam skew.
3. The backwall and cheekwall shall be designed to resist longitudinal and transverse seismic forces.

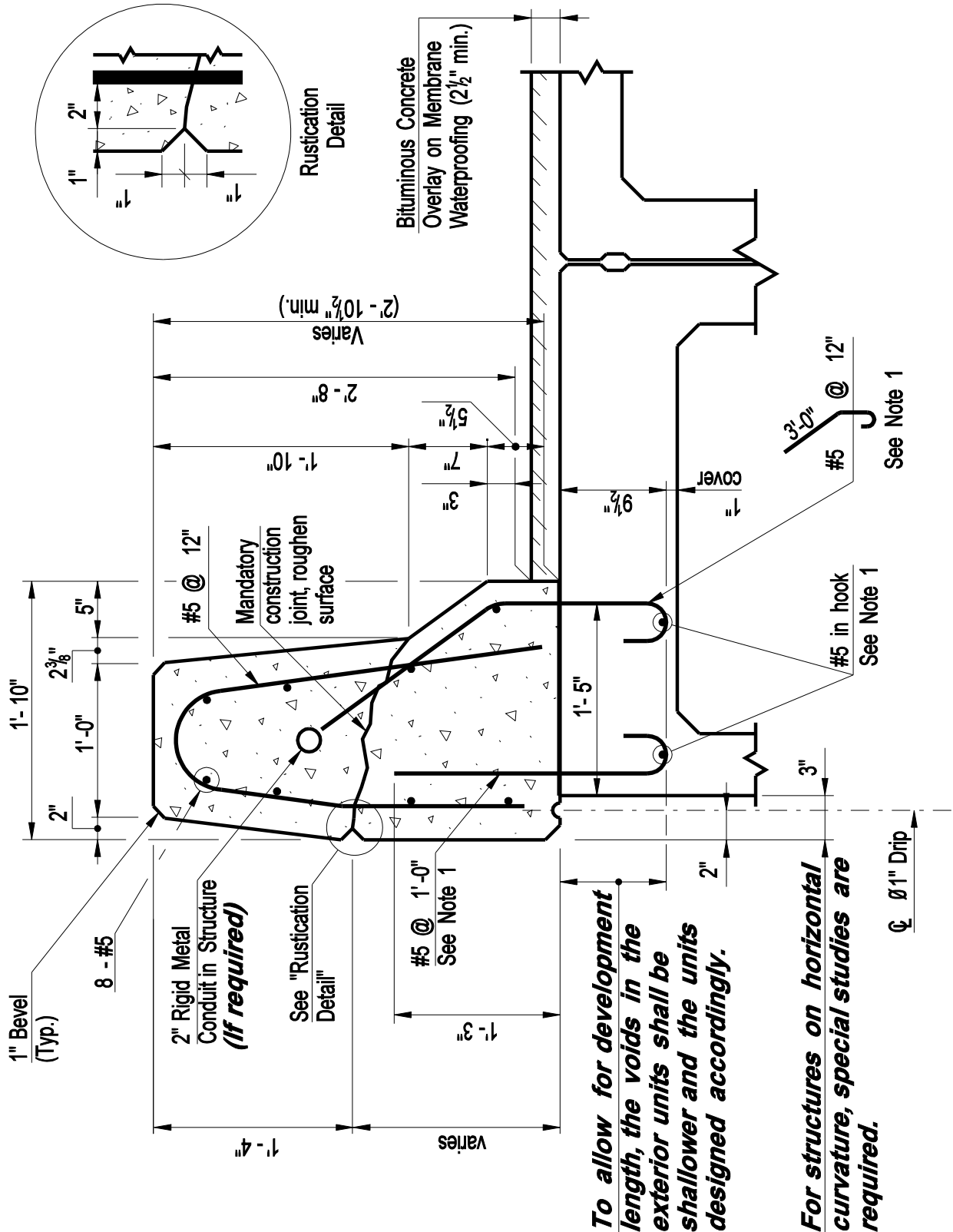


To allow for development length, the voids in the exterior units shall be eliminated as required and the units designed accordingly.

For structures on horizontal curvature, special studies are required.

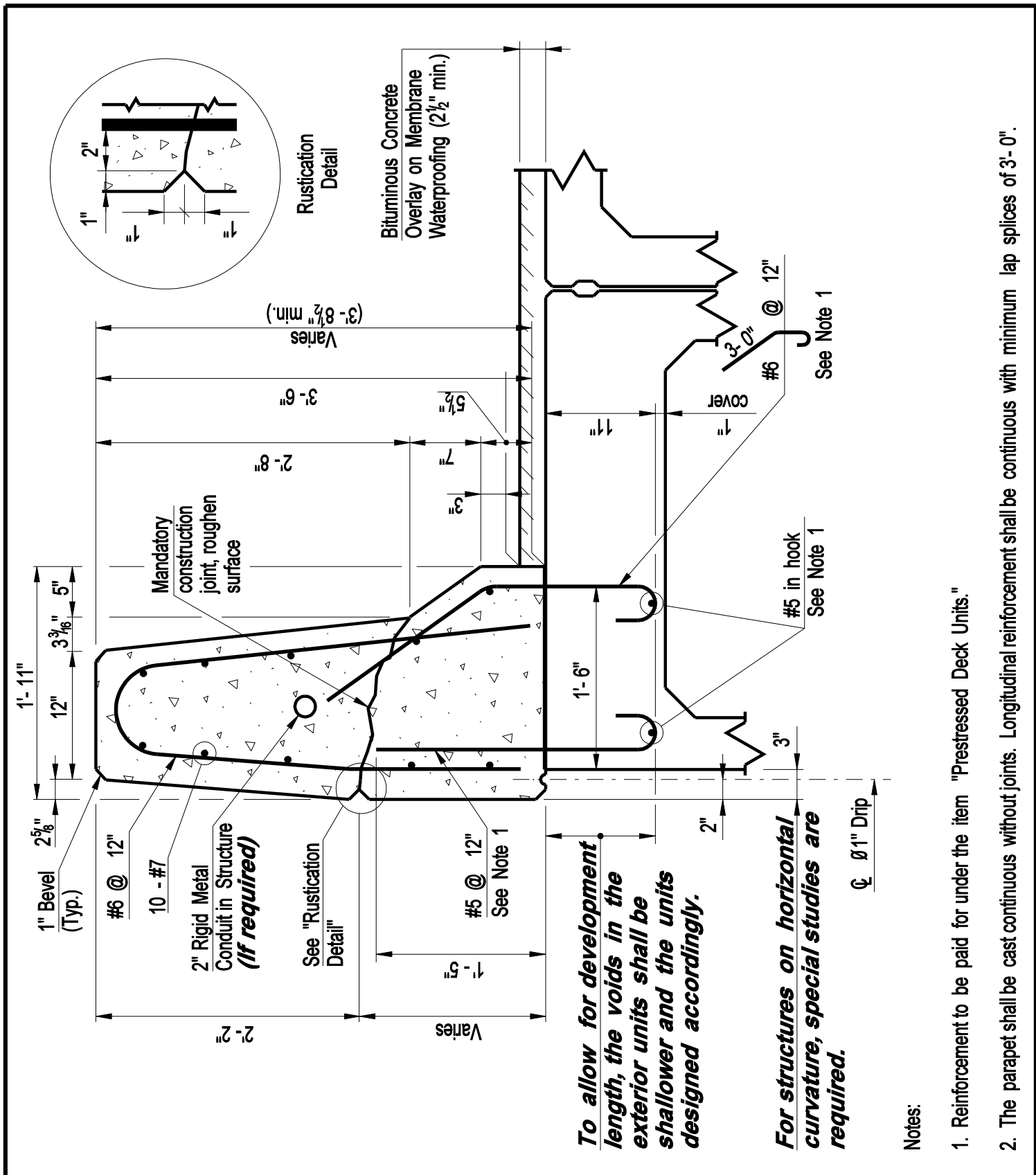
Notes:

1. Reinforcement to be paid for under the item "Prestressed Deck Units."
2. The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'-0".



Notes:

1. Reinforcement to be paid for under the item "Prestressed Deck Units."
2. The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'-0".



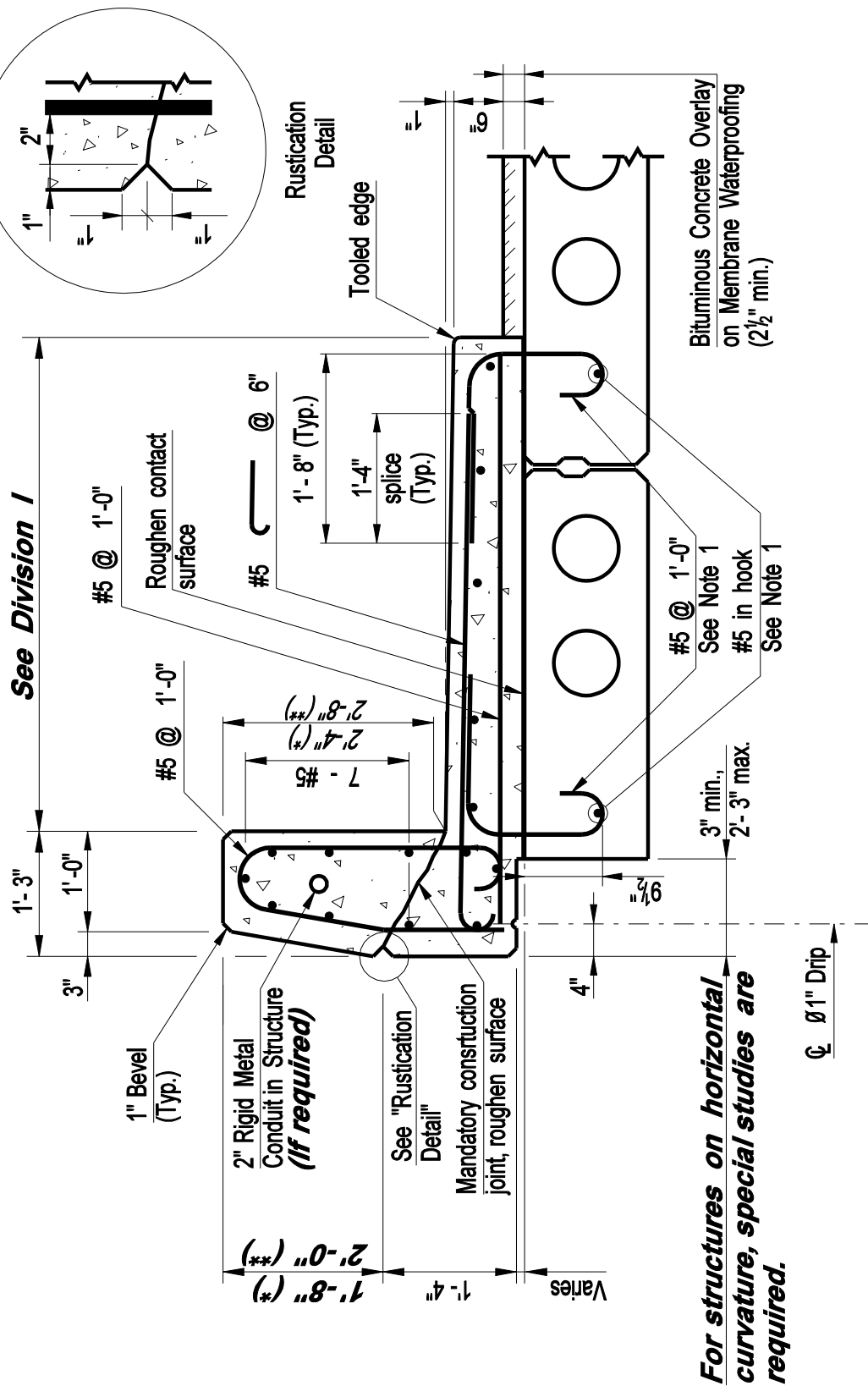
Notes:

1. Reinforcement to be paid for under the item "Prestressed Deck Units."
2. The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'-0".

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**PARAPET WITH SIDEWALK
(ON VOIDED SLABS)**

Issue Date: 10/03
Revision Date:
Plate Number: 5.6.5

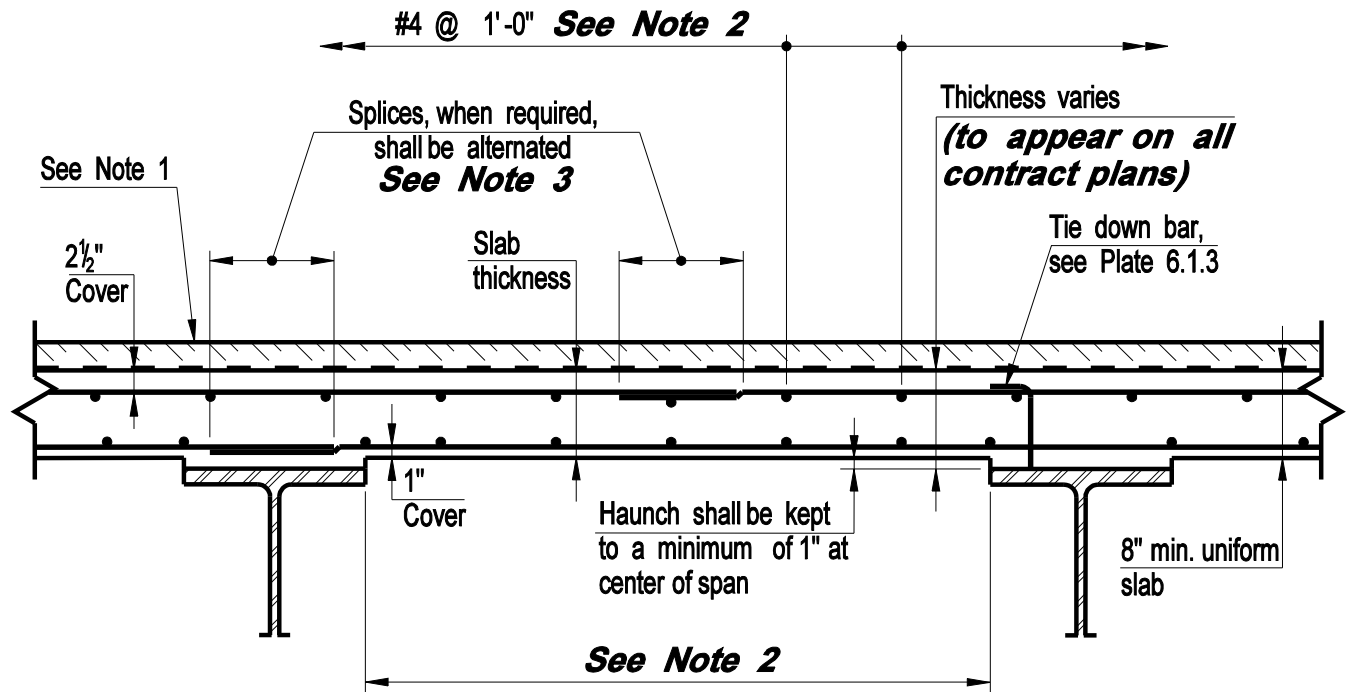


Notes:

1. Reinforcement to be paid for under the item "Prestressed Deck Units."
2. The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'-0".

DESIGN INFORMATION

* with protective fence
** with pedestrian railing



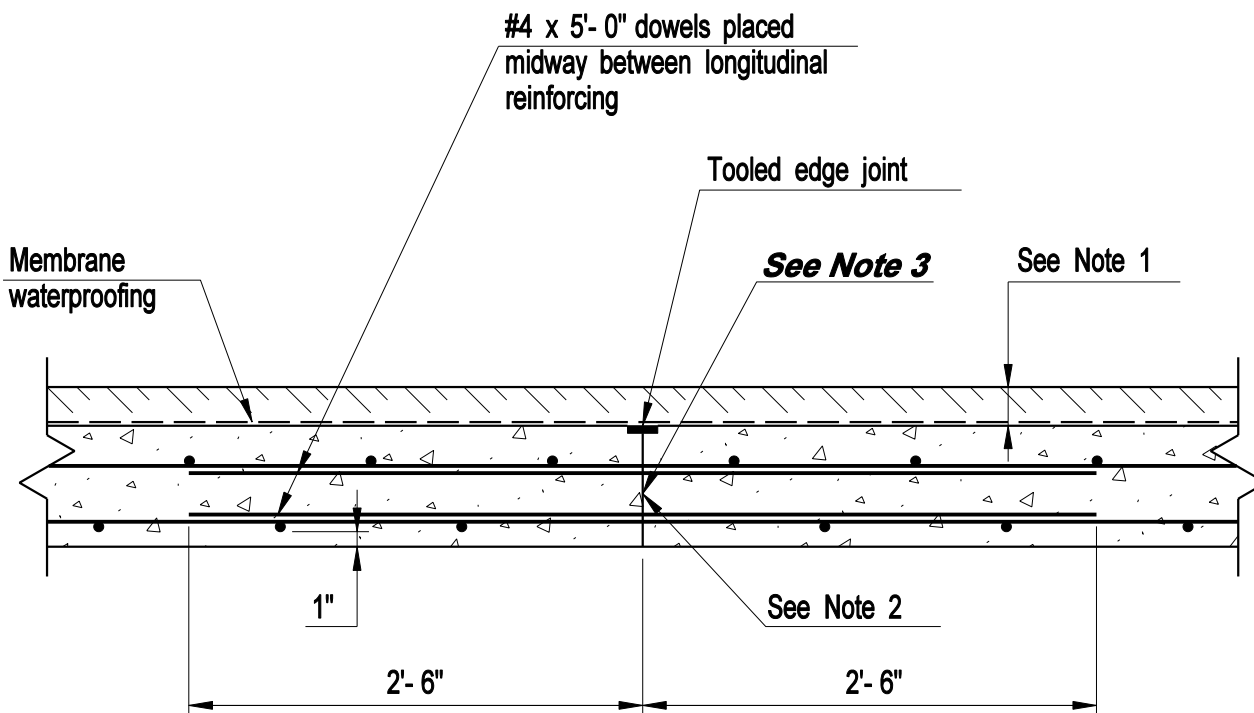
NOTES:

1. 2 1/2" bituminous concrete overlay on membrane waterproofing

DESIGN INFORMATION:

2. Bars shall be designed in accordance with current AASHTO specifications. For additional longitudinal slab reinforcement at ends of slab, see Plate 6.1.4. For additional slab reinforcement at acute corners, (skew angle greater than 20°), see Plate 6.1.5a.

3. Splices and development lengths shall be determined by the designer in accordance with the latest AASHTO design criteria.

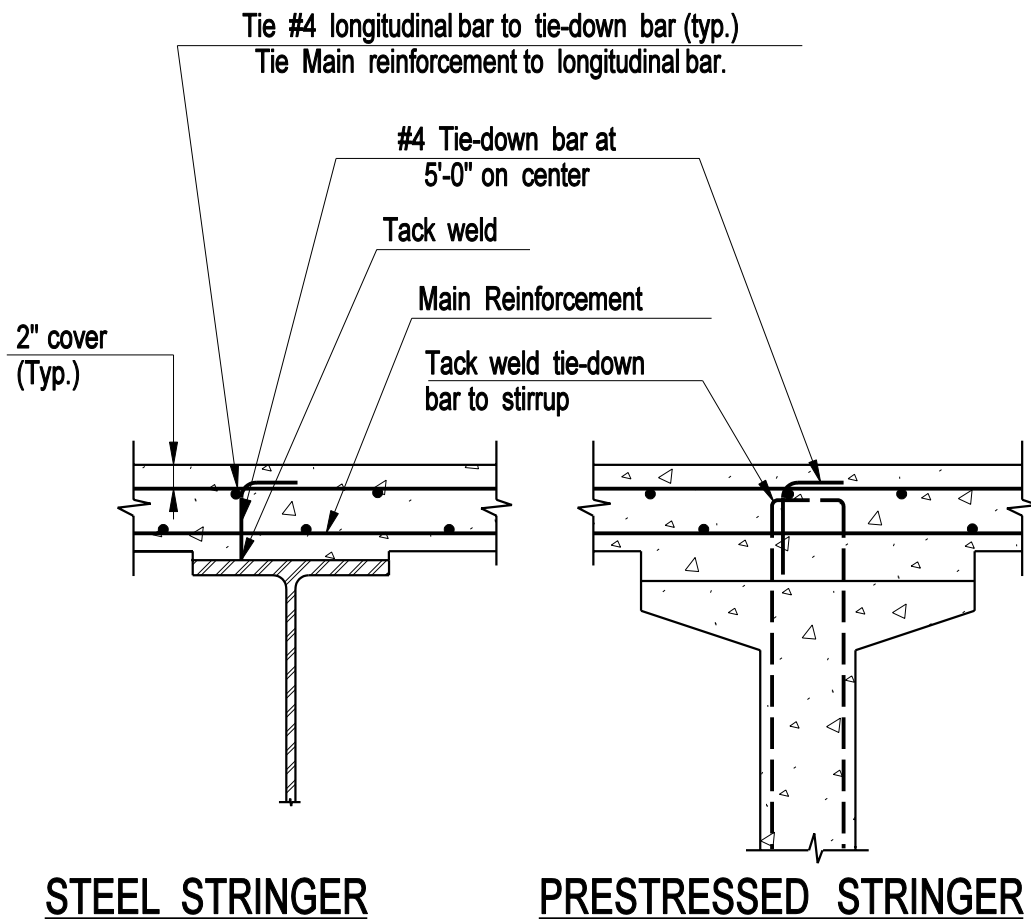


NOTES:

1. 2½" bituminous concrete overlay on membrane waterproofing
2. Roughen surface, blast clean then apply a neat cement grout or other suitable bonding material immediately prior to placing adjacent pour. **See Note 3.**

DESIGN INFORMATION:

3. **Transverse reinforcement placed on a skew to this joint shall be continuous through this joint.**
4. **This joint shall be allowed and shown on the plans only when sequence of pour is required.**

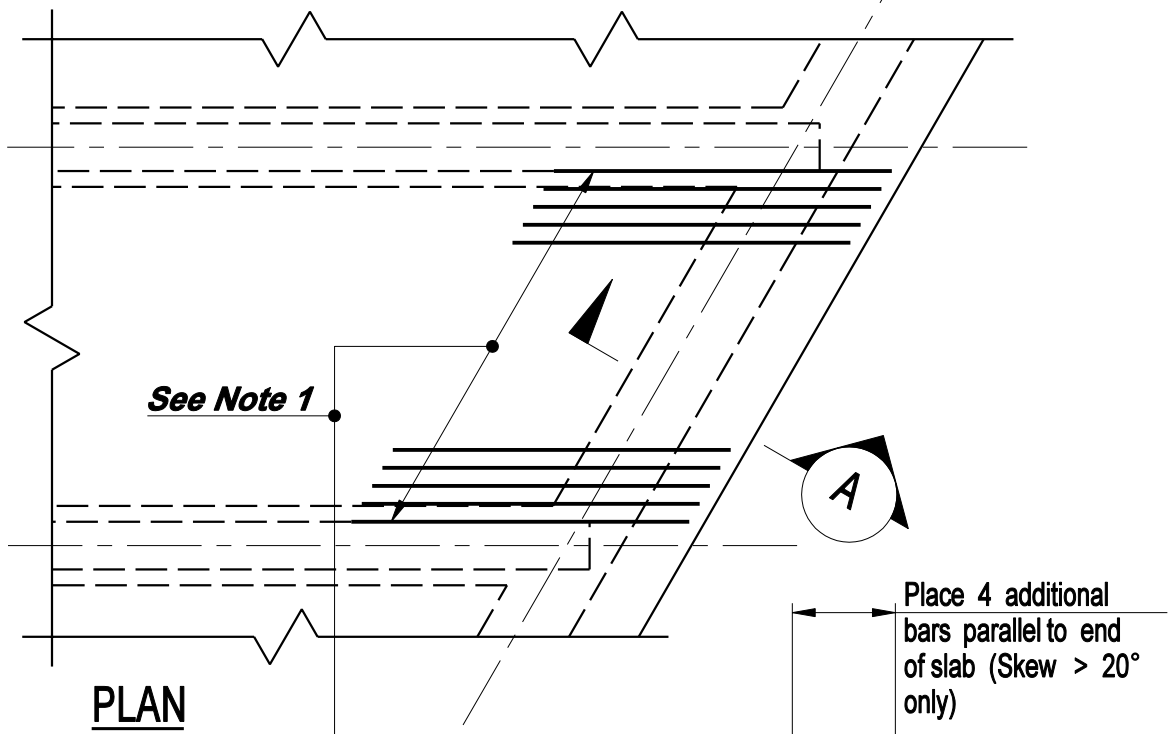


PLAN NOTES

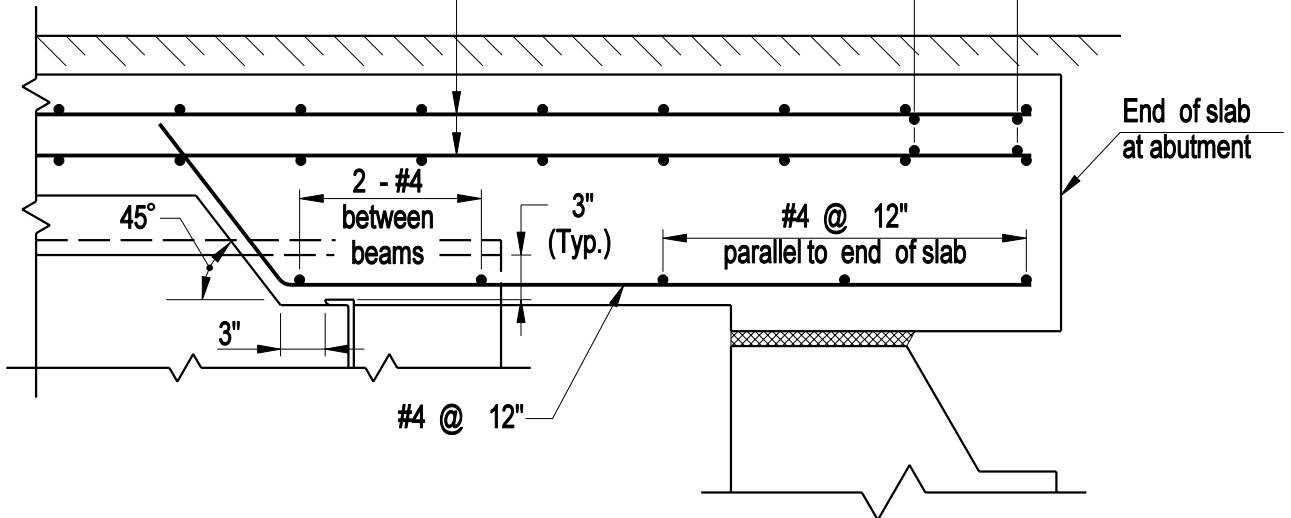
1. Tie-down bars do not exclude the use of chairs for supporting the reinforcement mat.
2. The cost of furnishing and placing tie-down bars to be included in the contract item "Deformed Steel Bars".
3. Tie-down bars and longitudinal bars shall clear shear connectors.

DESIGN INFORMATION:

Tie-downs for reinforcement shall not be welded to steel members or parts subjected to tensile stress unless the range of stress at the point of attachment does not exceed the allowable range as stated in the current AASHTO specifications. Hence the plans shall indicate the locations where this attachment shall not be tack welded to the tension flanges with the following note: "No attachment shall be fillet welded, plug welded or tack welded to the tension flange within these limits."



PLAN



SECTION A

DESIGN INFORMATION

1. Place additional #5 bars midway between longitudinal bars on both fixed and expansion ends, at piers and abutments.

Spans < 50'- 0"

Spans > 50'- 0" to 80'- 0"

Spans > 80'- 0"

Use #4 x 5'- 0"

Use #4 x 8'- 0"

Use #4 x 10'- 0"

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

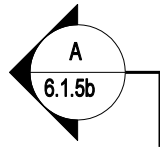
**DETAILS
AT ENDS OF SLAB
(STEEL STRINGERS)**

Issue Date: 10/03

Revision Date:

Plate Number:

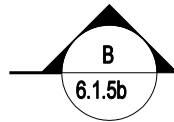
6.1.4



Place additional reinforcement (top only) in this area. (#5 @ 9")

Reinforcement designed for slab continuous over 3 or more supports

Limits of thickened slab

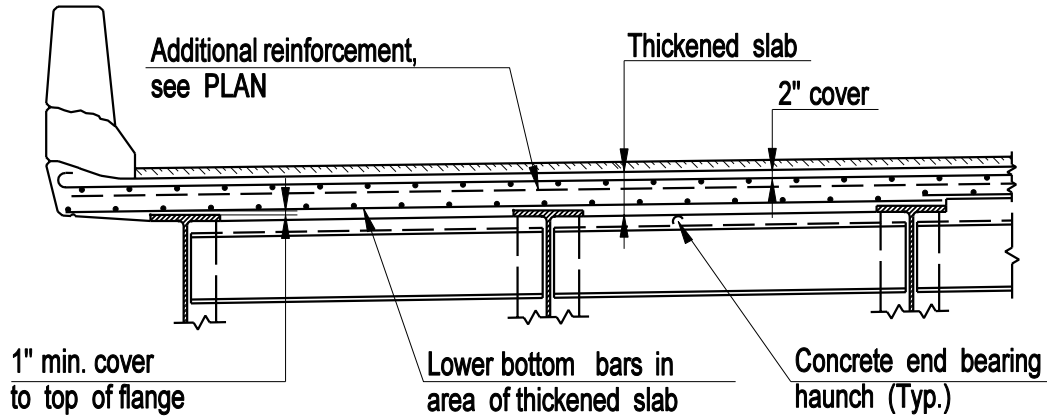


Reinforcement designed for slab simply supported using increased depth

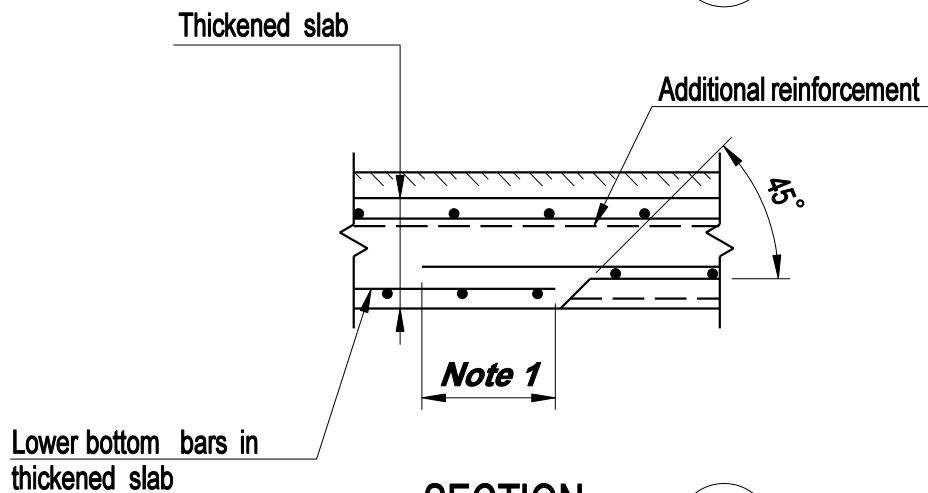
PLAN

DESIGN INFORMATION

For design information, see Plate 6.1.5b



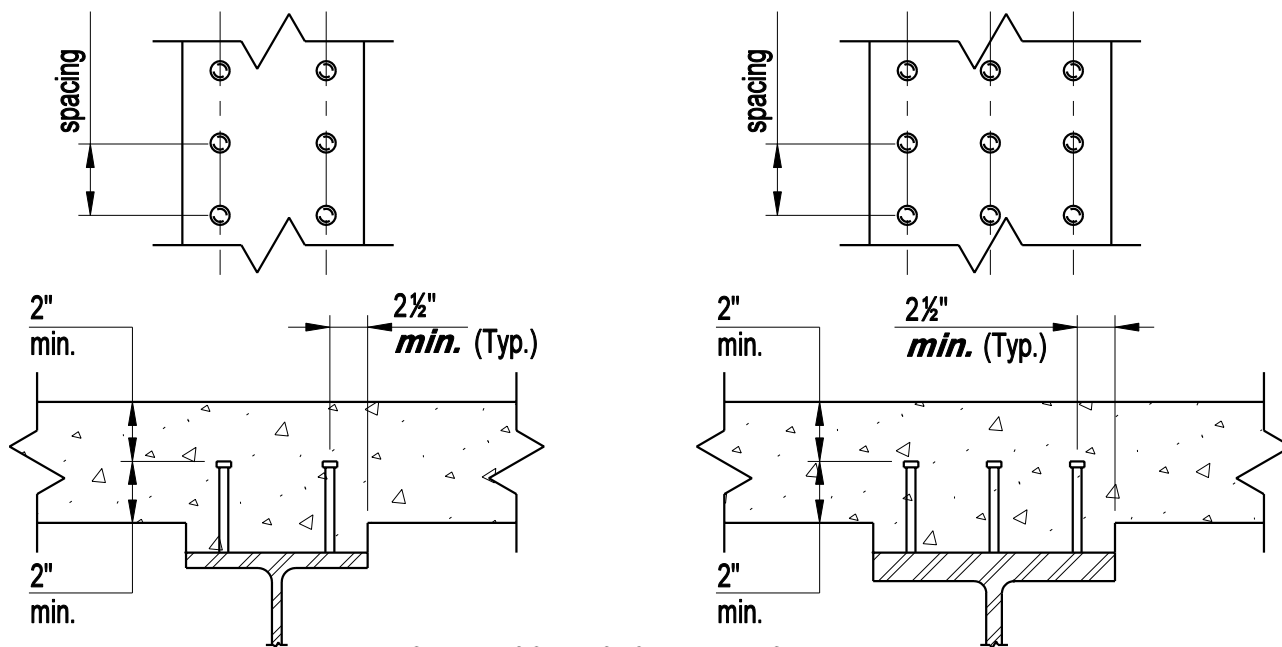
SECTION A



SECTION B

DESIGN INFORMATION

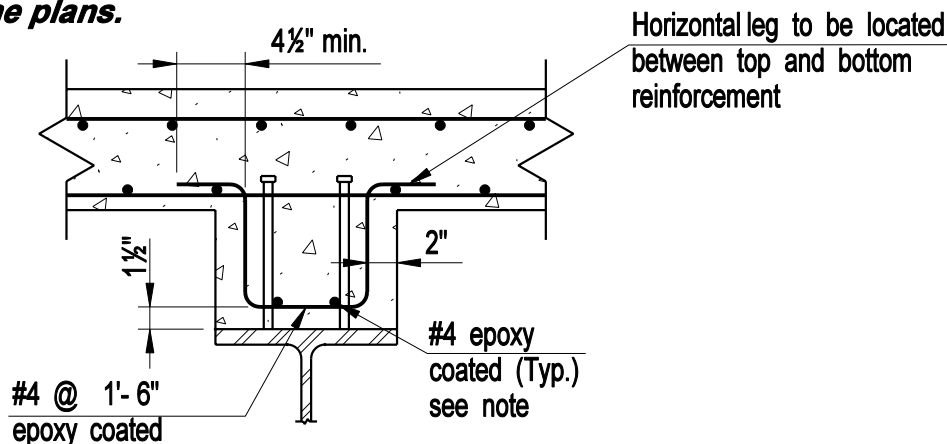
1. *Splice length shall be determined by the designer in accordance with the latest AASHTO design criteria.*
2. *Longitudinal reinforcement not indicated in "PLAN", detail shown at abutment, detail at pier similar.*



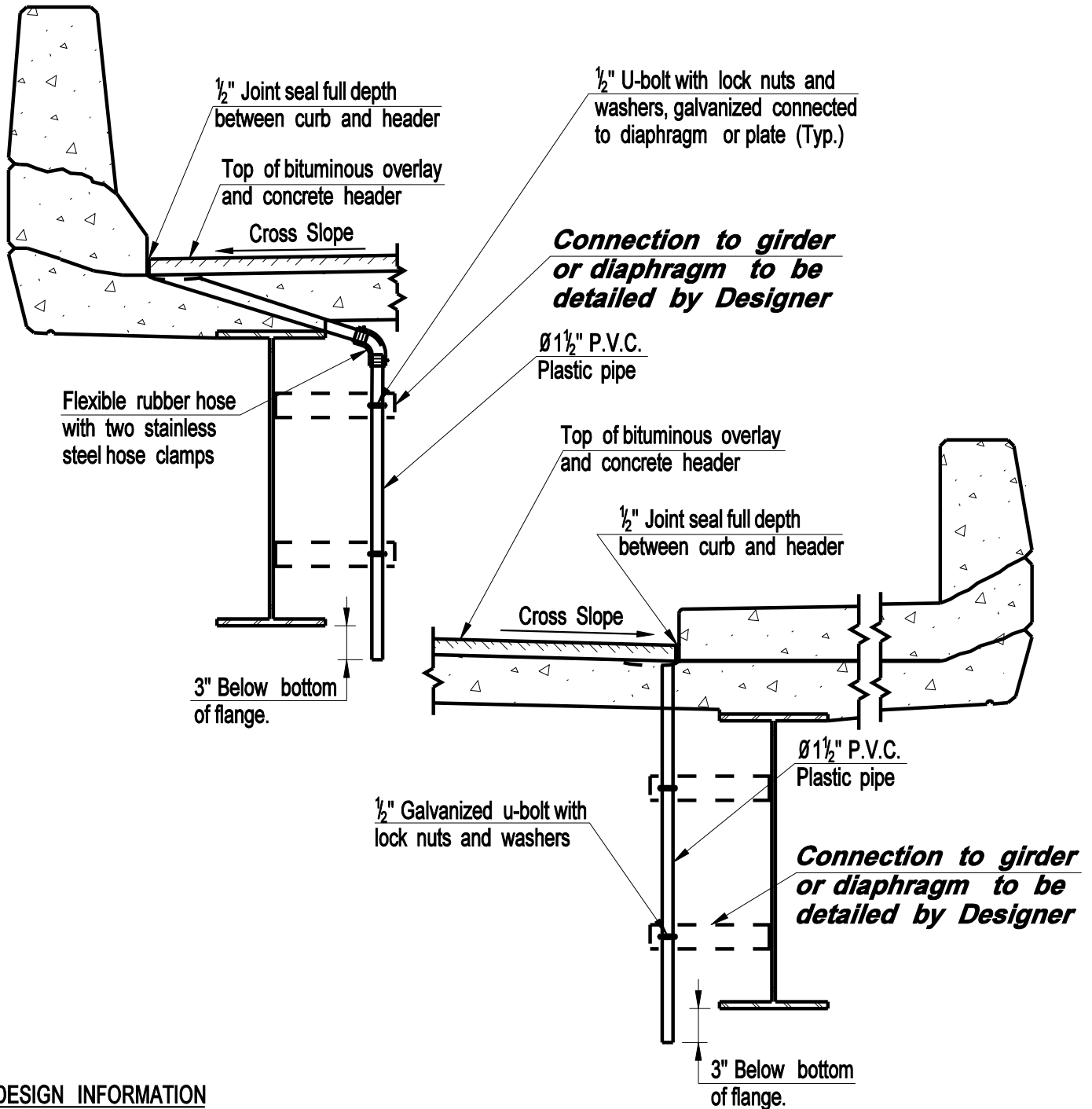
SHEAR CONNECTOR DETAILS

DESIGN INFORMATION

- 1. Preference shall be given to the use of 7/8" Ø studs. Lengths of studs shall be in increments of 1". Maximum permissible length of studs is 8". If the stud length required is in excess of 8", the required length may be obtained by stacking. Stacking of studs is provided for use in the specifications.**
- 2. Actual lengths or quantities of studs will not be given on the plans but shall be determined by the Contractor in accordance with the requirements shown in the details.**
- 3. Where the maximum depth of the haunch is excessive and studs are to be stacked, the haunch shall be reinforced as shown below.**
- 4. Haunch reinforcement shown is for haunch depth of 4" to 6". Reinforcement is not required for haunch depth less than 4". Reinforcement shall be designed for haunch depth greater than 6". If haunch depth in excess of 4" is anticipated, this detail shall be shown on the plans.**



**HAUNCH REINFORCEMENT DETAIL
(SEE NOTE 4)**



DESIGN INFORMATION

- 1. In no case shall weepholes on bridges with welded steel girders or rolled beams outlet on the outside of fascia girder. Omit weepholes in cases where outletting on the inside is not feasible.**
- 2. For additional notes and design information, see Plate 6.1.9.**

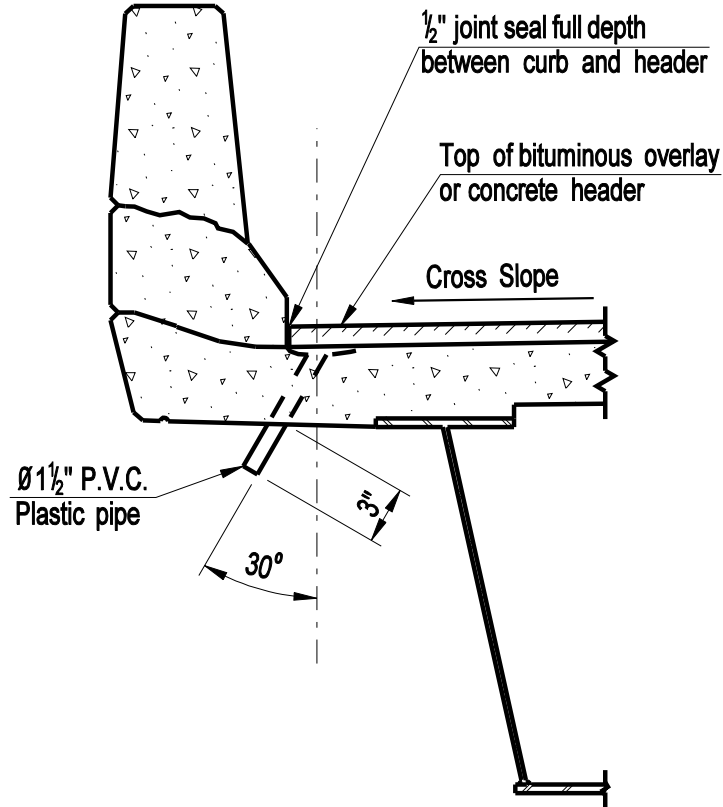
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**DECK WEEPHOLE DETAILS
(WELDED GIRDERS AND
ROLLED BEAMS)**

Issue Date: 01/05

Revision Date:

Plate Number:
6.1.7



DESIGN INFORMATION

1. *Similar details may be used for bridges with concrete beams.*
2. *In no case shall weepholes which outlet on the outside of fascia girder extend more than 3" below the bottom of slab. Omit weepholes in cases where steel flanges or bearings are exposed to leakage.*
3. *For additional notes and design information, see Plate 6.1.9.*

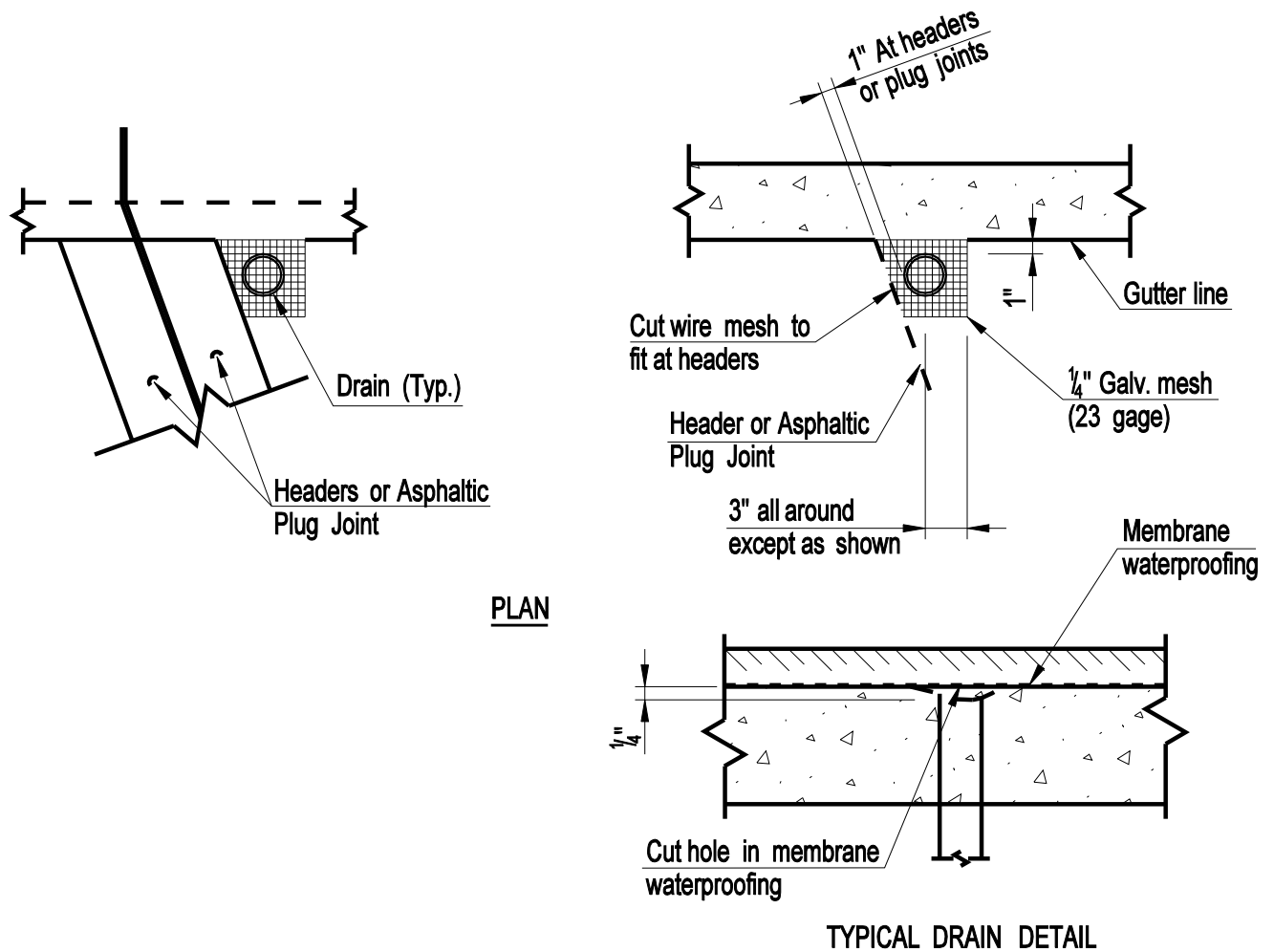
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**DECK WEEPHOLE DETAILS
(STEEL BOX GIRDERS)**

Issue Date: 01/05

Revision Date:

Plate Number:
6.1.8



PLAN

TYPICAL DRAIN DETAIL

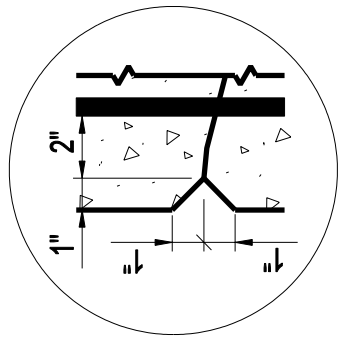
NOTES:

The cost of furnishing and installing $\frac{1}{4}$ " square galvanized wire mesh shall be included in the contract bid price for "Superpave 0.25".

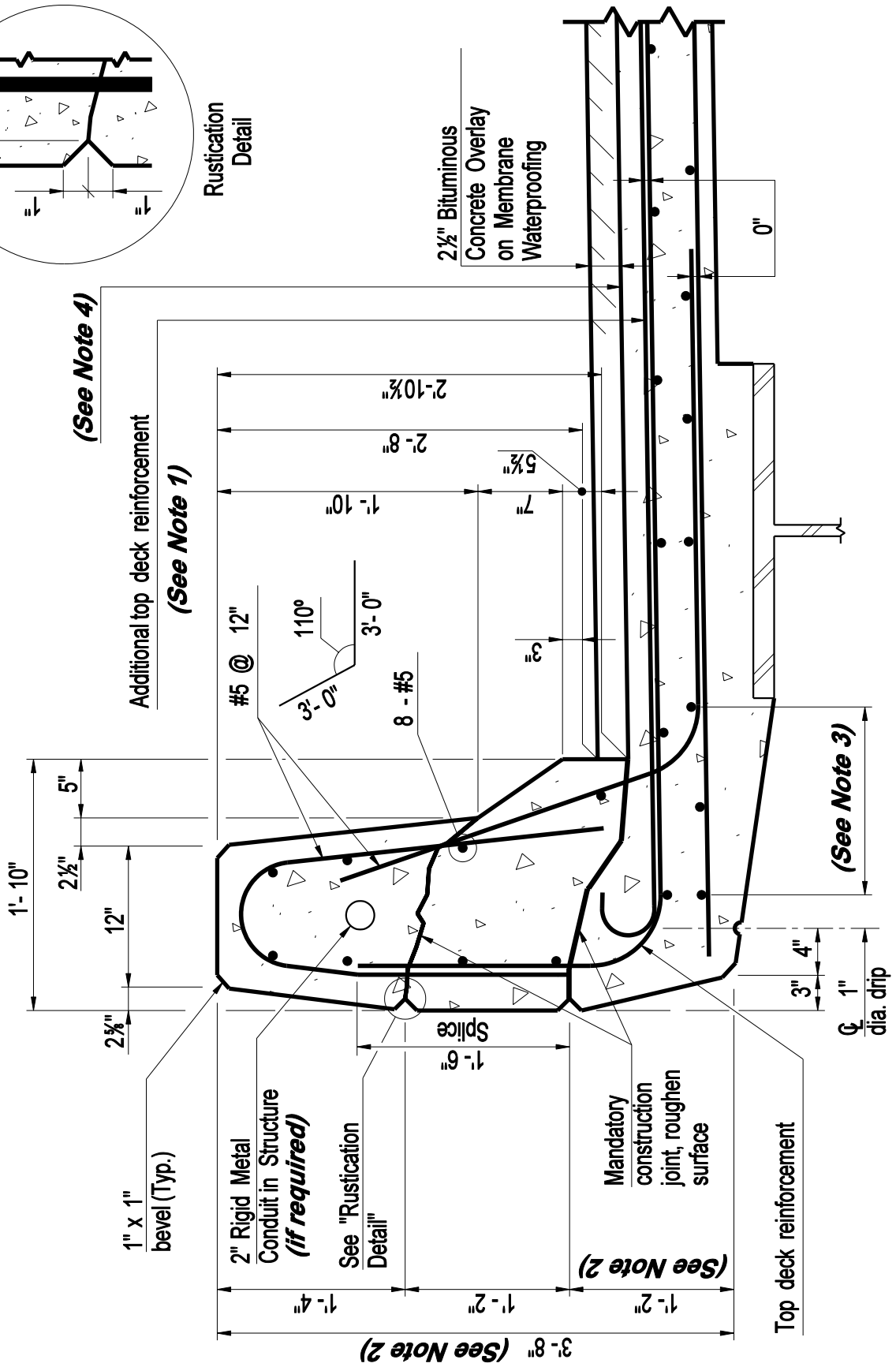
DESIGN INFORMATION

1. Weepholes to be located by the designer as follows:

Weepholes shall be placed along gutter line on the low end of cross slopes adjacent to headers and joints at the low end of span only. No weepholes shall be placed where they will drain onto travelways, shoulders, sidewalks or parking areas. Omit weepholes where these conditions cannot be met. On structures over railroads, the weepholes shall generally not be located in spans over tracks. However, for long span structures the pipes may be located in spans over tracks but shall not be located closer than 25 ft. from the center line of the outside tracks.

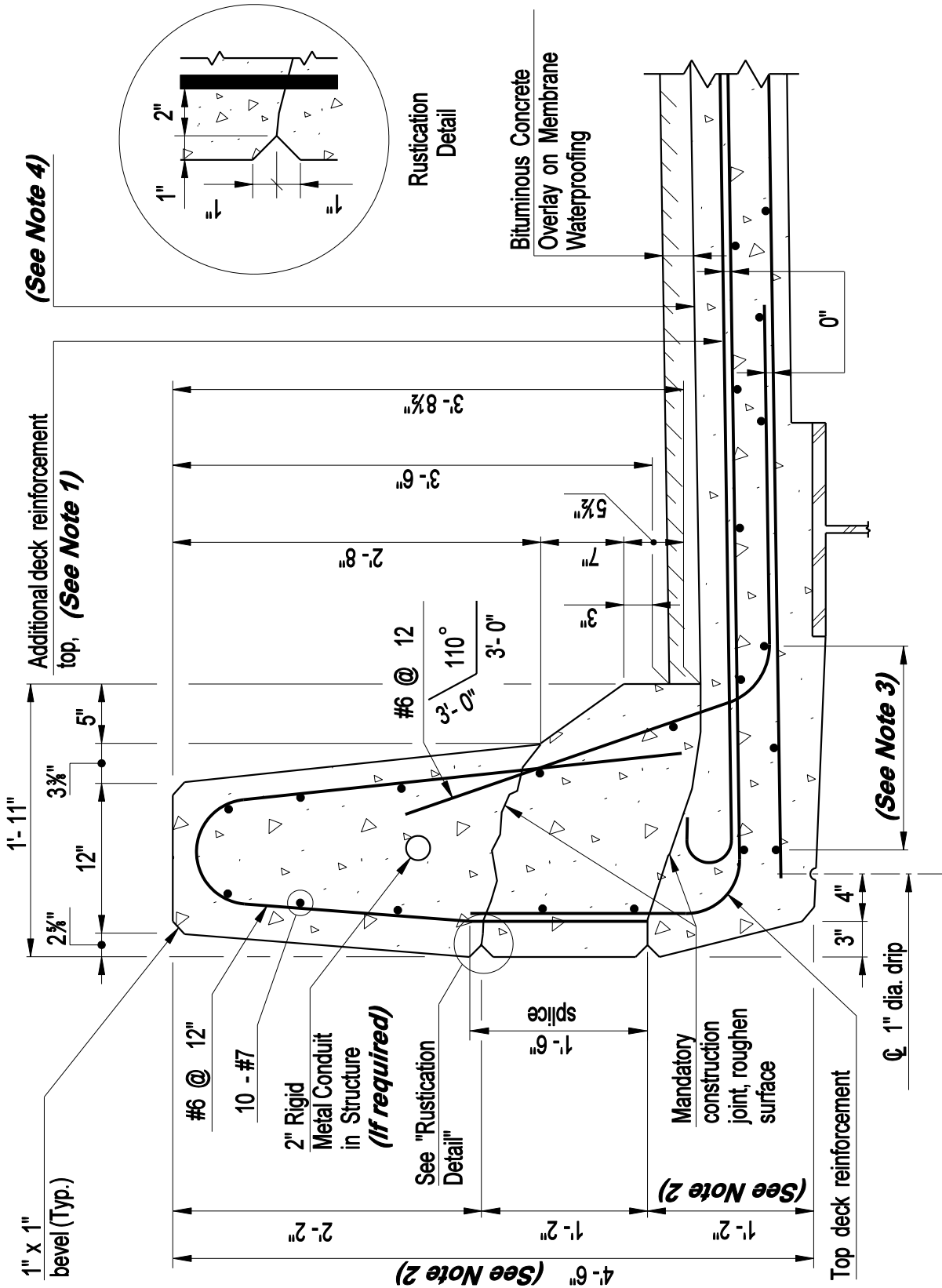


Rustication Detail



Note:
The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'-0".

Issue Date:	10/03
Revision Date:	
Plate Number:	6.2.1



Note: For Notes 1 - 5, See Plate No. 6.2.4

(See Note 4)

DESIGN INFORMATION

Note 1: The Designer shall determine the additional deck reinforcement required to satisfy the AASHTO specifications and include this information in the note.

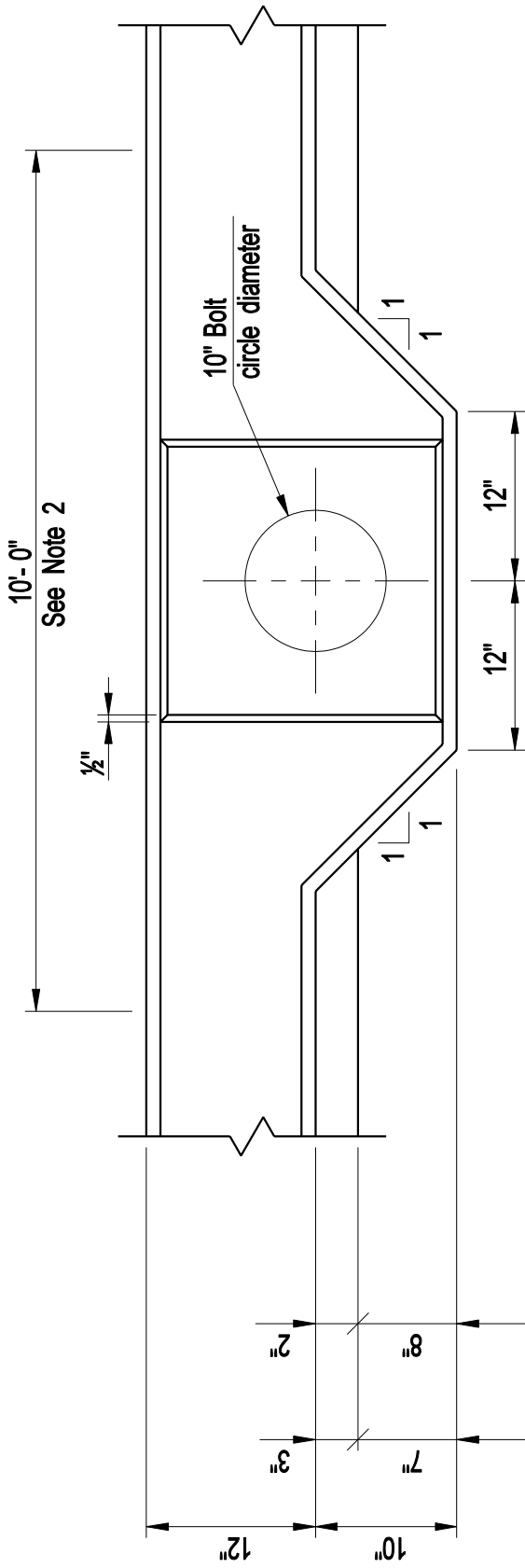
Note 2: This dimension may be increased by the Designer to maintain cover of the bottom deck reinforcement.

**Note 3: Designer shall specify the number of bars.
Number of bars to be based on #5 @ 10" (max.)**

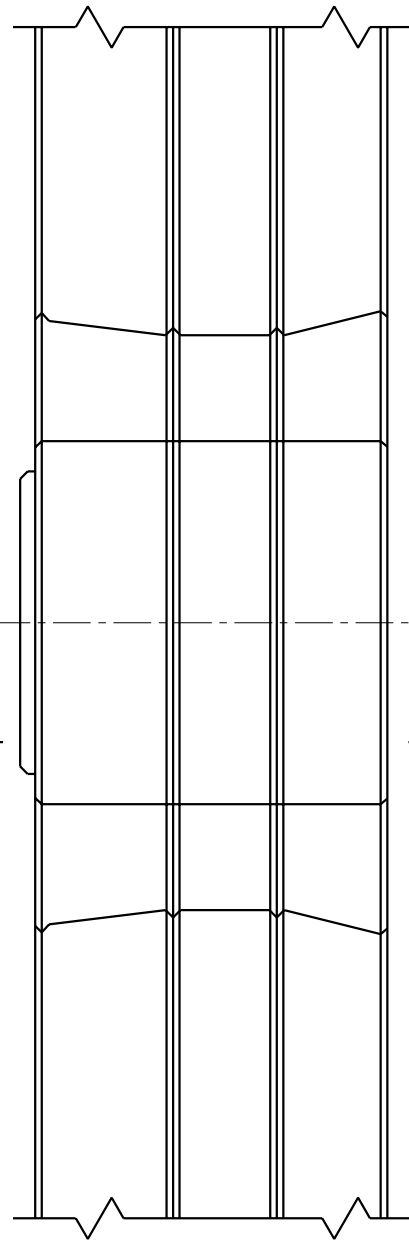
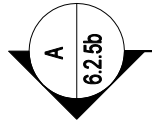
PLAN NOTES

Note 4: Concrete above this line to be poured after the concrete in the deck slab has reached a strength of $f' = 3500$ psi.

Note 5: The parapet shall be cast continuous without joints. Longitudinal reinforcement shall be continuous with minimum lap splices of 3'- 0".



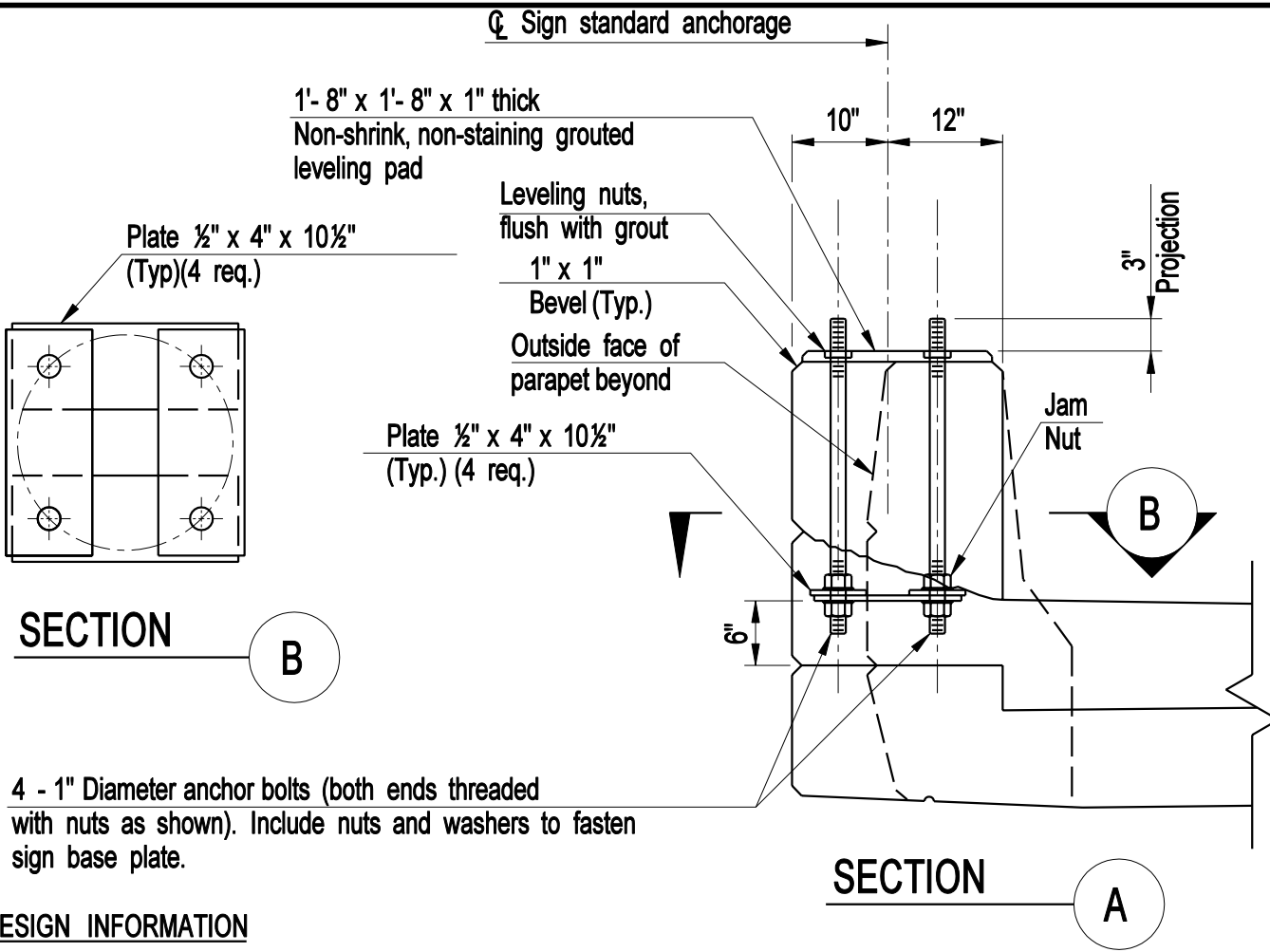
PLAN



ELEVATION

DESIGN INFORMATION:

1. For design information, see Plate 6.2.5b
2. For parapet reinforcement within these limits, see Plate 6.2.7c

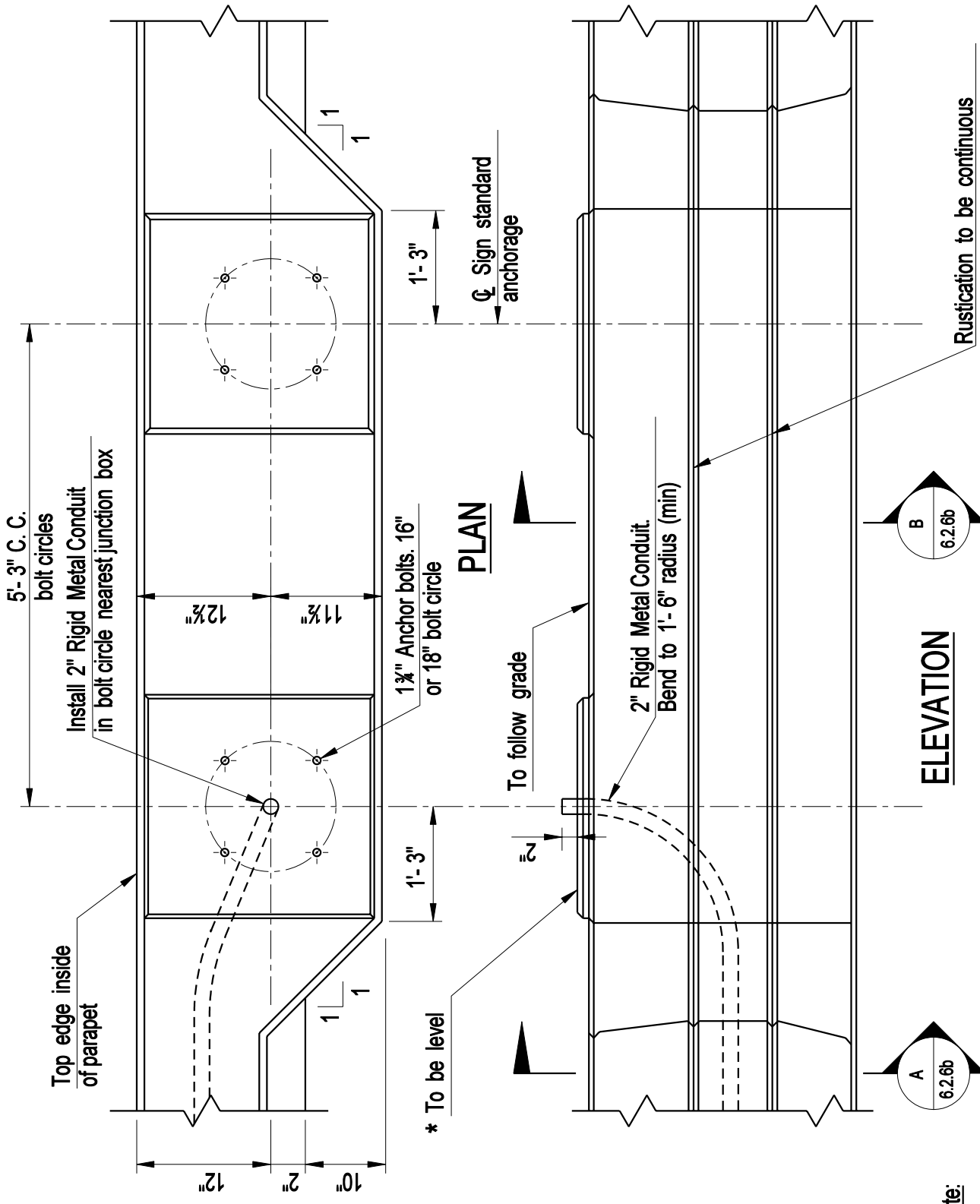


DESIGN INFORMATION

1. **Structural design for slab and details required, including reinforcement, shall be determined by the designer.**
2. **Maximum sign size is 4'- 0" x 8'- 6" at 8'- 2" above gutter line.**
3. **Dimensions shown will provide for continuity of "Metal Bridge Rail (Traffic)". These dimensions shall be reviewed for other railings as required to provide for continuity of rail.**

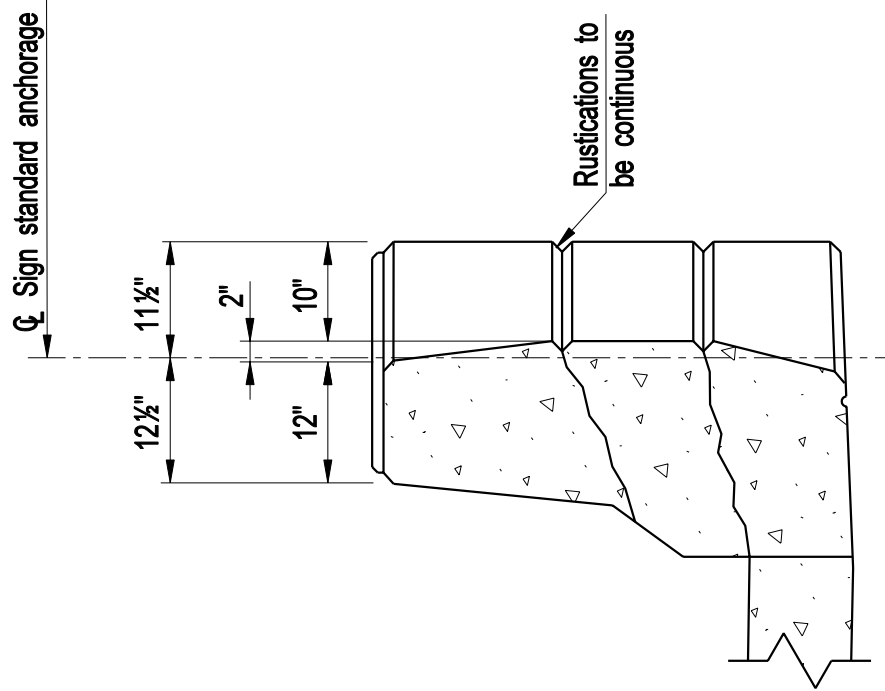
Notes:

4. Anchor bolts and nuts shall be manufactured of steel conforming to the following requirements:
 Square leveling nuts may be low carbon steel.
 Bolts - ASTM A-449
 Hex Nuts - ASTM A-563 Grade DH
 Anchor bolts and nuts shall be galvanized in accordance with ASTM A-153.
 Structural steel plates shall conform to ASTM A-36.
5. Cost of furnishing and installing anchor bolts, nuts and steel plates to be paid for at the contract unit price per pound for "Deformed Steel Bars".



Note:

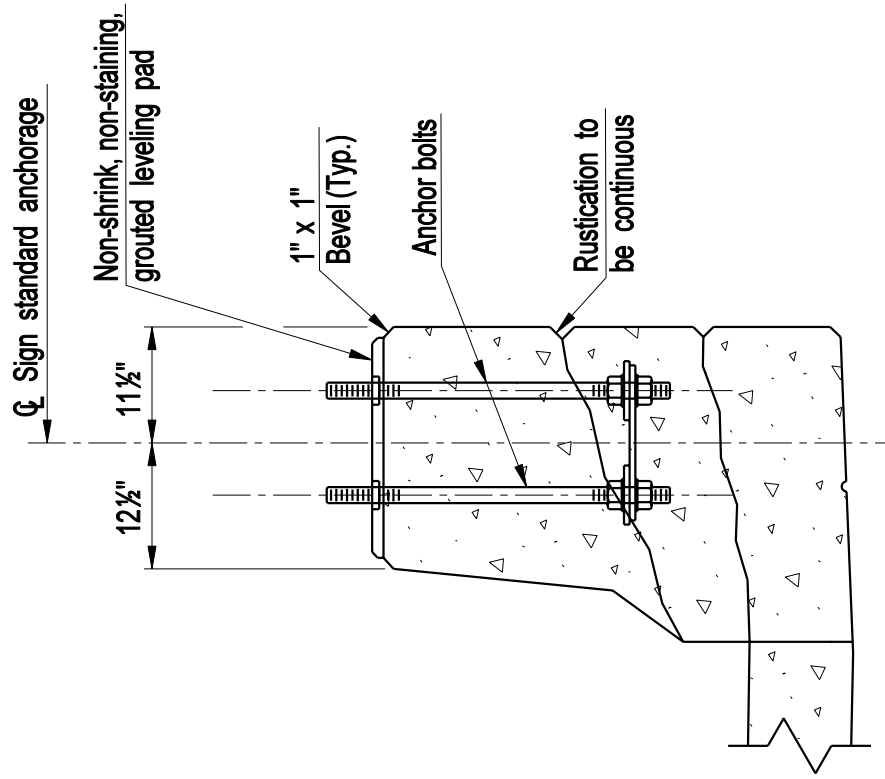
1. * Both pads to be level and at the same elevation.
2. For design information, see Plate 6.2.6b.



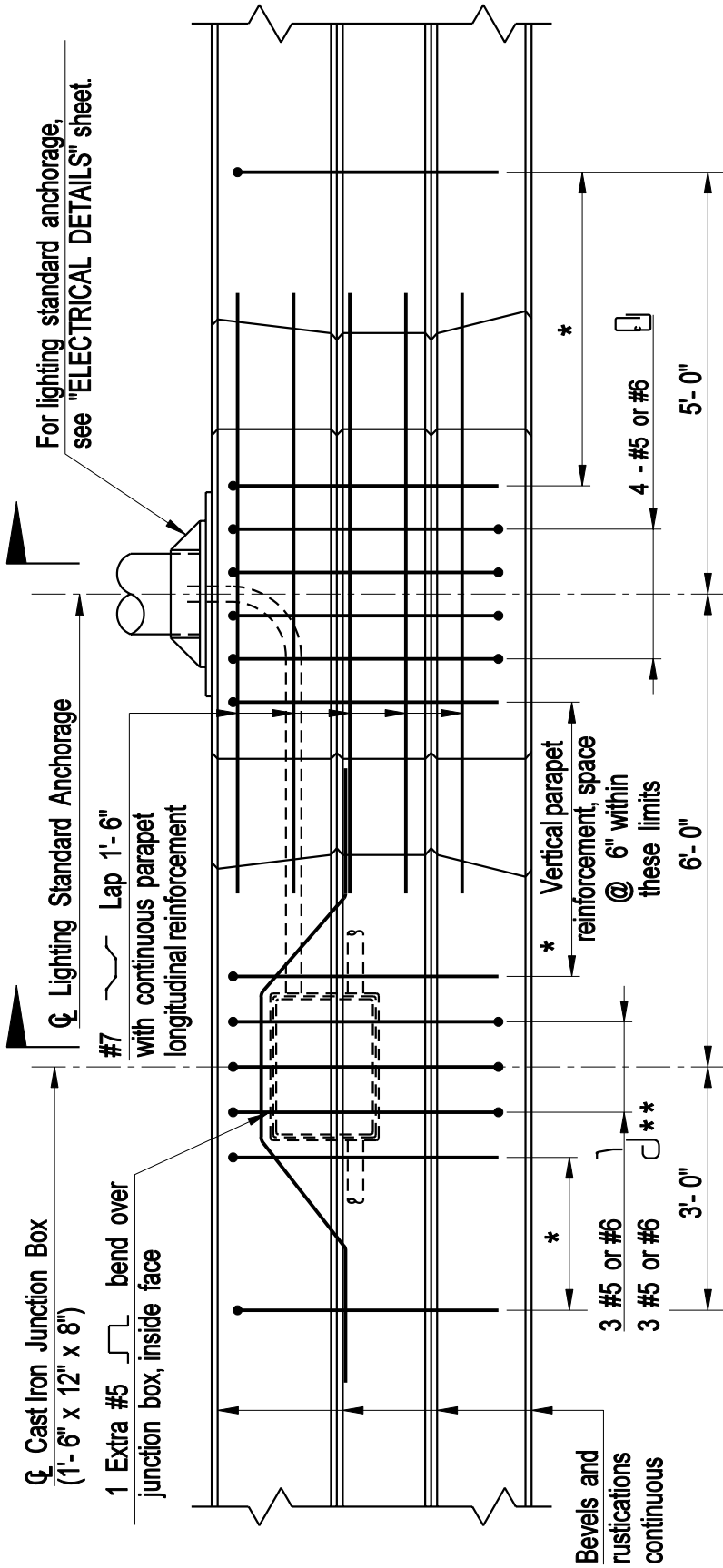
SECTION A

DESIGN INFORMATION

1. All structural design and details required, including reinforcement, length of anchor bolts, and supporting steel, when necessary, shall be determined by the Engineer.
2. Bolt circles of each sign support foundation shall be level and at the same elevation. Elevation to be given.
3. When the box truss is on a skew angle with the parapet, this angle shall be shown on the plans.

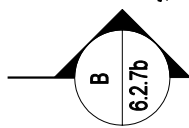


SECTION B

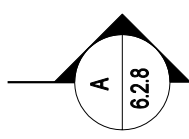


Vertical parapet joints to be outside these limits. Reinforcement shown within these limits applies at junction box with lighting standard. For reinforcement at junction box only, see Plate 6.2.8.

* The vertical parapet reinforcement is to be doubled (#5 @ 6") within these limits.
 ** At sloped curb only.

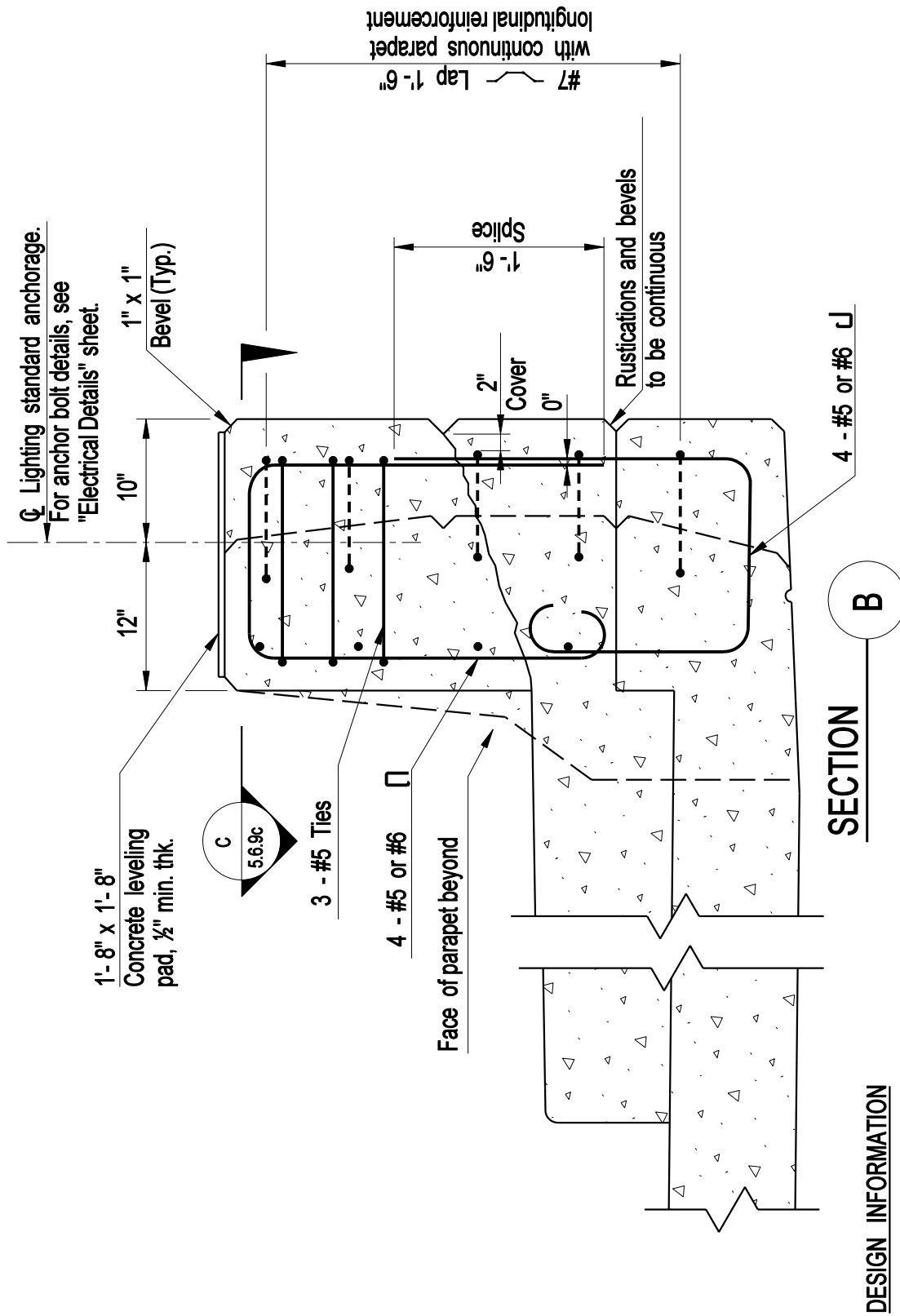


ELEVATION



DESIGN INFORMATION

1. The above reinforcement details must be shown on the pertinent structure plans and not on the "ELECTRICAL DETAILS" sheet.
2. Bridge rail posts shall not be located within 1'- 6" of the centerline of the junction box or lighting standard anchorage.
3. 3'- 6" sloped curb parapet shown, 2'- 8" sloped curb parapet and sidewalk parapet similar.



⊕ Lighting standard anchorage.
For anchor bolt details, see
"Electrical Details" sheet.

1'-8" x 1'-8"
Concrete leveling
pad, ½" min. thk.

C
5.6.9c

3 - #5 Ties

4 - #5 or #6

Face of parapet beyond

12"

10"

1" x 1"

Bevel (Typ.)

#7
Lap 1'-6"
with continuous parapet
longitudinal reinforcement

1'-6"
Splice

2"
Cover

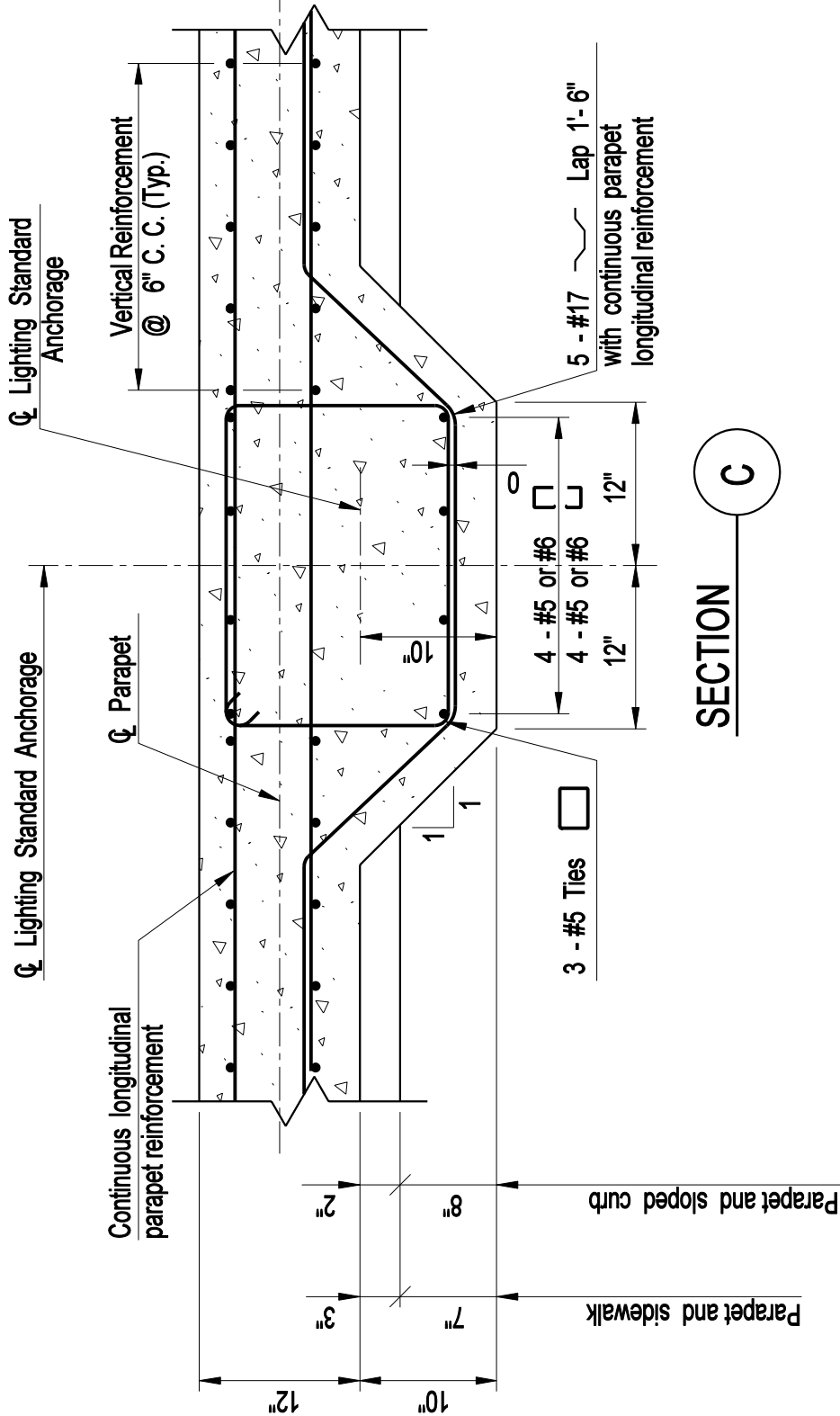
0"

Rustications and bevels
to be continuous

SECTION

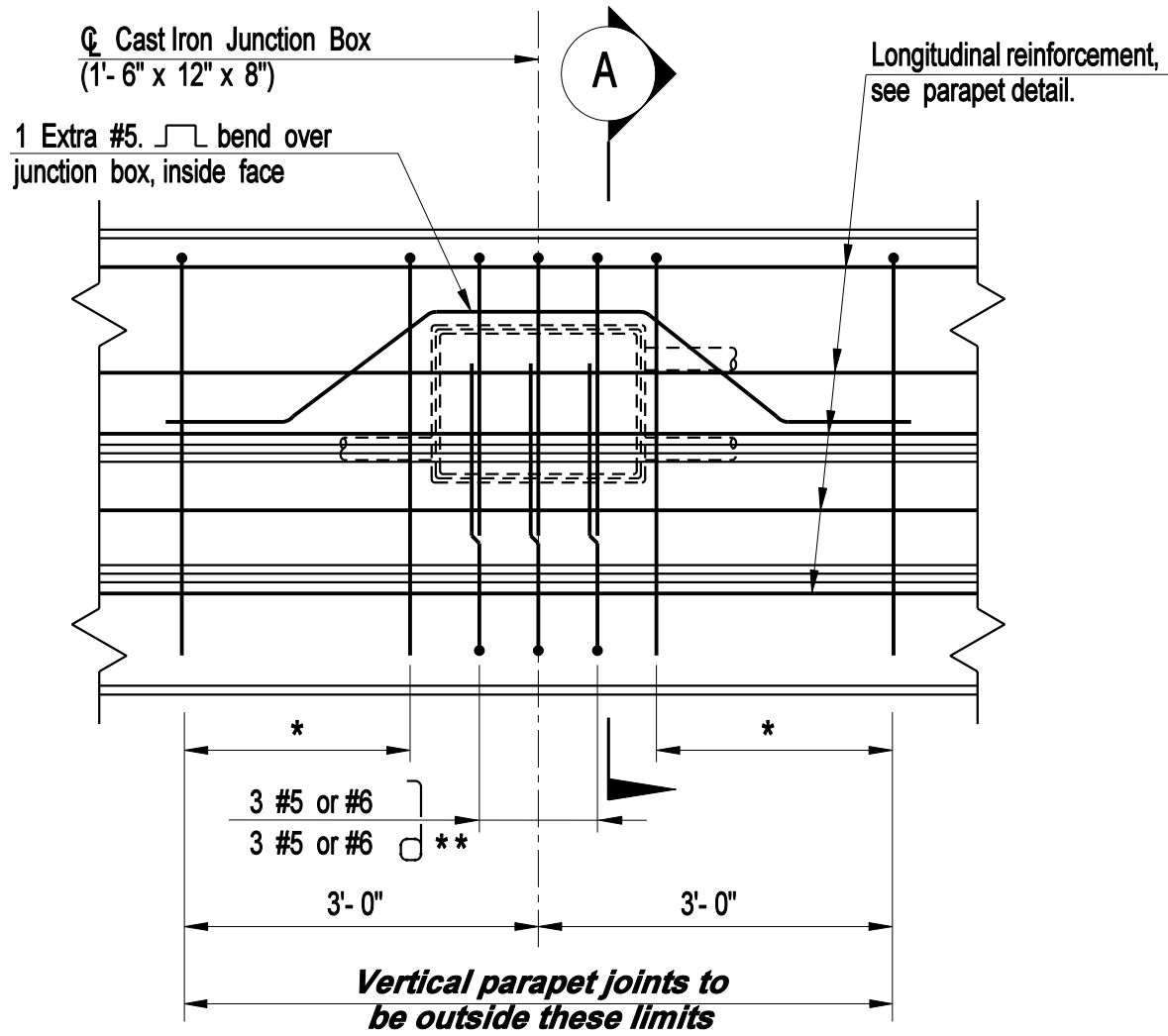
B

4 - #5 or #6



Note:

For design information, see Plate 6.2.7a



* The vertical parapet reinforcement is to be doubled (@ 6") within these limits.

** At sloped curb only.

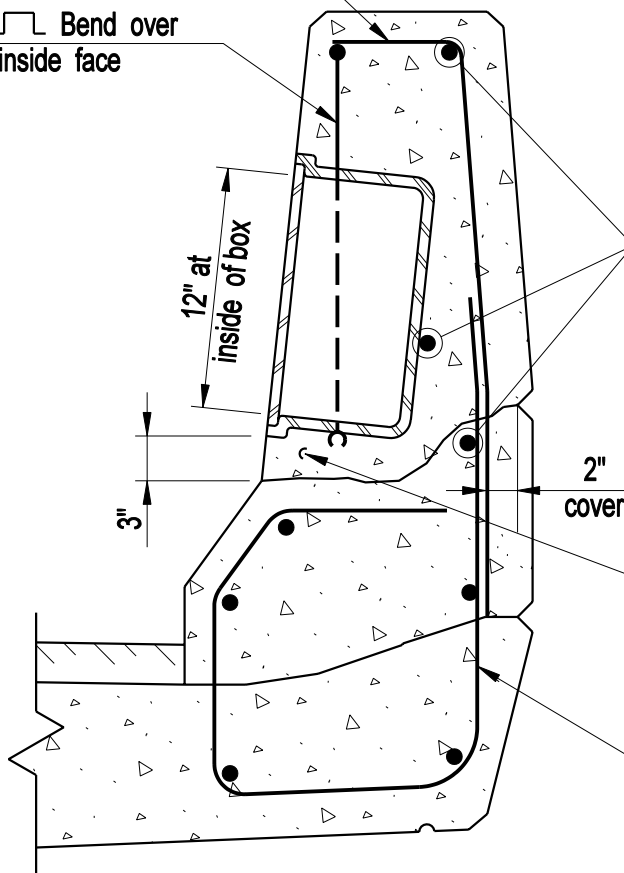
DESIGN INFORMATION

ELEVATION

1. **The above reinforcement details must be shown on the pertinent structure plans and not on the "ELECTRICAL DETAILS" sheet.**
2. **Bridge rail posts shall not be located within 1'-6" of the centerline of the junction box.**
3. **When the junction box is located in the parapet of U-Wings, this detail shall be modified accordingly.**
4. **For Section A, see Plates 6.2.8b and 6.2.8c**

3 - #5 or #6 \perp @ 6"
At junction box only

1 Extra #5. \perp Bend over
junction box, inside face



3 - #7 to be continuous between
vertical parapet joints. (2 - #7 to be
discontinuous at junction boxes)

Place box in a bed of mortar.
Cost of furnishing and placing
mortar to be included in the
item for "Class "F" Concrete"

3 - #5 or #6 \perp @ 6"
At junction box only

SECTION

A

Note.

1. For design information, see Plate 6.2.8a.

2. 3'- 6" high parapet shown. 2'- 8" high parapet similar.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

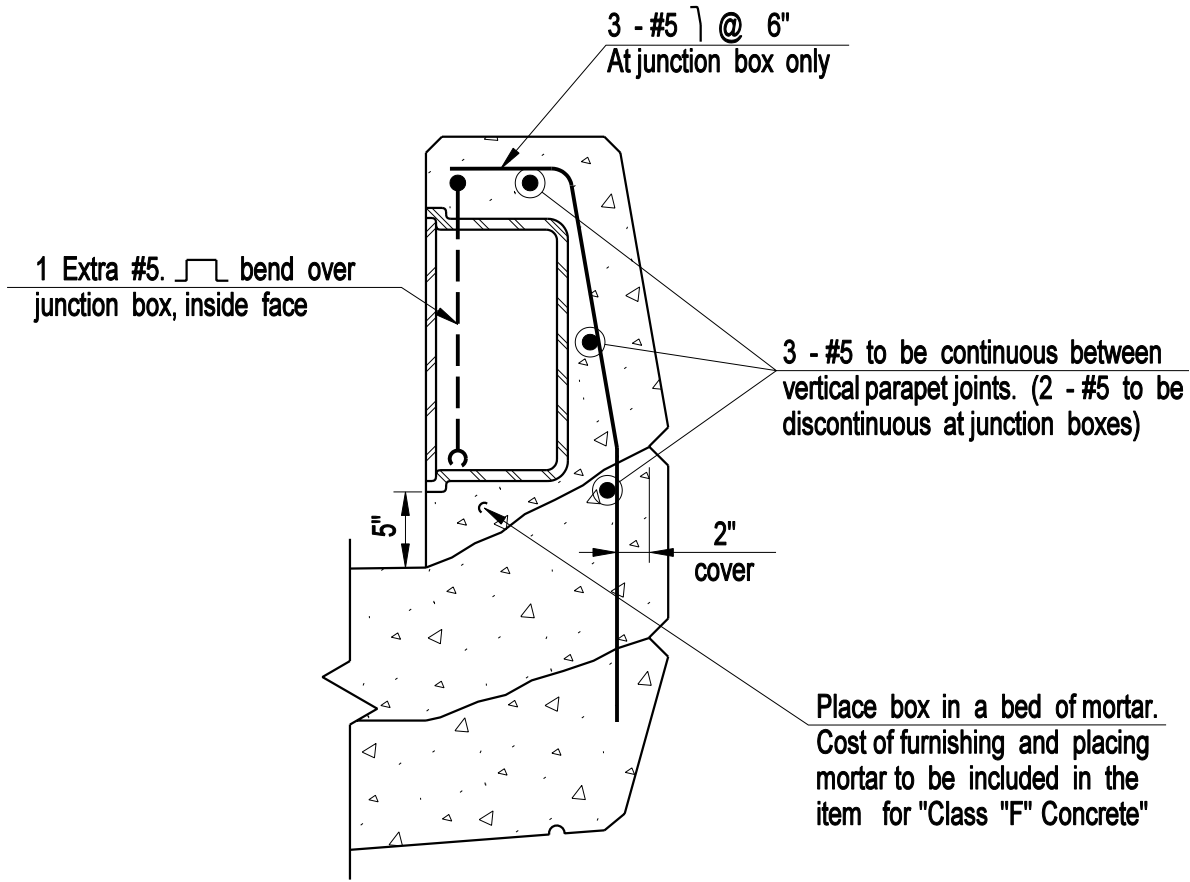
**PARAPET REINFORCEMENT
AT JUNCTION BOX**

Issue Date: 10/03

Revision Date:

Plate Number:

6.2.8b



SECTION

A

Note:

For design information, see Plates 6.2.8a and 6.2.8b

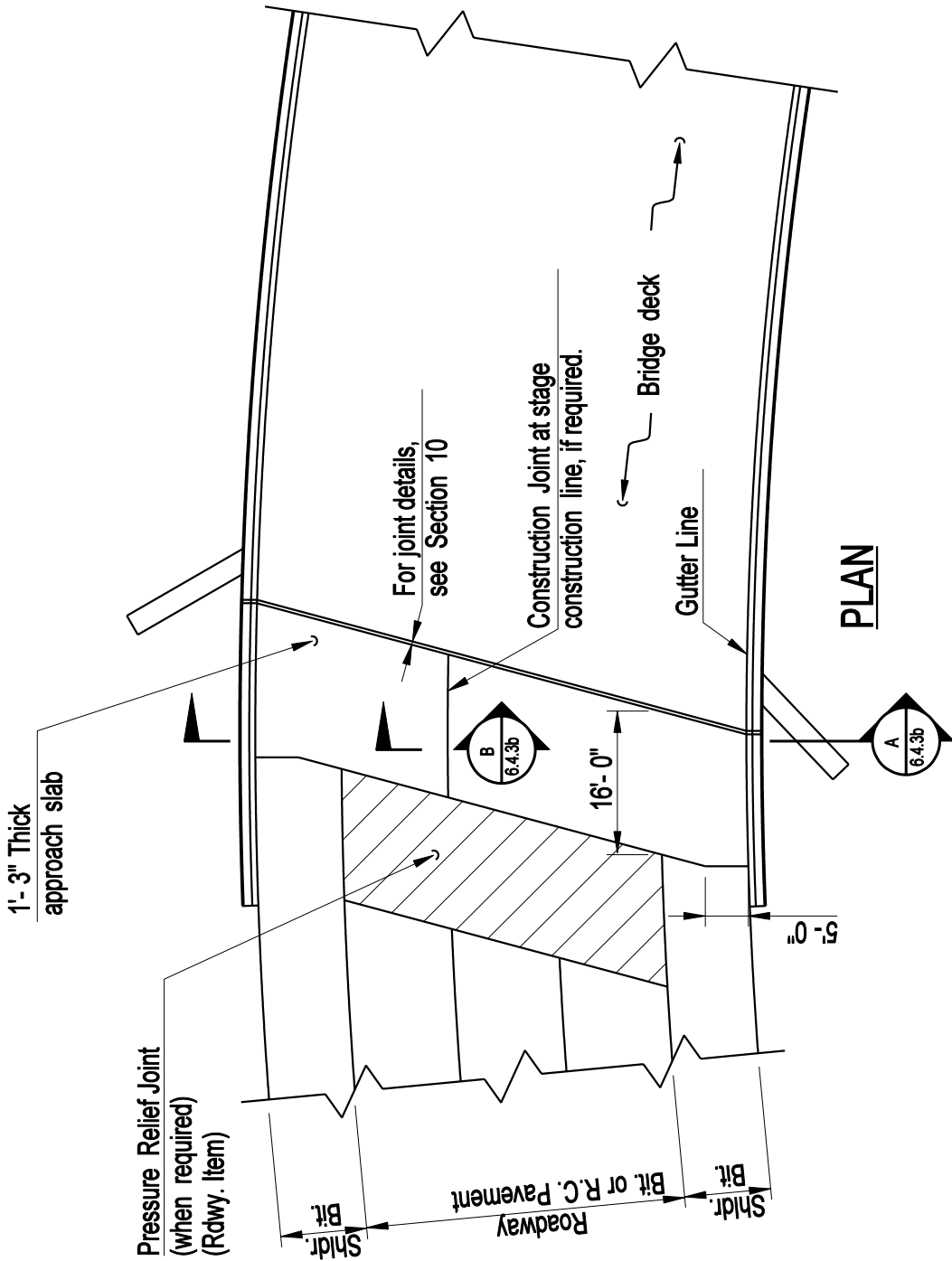
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

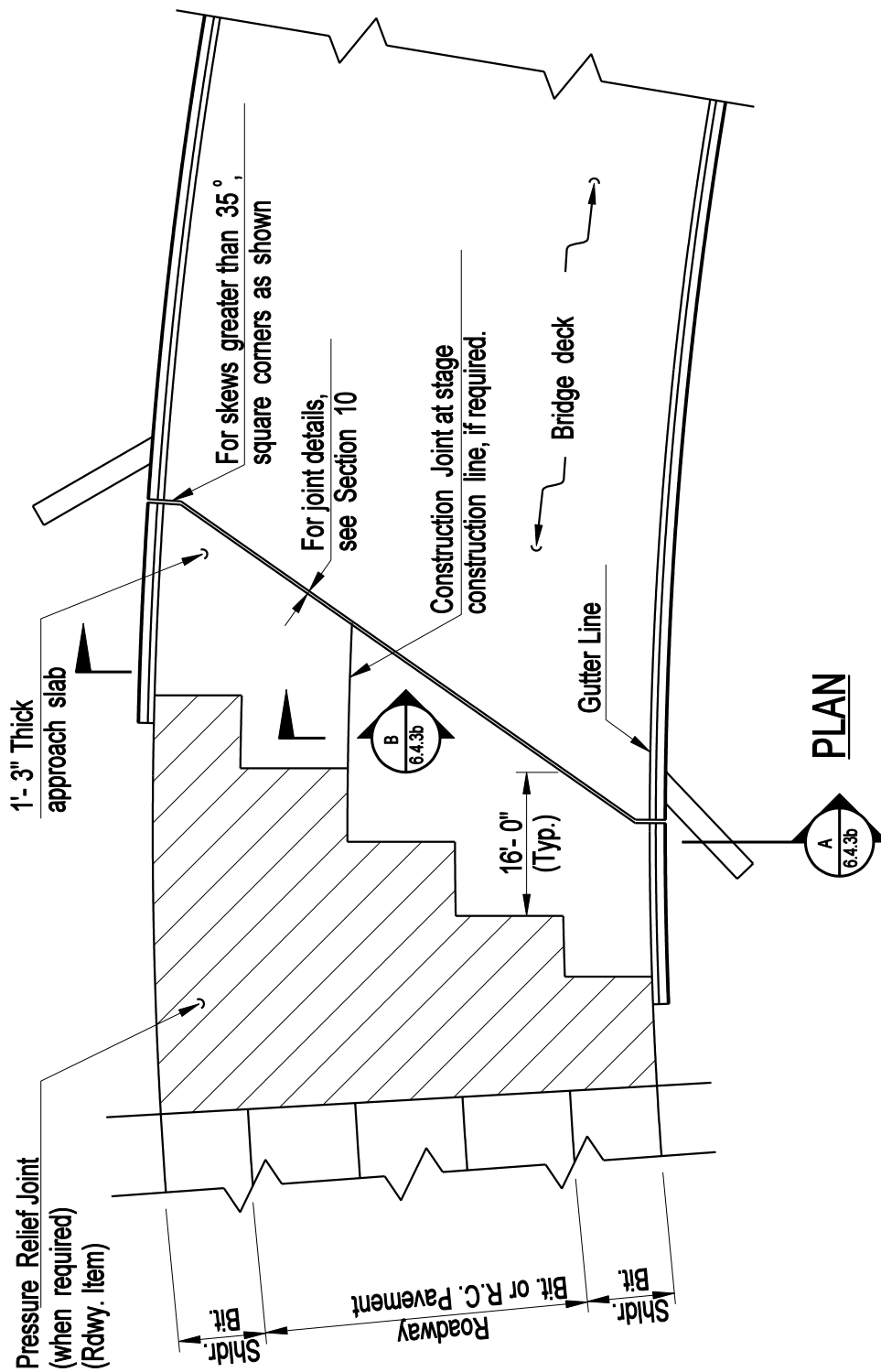
**PARAPET REINFORCEMENT
AT JUNCTION BOX
(PARAPET AND SIDEWALK)**

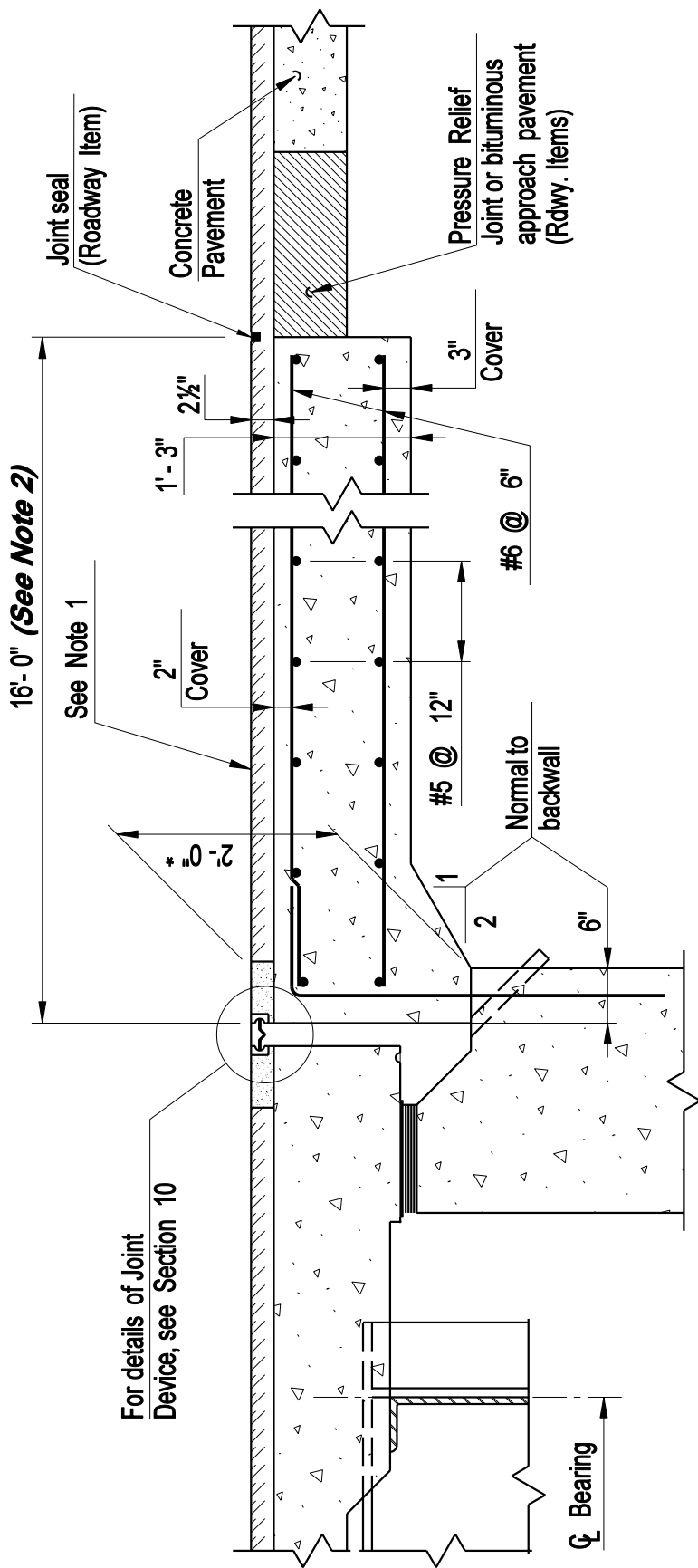
Issue Date: 10/03

Revision Date:

Plate Number:
6.2.8c







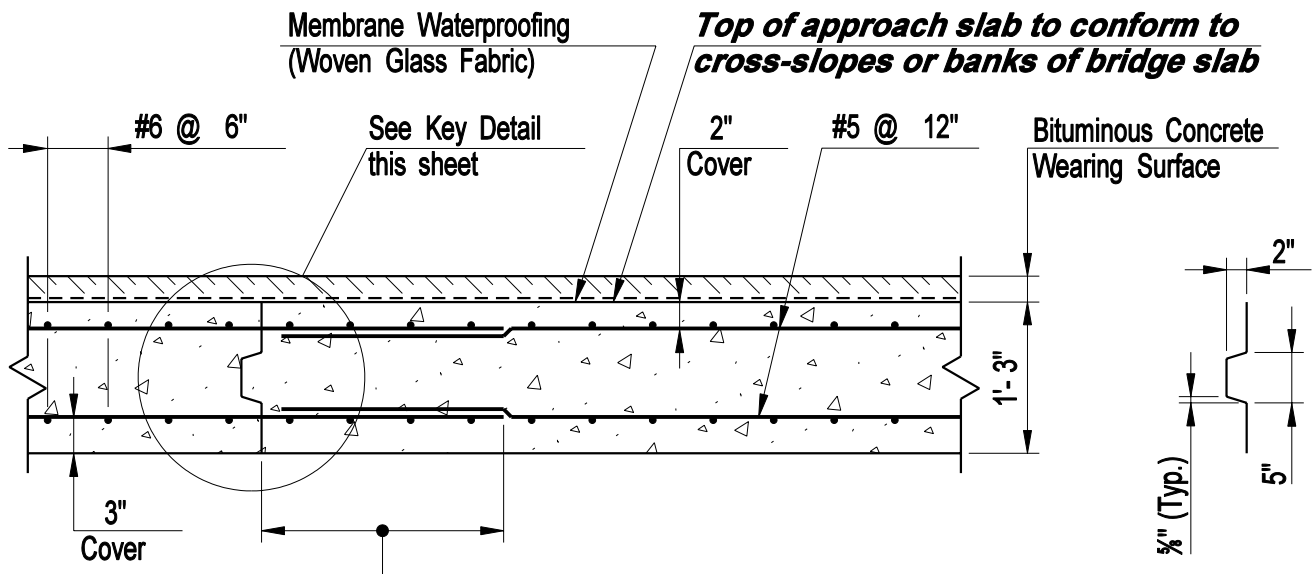
TYPICAL LONGITUDINAL SECTION

Notes:

1. 2½" bituminous concrete overlay on membrane waterproofing

DESIGN INFORMATION

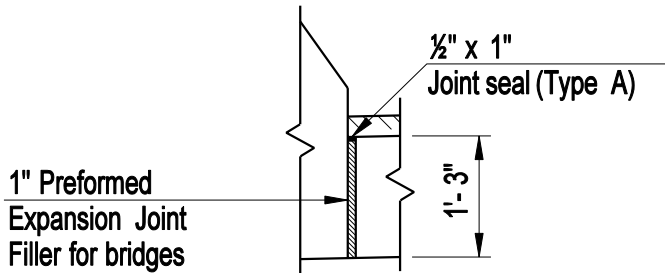
2. On bridges with skew angle greater than 35°, ends of approach slabs are squared off and this dimension is the minimum length at the shortest point.



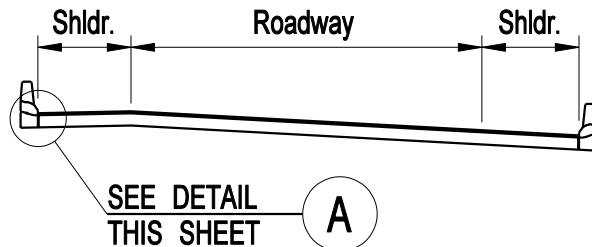
2'- 0". At acute corners, eliminate splice and vary this length up to 12'- 0" to omit short bars in the adjacent slab.

KEY DETAIL

SECTION B



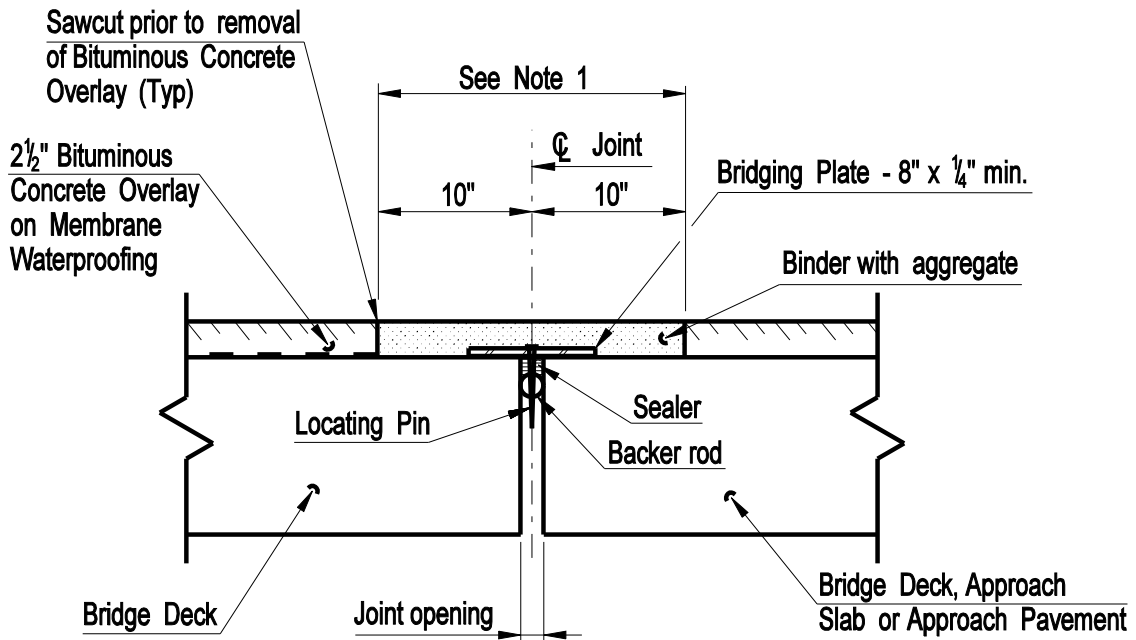
DETAIL A



SECTION A

DESIGN INFORMATION

- 1. Reinforcing steel to be included in the item "Deformed Steel Bars (Epoxy Coated)."**
- 2. Concrete to be included in the item "Class "F" Concrete."**
- 3. This plate shall be used in conjunction with Plates 6.4.1 and 6.4.2.**

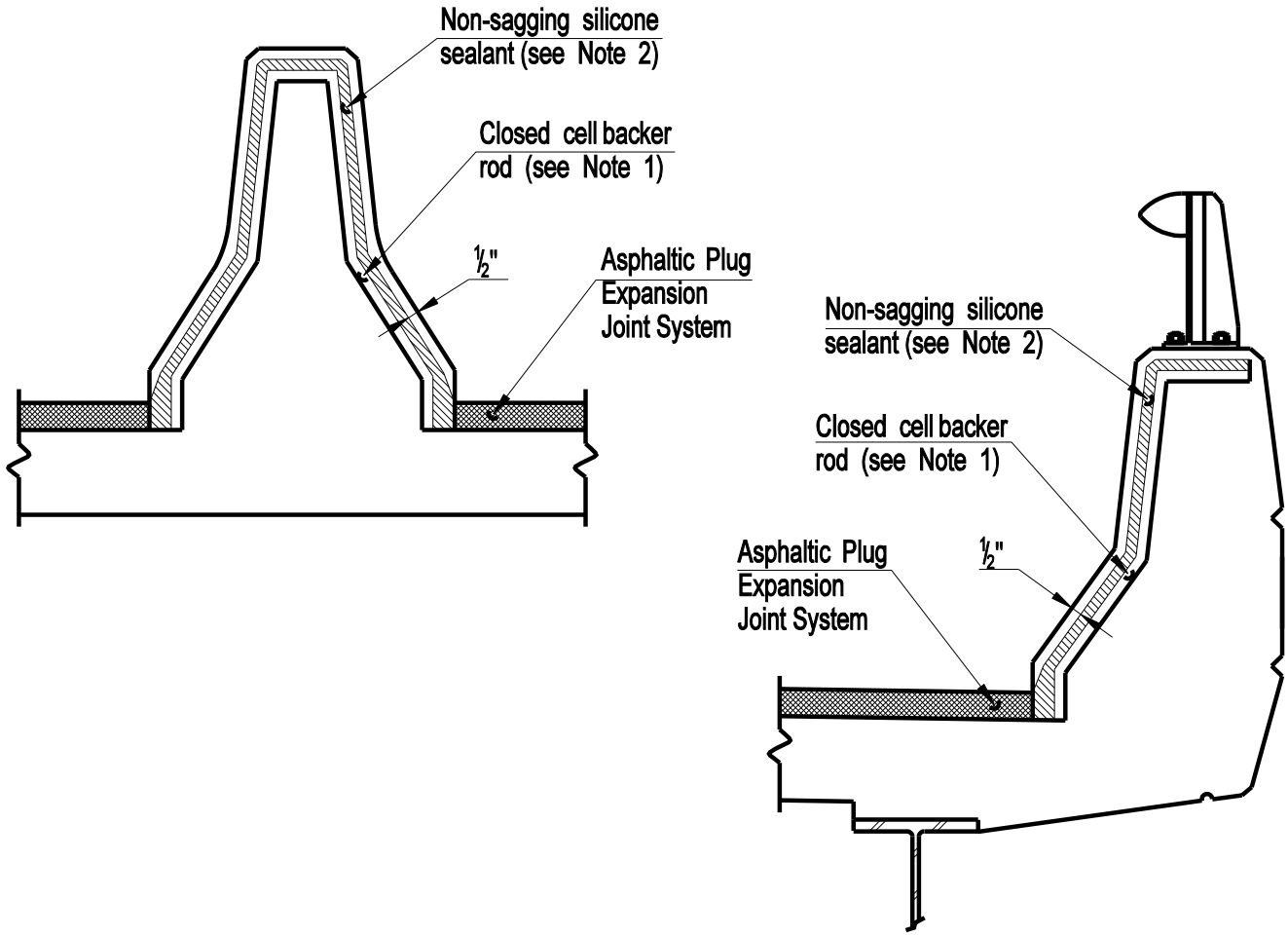


NOTES:

1. Remove new bituminous concrete overlay and membrane waterproofing. Replace with Asphaltic Plug Expansion Joint System. To be paid for under the item "Asphaltic Plug Expansion Joint System". (See Special Provision)

DESIGN INFORMATION

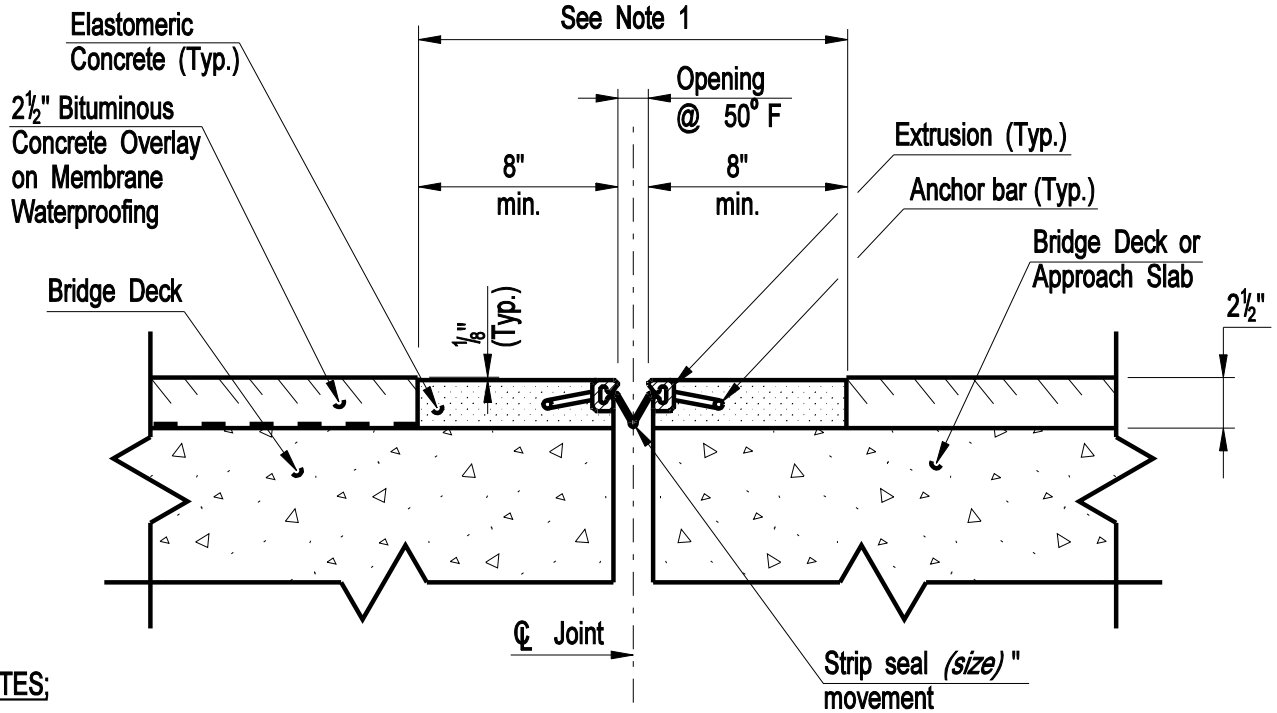
2. ***Asphaltic Plug Expansion System shall be used at fixed and expansion joints with computed movements from 0" to 1 1/2" based on a moderate climate in accordance with AASHTO.***
3. ***Asphaltic Plug Expansion joints shall be installed when the ambient air temperature is between 40° F and 80° F.***



**ASPHALTIC PLUG EXPANSION JOINT TREATMENT
AT PARAPETS AND MEDIAN BARRIER**

NOTES:

- 1: The Closed Cell Backer Rod shall be placed a minimum of 2" from the outside face of parapets and median barriers.
- 2: The non-sagging silicone sealant shall be placed on the backer rod $\frac{1}{2}$ " thick. At the gutter, the silicone sealant shall be placed flush with the outside face of concrete.
- 3: Prior to installing the silicone sealant, clean joint sides by sandblasting. Dust shall be removed by the method approved by the Engineer. This work shall be paid for under the item "Asphaltic Plug Expansion Joint System". (see special provisions)

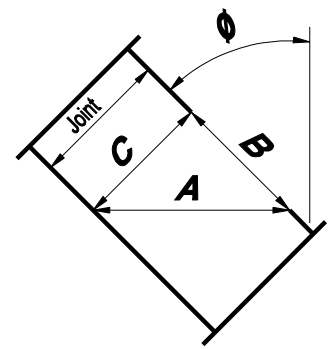


NOTES:

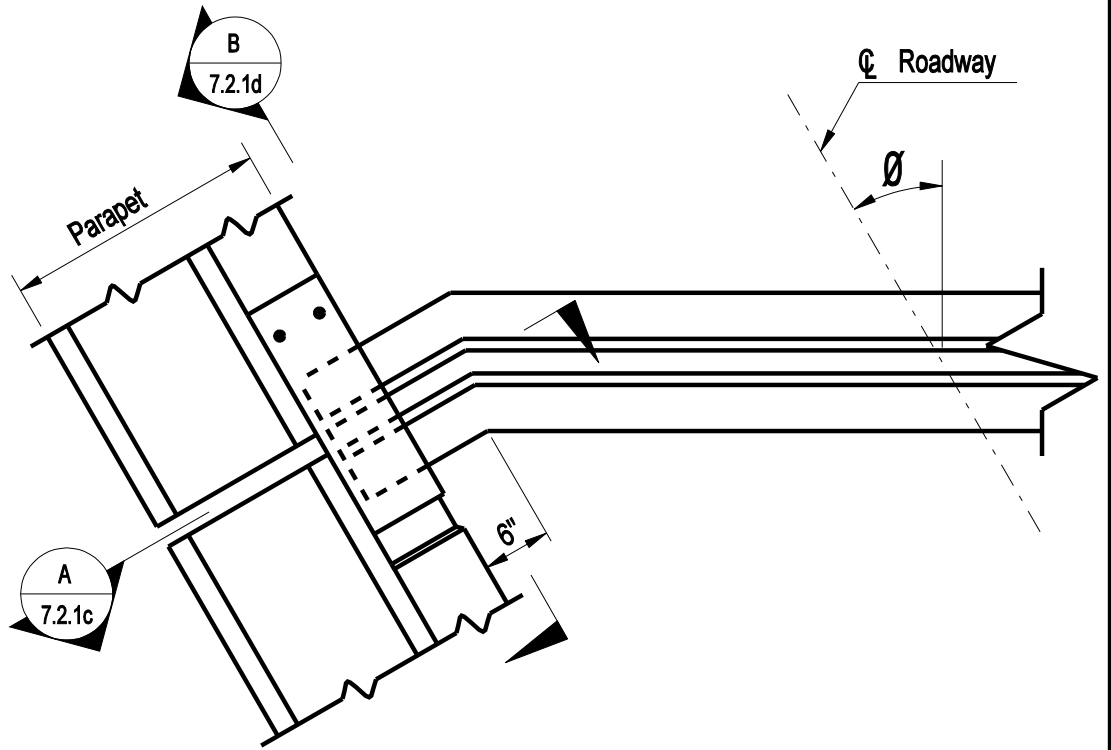
1. Remove new bituminous concrete overlay and membrane waterproofing and replace with Elastomeric Concrete Expansion Joint System. To be paid for under the item "Elastomeric Concrete Expansion Joint System". (See Special Provision)

DESIGN INFORMATION:

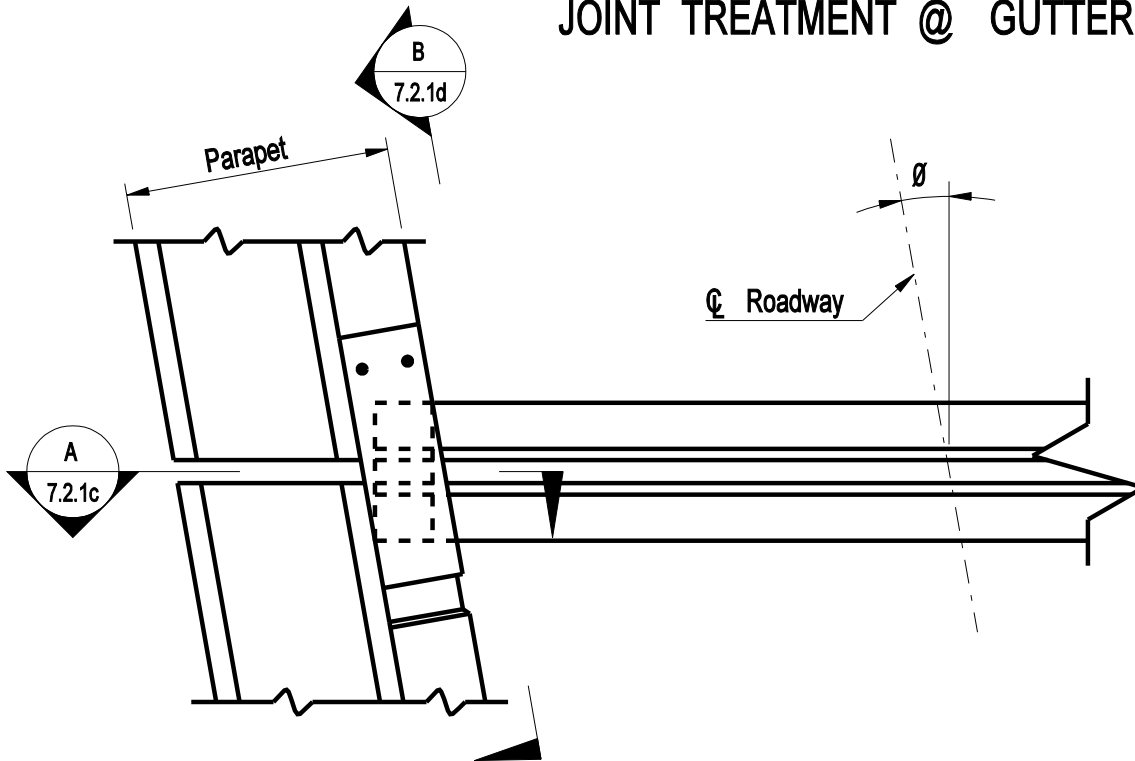
2. **Elastomeric concrete headers with strip seals shall be used at expansion joints with computed movements between 3" and 4".**
3. **The temperature range used for computation of movement shall be based on a moderate climate in accordance with AASHTO.**
4. **The strip seal movement capacity and opening @ 50° F shall be determined by the Designer, in-accordance with approved product information.**
5. **The Designer shall consider the effects of skew when determining the strip seal movement capacity. The movement rating of the gland shall be greater than or equal to the computed movements along the skew, normal to the joint or along the center line of bridge.**



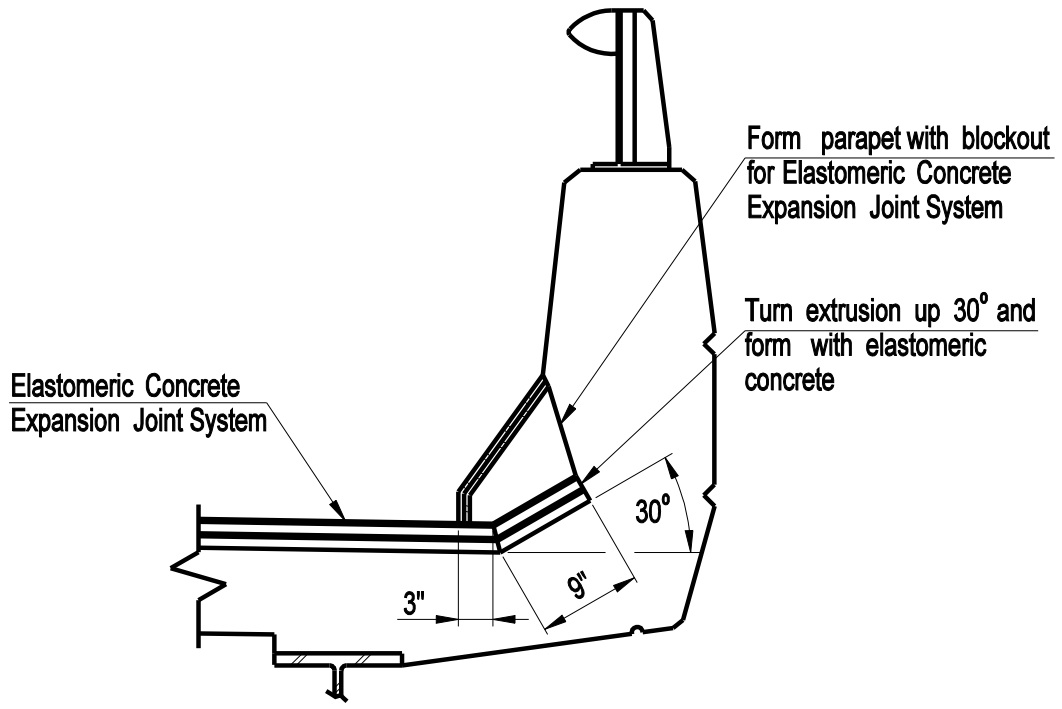
- θ = Skew Angle
- A = movement along C Bridge
- B = movement along Skew $B = A \sin \theta$
- C = movement normal to joint $C = A \cos \theta$



JOINT TREATMENT @ GUTTERLINE $\theta > 35^\circ$



JOINT TREATMENT @ GUTTERLINE $\theta \le 35^\circ$



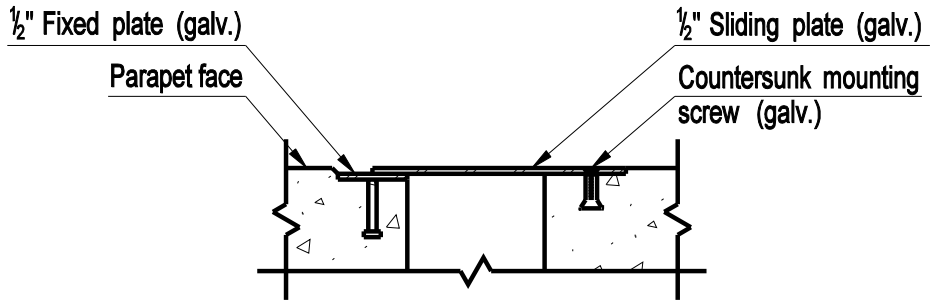
SECTION A

JOINT TREATMENT AT CONCRETE PARAPET

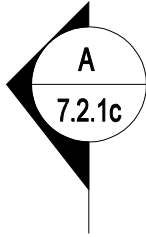
DESIGN INFORMATION

1. This plate shall be used in conjunction with Plate 7.2.1b and 7.2.1d.

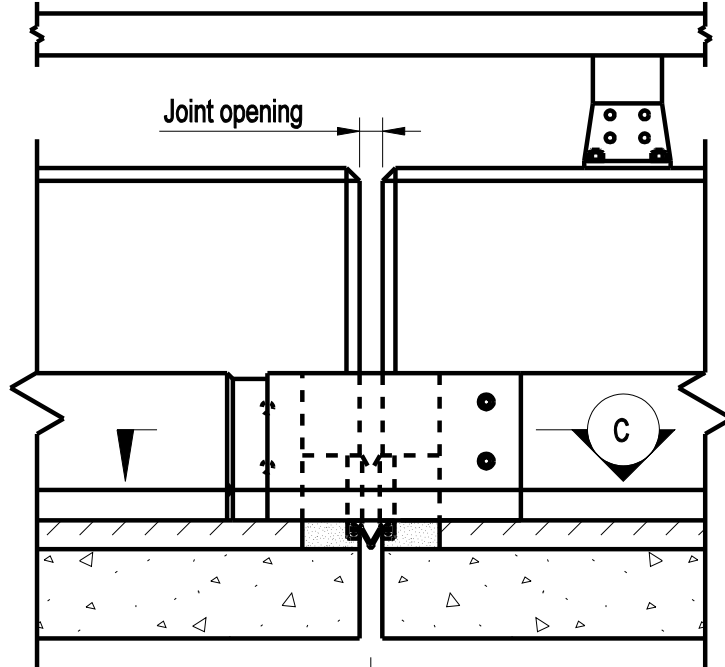
CONNECTICUT BRIDGE DESIGN MANUAL	ELASTOMERIC CONCRETE EXPANSION JOINT SYSTEM	Issue Date: 10/03
		Revision Date:
		Plate Number: 7.2.1c



SECTION C



DIRECTION OF TRAFFIC



VIEW B
7.2.1b

JOINT TREATMENT AT CONCRETE PARAPET

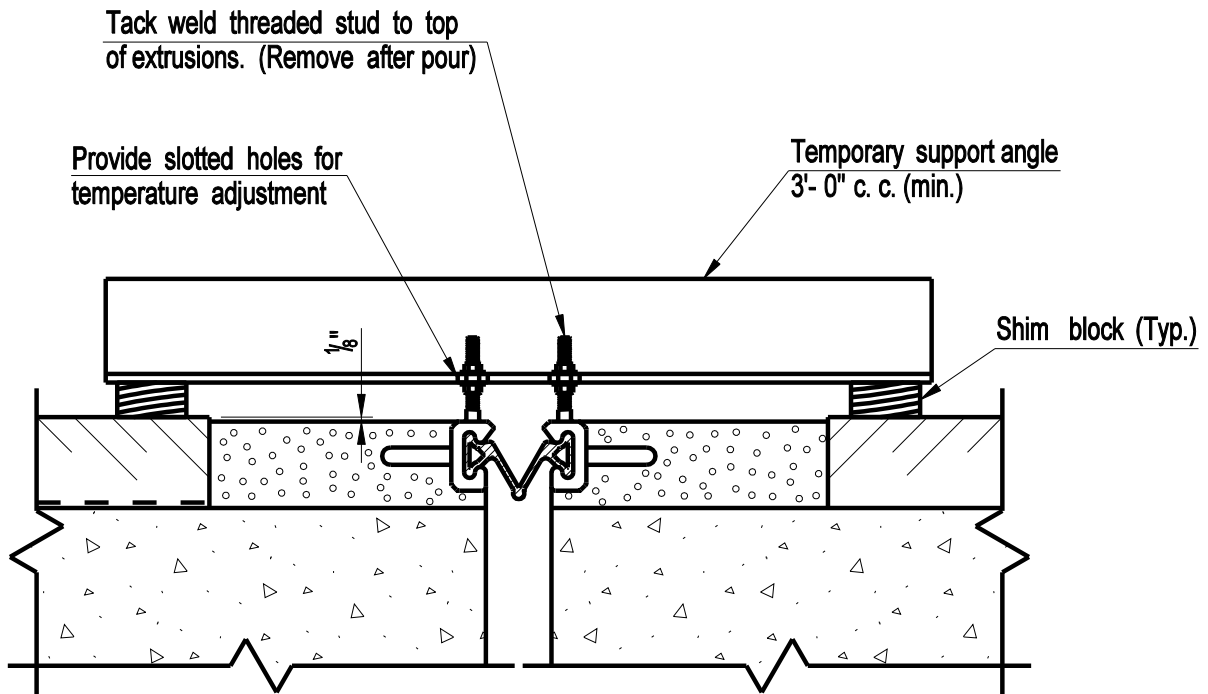
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**ELASTOMERIC CONCRETE
EXPANSION JOINT SYSTEM**

Issue Date: 10/03

Revision Date: 01/05

Plate Number:
7.2.1d



INSTALLATION DETAIL

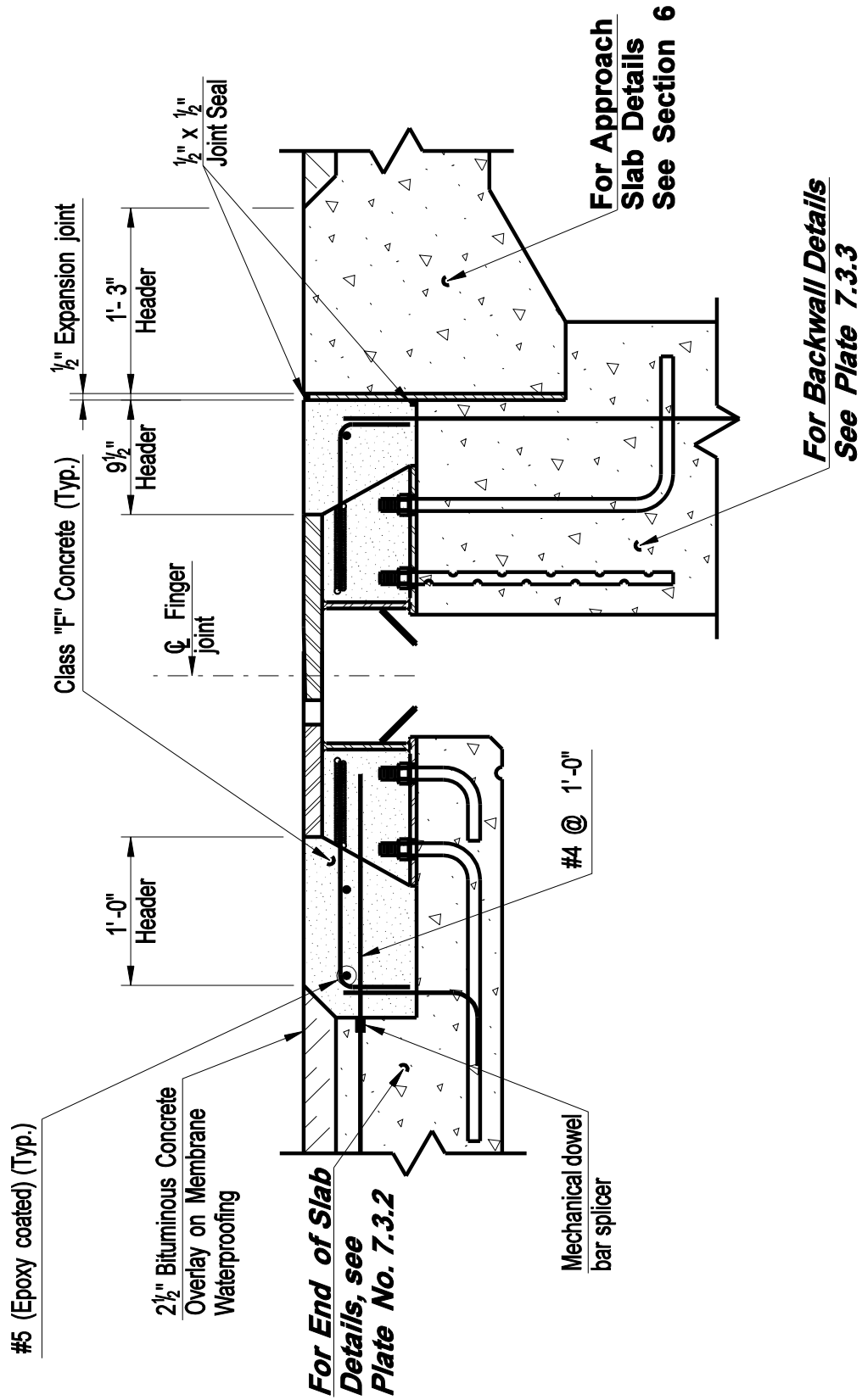
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

ELASTOMERIC CONCRETE
EXPANSION JOINT SYSTEM

Issue Date: 10/03

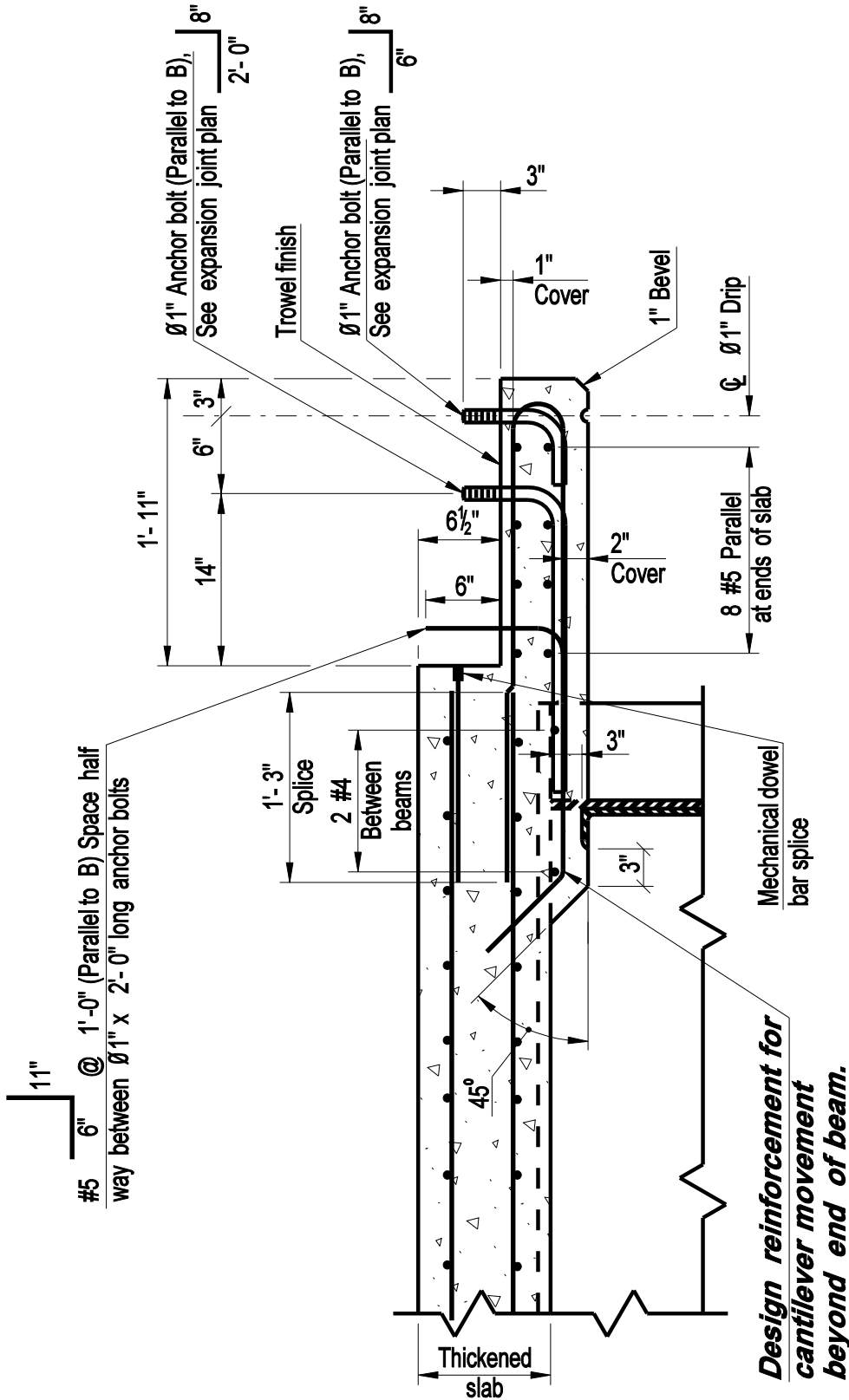
Revision Date:

Plate Number:
7.2.1e

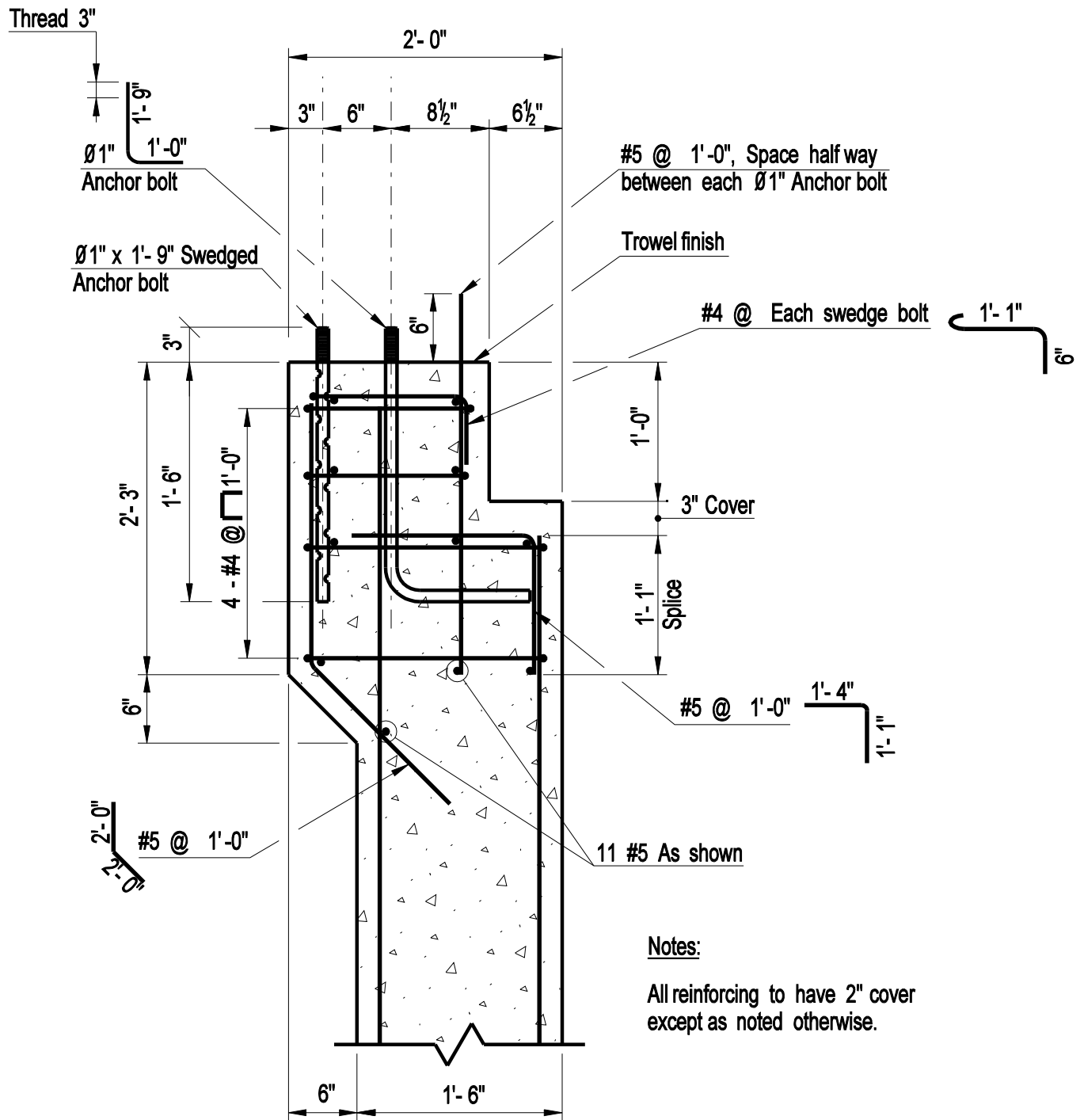


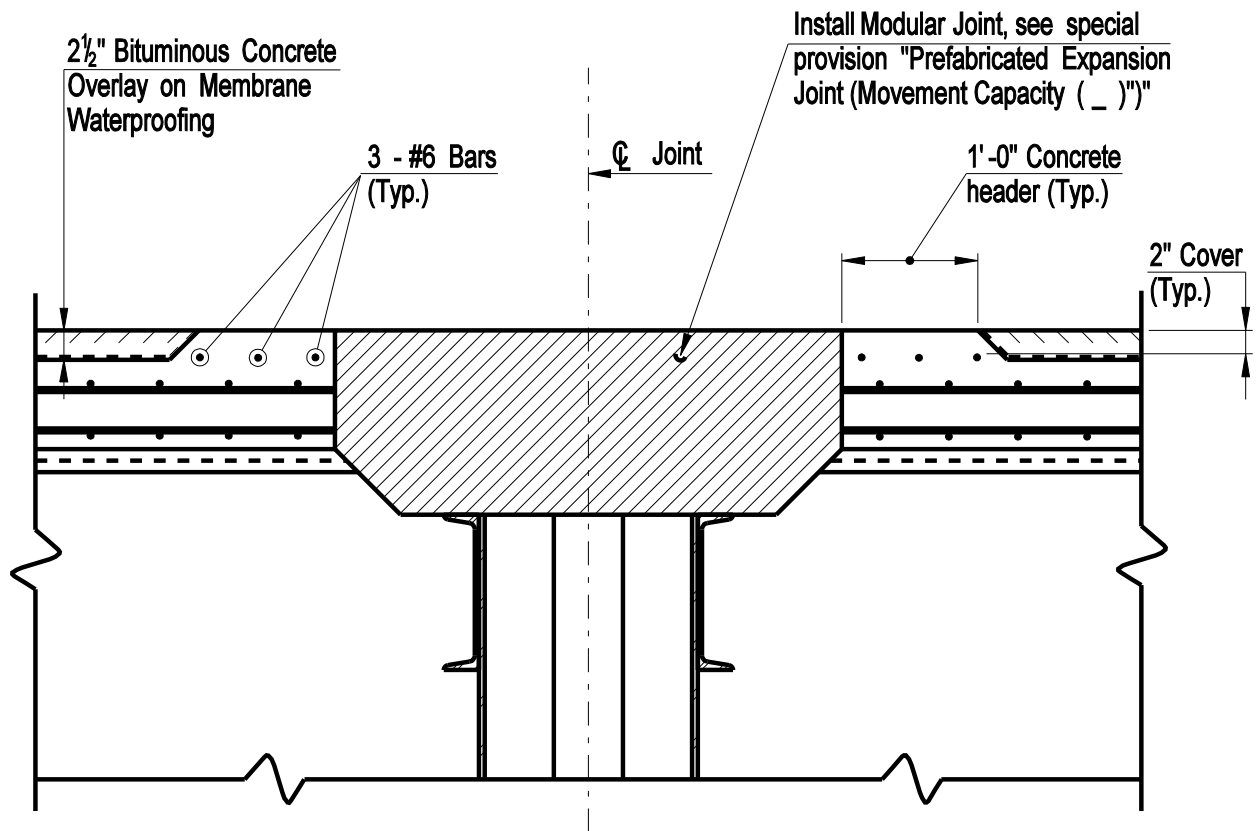
DESIGN INFORMATION

1. Finger joints to be used for joint movement greater than 4" at pedestal type abutments only, (See Plates 3.1.2a thru 3.1.2e)
2. All structural steel, weldable bars and anchor bolts shall be included in the pay item for "Finger Joint".



SECTION AT END OF SLAB





TYPICAL SECTION

NOTES:

See special provision "Prefabricated Expansion Joint (Movement Capacity (_))".

DESIGN INFORMATION:

The temperature range used for computation of movement shall be based on a moderate climate in accordance with AASHTO.

The required movement capacity of each joint shall be determined by the Designer and shown on the plans.

The contract plans shall show a blocked out area for the Modular Joint. The manufacturer will be responsible for the joint and anchorage details in accordance with the special provisions.

Modular joints should be used for joint movements greater than 4" at piers.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

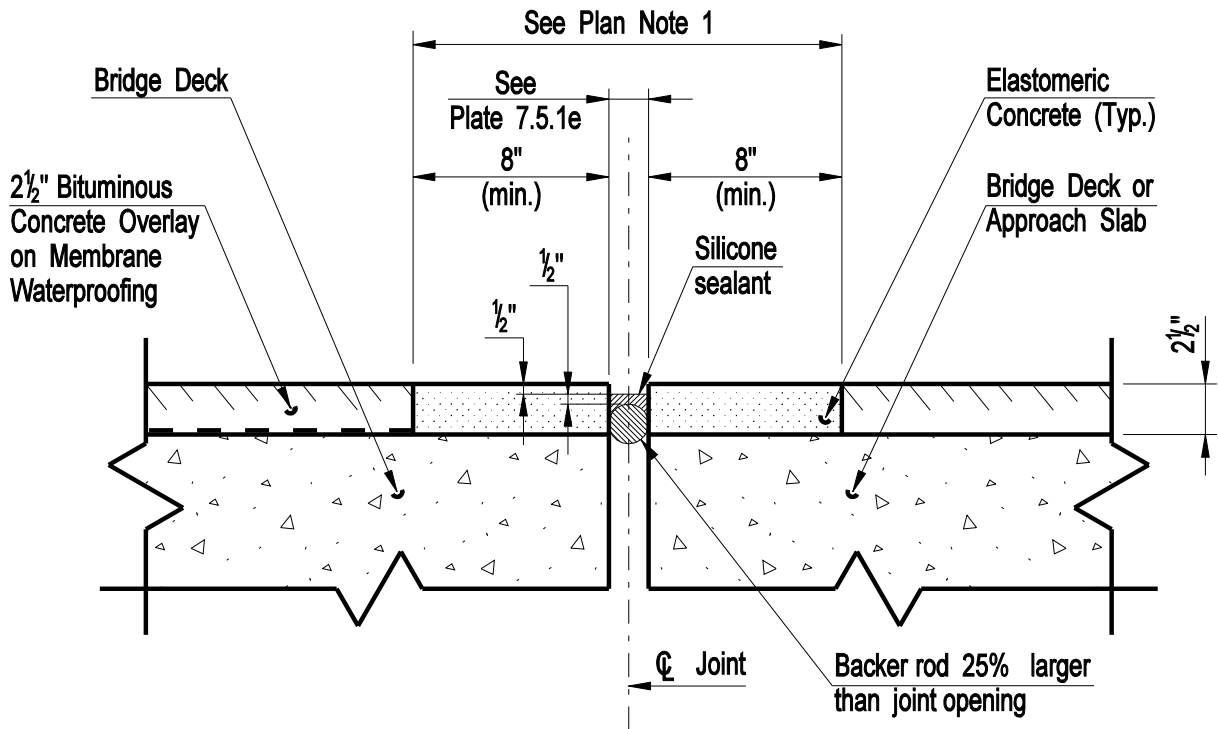
**MODULAR EXPANSION
JOINT SYSTEM**

Issue Date: 10/03

Revision Date:

Plate Number:

7.4.1



PLAN NOTES:

1. Remove new bituminous concrete overlay and membrane waterproofing and replace with Silicone Expansion Joint System. To be paid for under the item "Silicone Expansion Joint System". (See Special Provision)
2. Silicone sealant shall be installed when the ambient temperature is between 50° F and 80° F.

DESIGN INFORMATION:

1. *Silicone Expansion Joint System shall be used at expansion joints with computed movements between 1 1/2" and 3".*

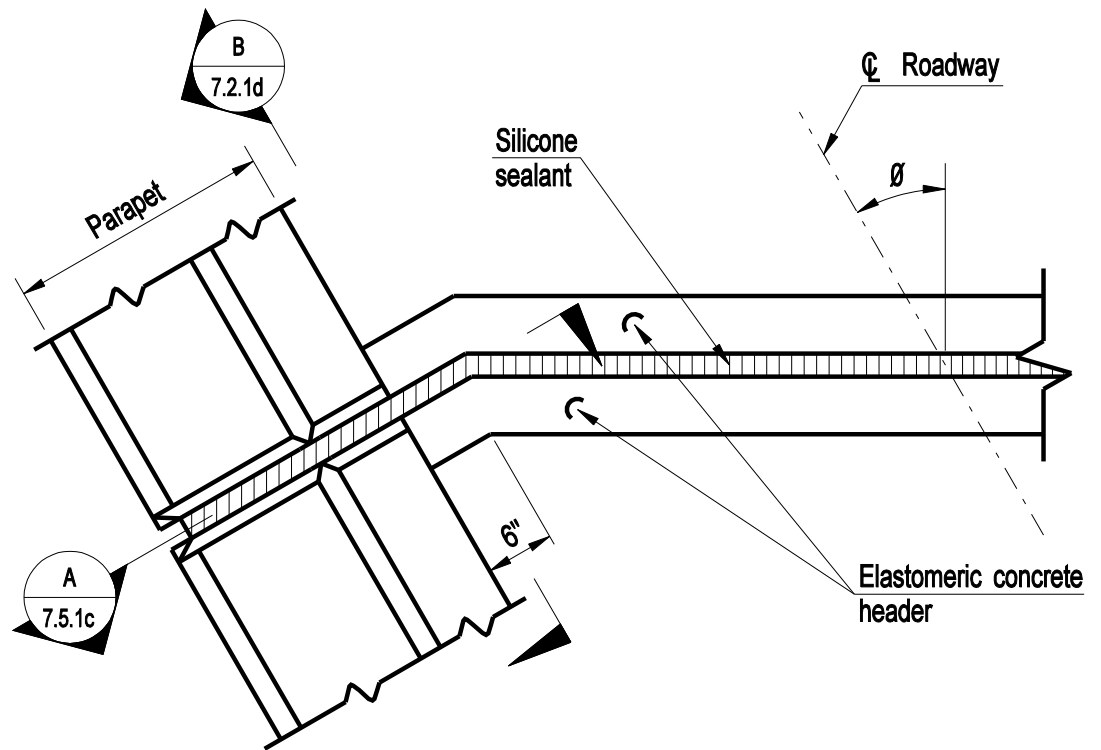
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SILICONE
EXPANSION
JOINT SYSTEM**

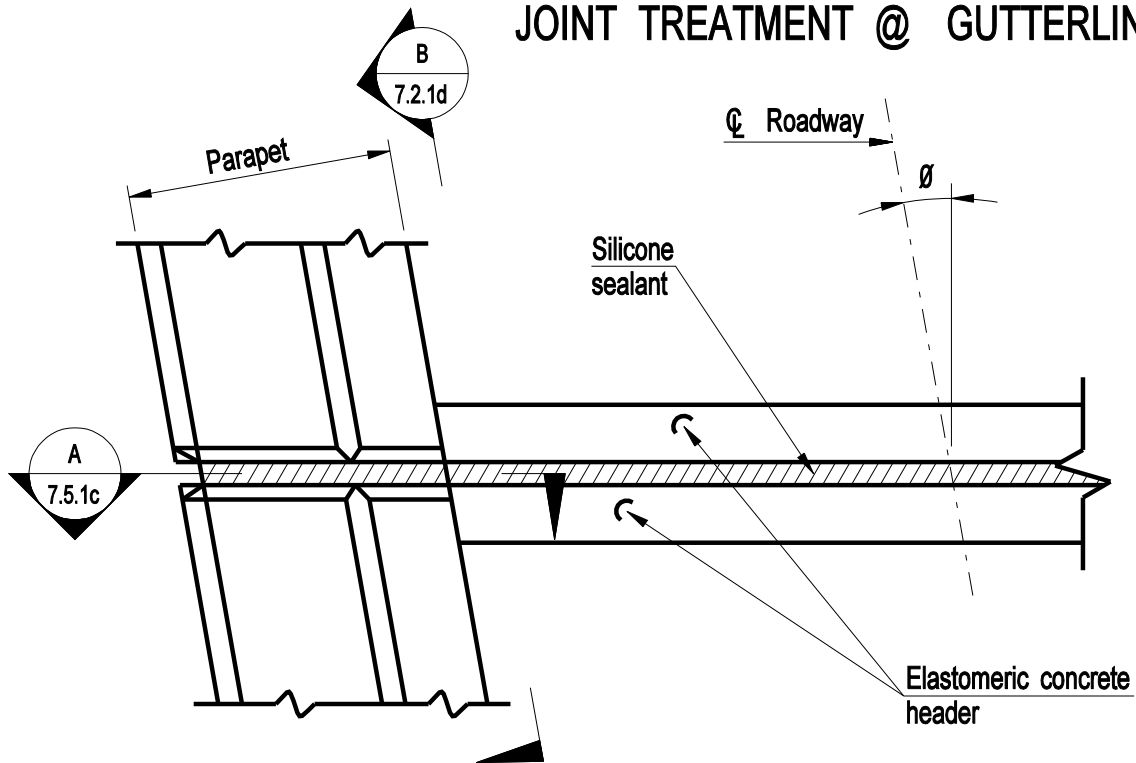
Issue Date: 10/03

Revision Date: 01/05

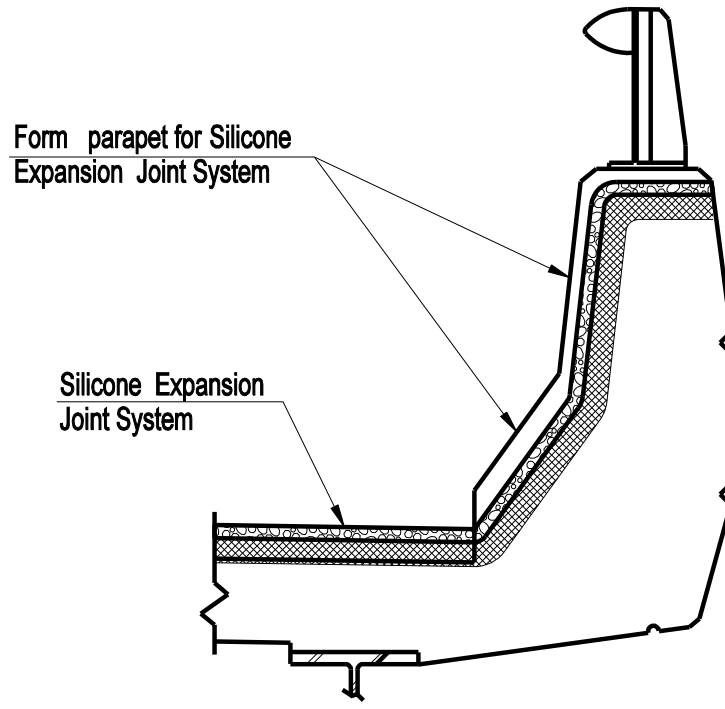
Plate Number:
7.5.1a



JOINT TREATMENT @ GUTTERLINE $\theta > 35^\circ$



JOINT TREATMENT @ GUTTERLINE $\theta \le 35^\circ$



SECTION A

JOINT TREATMENT AT CONCRETE PARAPET

DESIGN INFORMATION

- 1. This plate shall be used in conjunction with Plate 7.5.1b and 7.5.1d.*

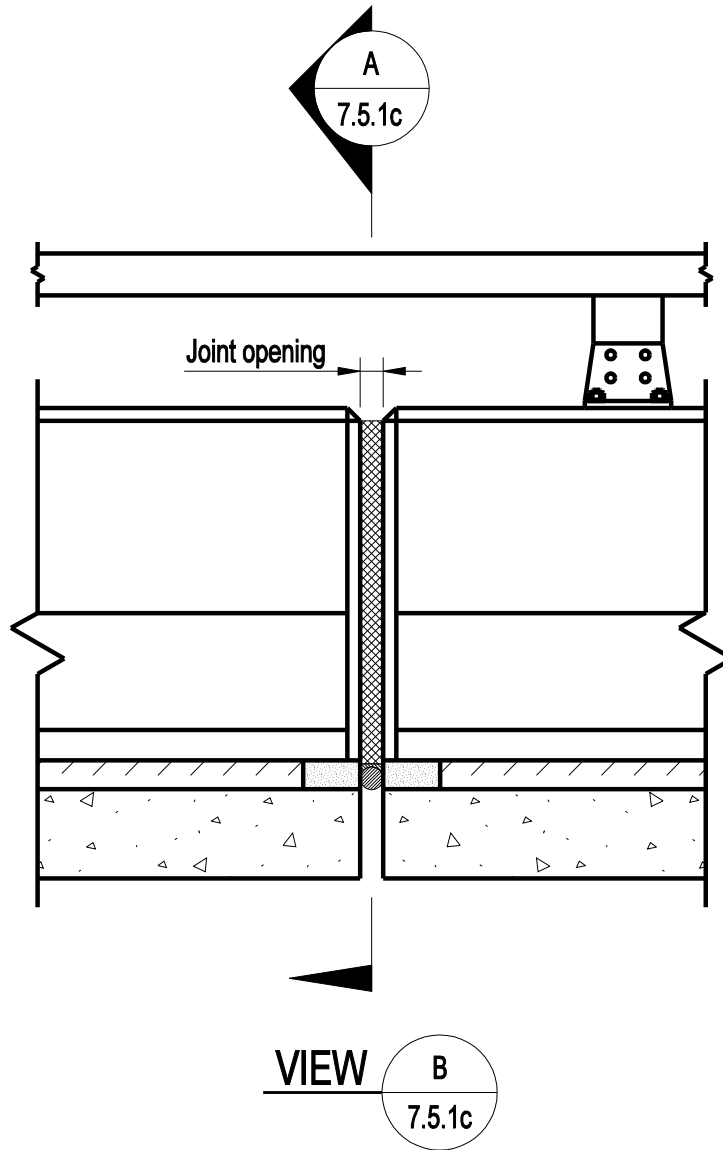
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SILICONE
EXPANSION
JOINT SYSTEM**

Issue Date: 10/03

Revision Date:

Plate Number:
7.5.1c



JOINT TREATMENT AT CONCRETE PARAPET

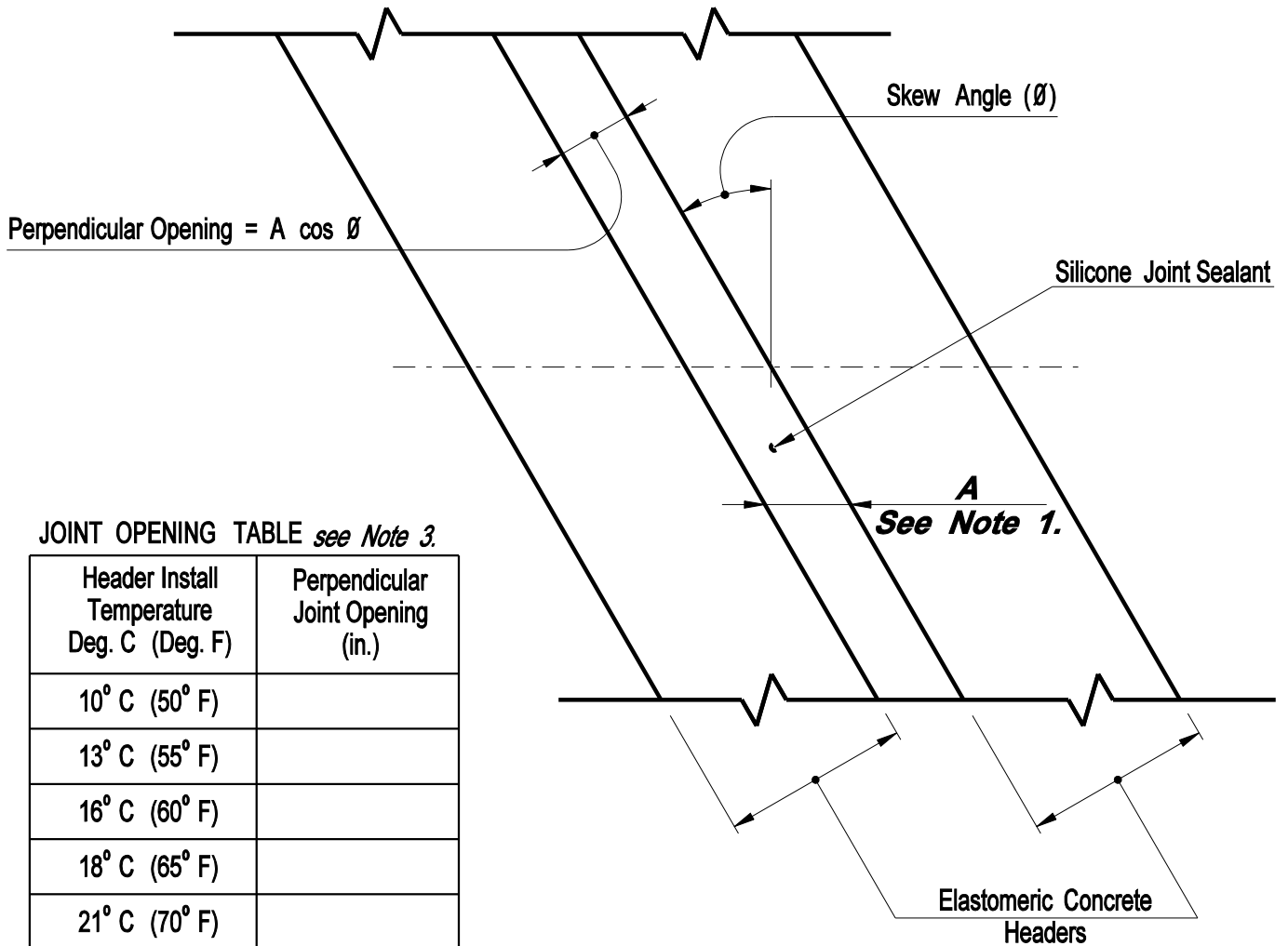
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SILICONE
EXPANSION
JOINT SYSTEM**

Issue Date: 10/03

Revision Date: 01/05

Plate Number:
7.5.1d



JOINT OPENING TABLE *see Note 3.*

Header Install Temperature Deg. C (Deg. F)	Perpendicular Joint Opening (in.)
10° C (50° F)	
13° C (55° F)	
16° C (60° F)	
18° C (65° F)	
21° C (70° F)	
24° C (75° F)	
27° C (80° F)	

**SILICONE EXPANSION JOINT SYSTEM
PLAN VIEW**

DESIGN INFORMATION:

- 1. The joint opening along the skew (Dimension A) shall be set such that it is equal to the actual computed movement at the joint at 10° C (50° F).**
- 2. The temperature range used for computation of movement shall be as specified in Division 1.**
- 3. The designer shall provide a table on the plans specifying the perpendicular opening to be provided at all header installation temperatures between 10° C (50° F) and 27° C (80° F).**

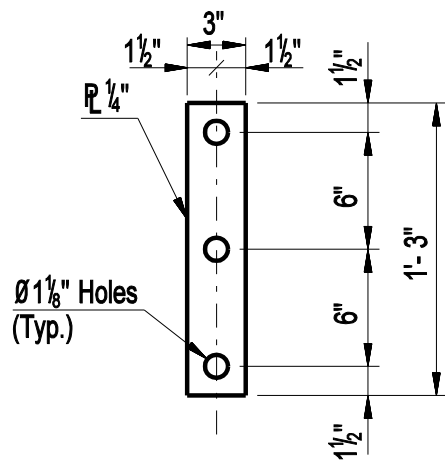
**CONNECTICUT
BRIDGE DESIGN
MANUAL**

**SILICONE
EXPANSION
JOINT SYSTEM**

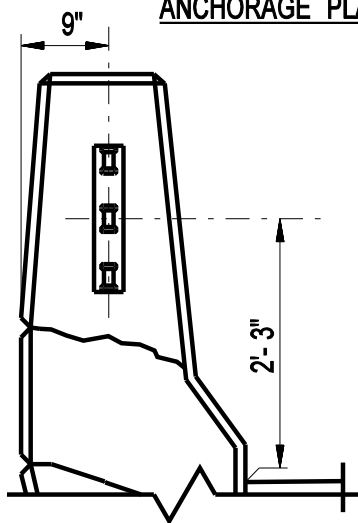
Issue Date: 01/05

Revision Date:

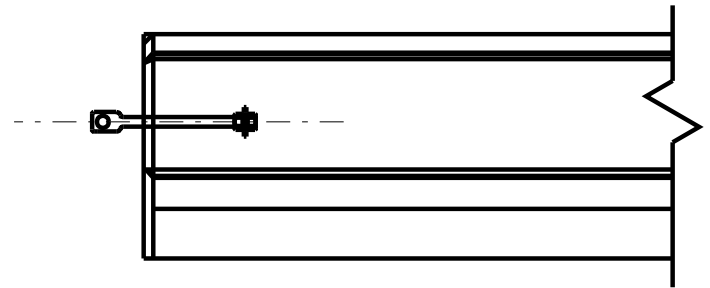
Plate Number:
7.5.1e



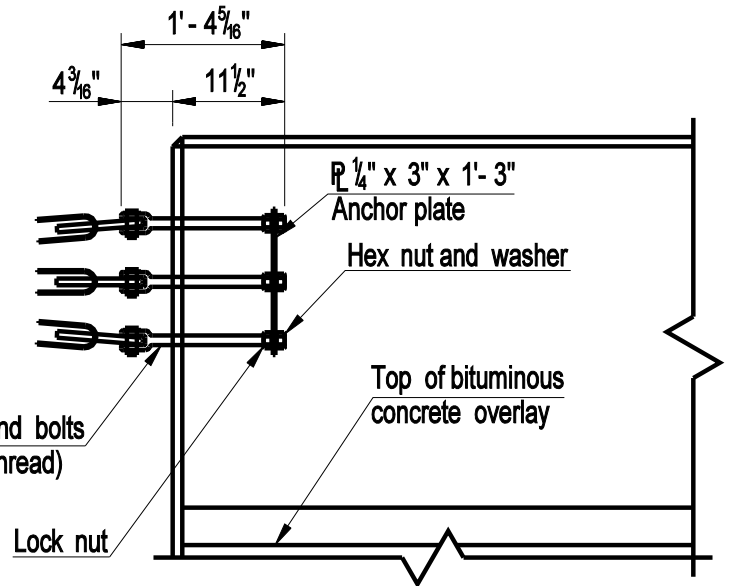
ANCHORAGE PLATE



END VIEW



PLAN



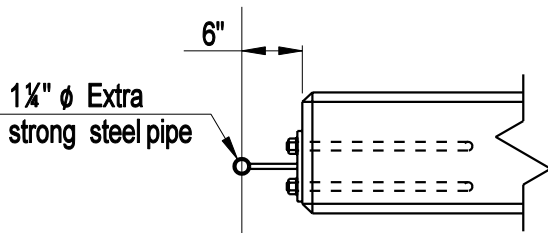
ELEVATION

Notes:

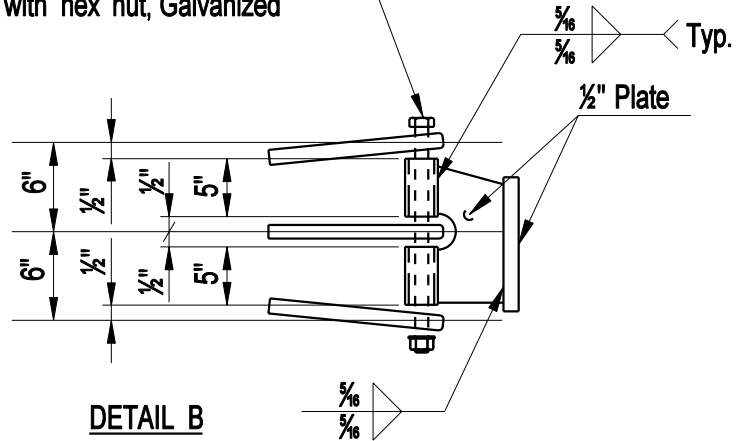
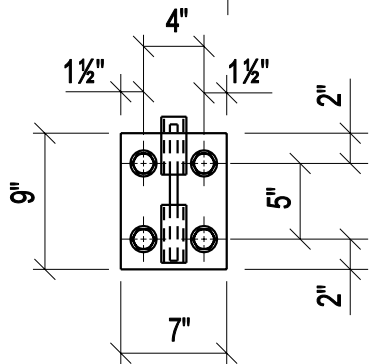
1. The shackle end bolts shall conform to the requirements of ASTM A688 Class E or AISI 1035 forged steel, galvanized in accordance with the requirements of ASTM A153.
2. The standard hex nuts, anchor plates and lock nuts shall conform to the requirements of ASTM A36.
3. Longitudinal reinforcement in parapet to clear anchor plate.
4. All anchorage material shall be paid for as part of the pay item "End Anchorage - Bridge Type" (Roadway Item).

DESIGN INFORMATION

This detail to be used to anchor Three-Cable Guide Railing at trailing end of 3'-6" high parapets with sloped curb on one-way roads.

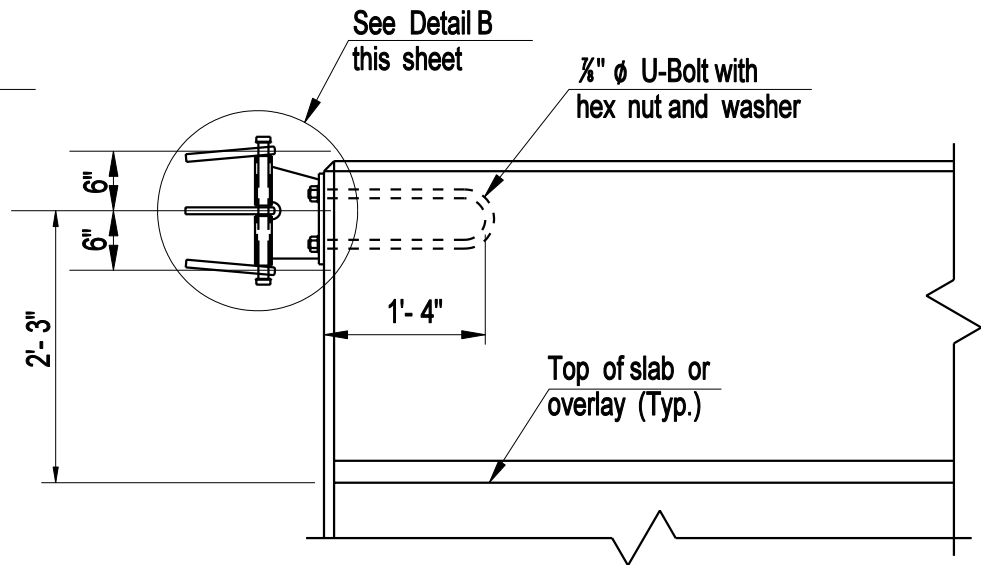
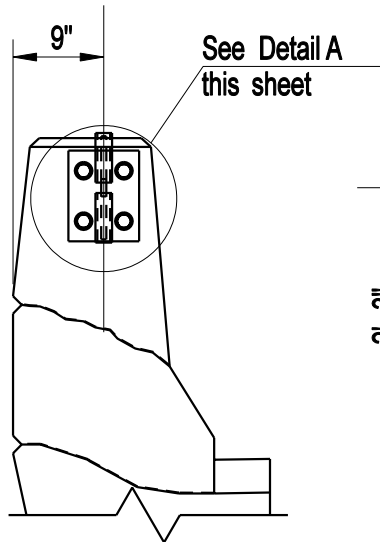


$\frac{7}{8}$ " ϕ x 1'-2" Long
bolt with hex nut, Galvanized



DETAIL B

DETAIL A

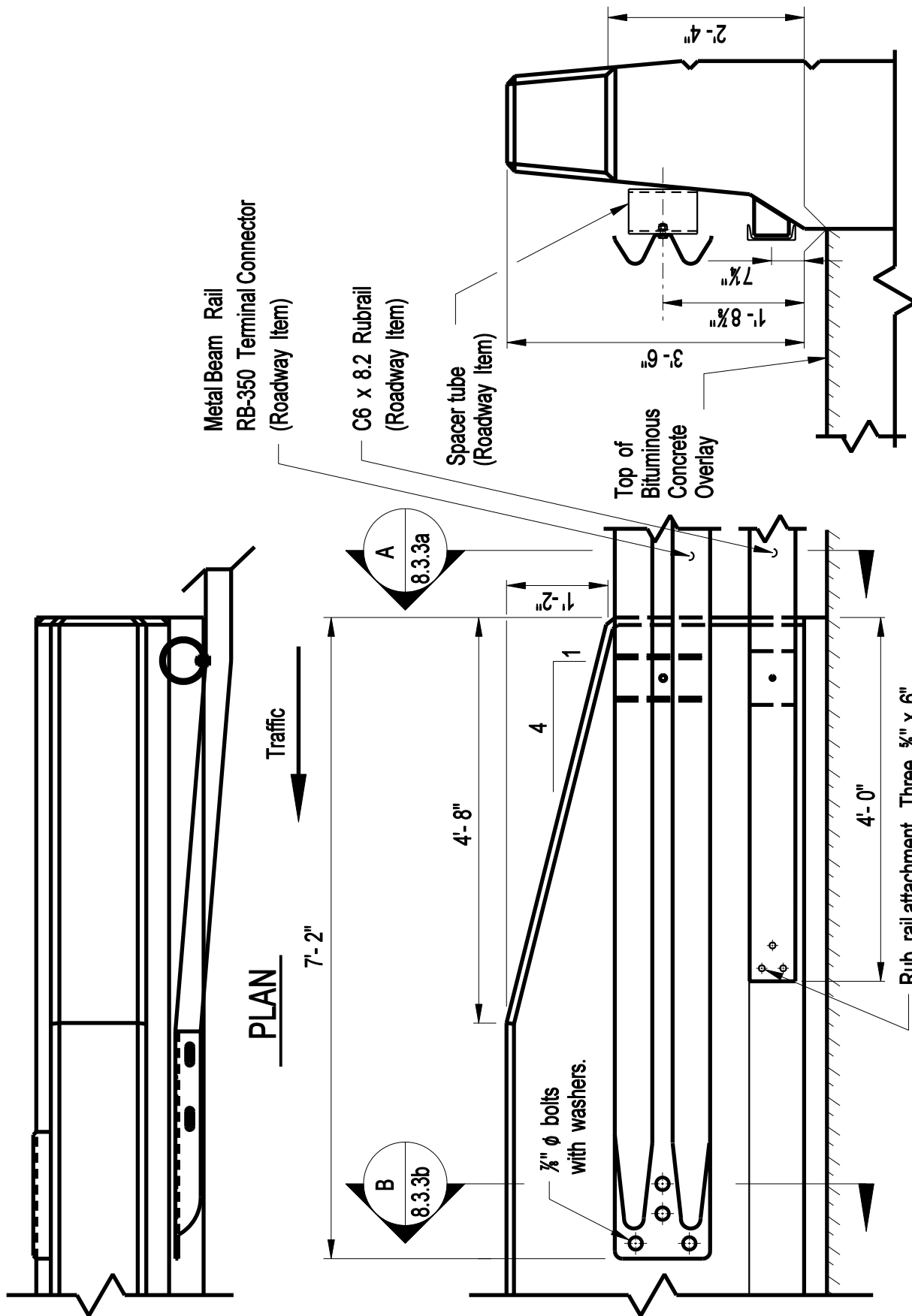


Notes:

1. Anchor bolts shall conform to the requirements of ASTM A449 with nuts and washers conforming to A563 Grade B.
2. Anchor bolts, nuts, washers and exposed metal parts shall be galvanized in conformance with the requirements of ASTM A153.
3. Steel plates shall conform to the requirements of ASTM A36.
4. All anchorage material shall be paid for as part of the pay item for "End Anchorage - Bridge Type" (Roadway Item).
5. Entire anchorage assembly shall be galvanized after fabrication.

DESIGN INFORMATION

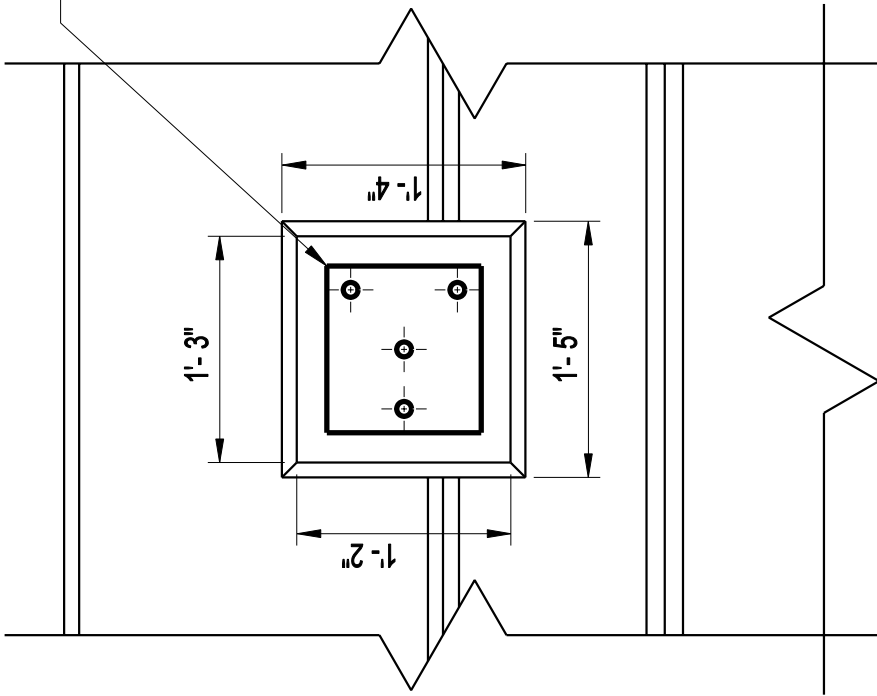
This detail is to be used to anchor Three Cable Guide Rail at trailing end of 2'-8" high parapet with sloped curb on one-way roads.



VIEW A 8.3.3a

DESIGN INFORMATION: For parapet reinforcement within these limits, see plate 8.3.3c. This detail to be used at both ends on bi-directional roadways.

LEADING END R-B 350 RAIL ATTACHMENT

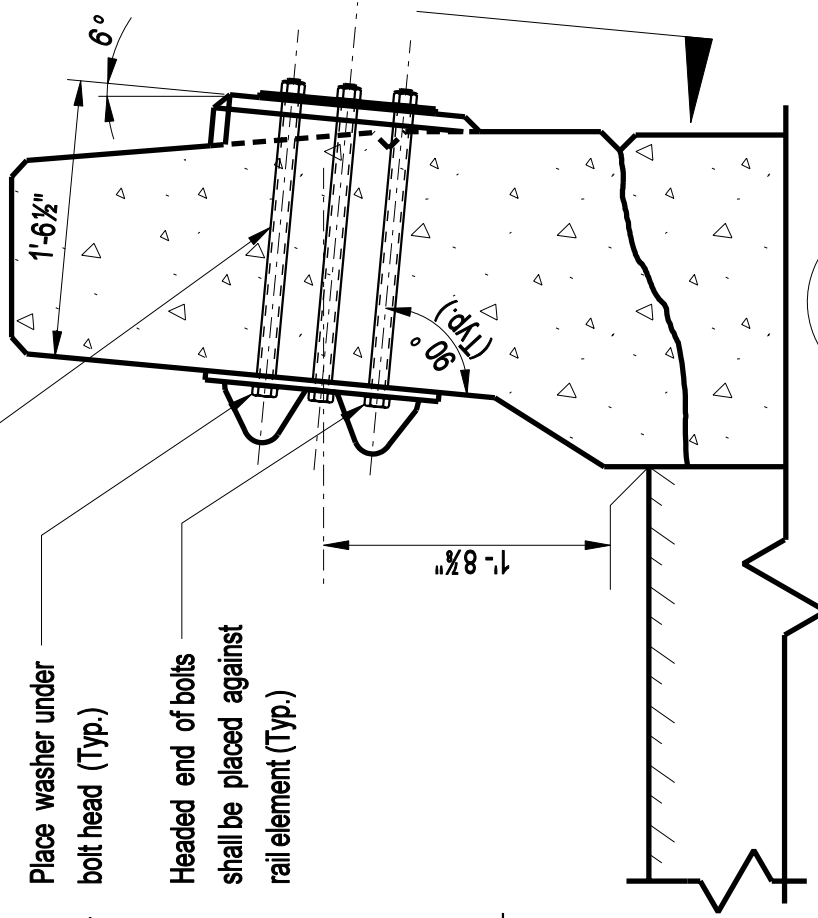


See Plate 8.3.3d
"Anchor Plate Detail"

1" *Standard
pipe sleeve (Typ.)
See Note A

Place washer under
bolt head (Typ.)

Headed end of bolts
shall be placed against
rail element (Typ.)



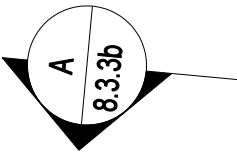
*Dimension taken from top of
parapet to intersection of anchor
bolt $\text{\textcircled{C}}$ and face of buildout.

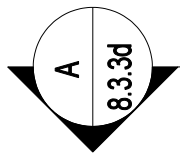
For reinforcement not shown, see plate 8.3.3d
For parapet dimensions not shown, see plate 3.4.4
LEADING END R-B 350 RAIL ATTACHMENT

NOTE A

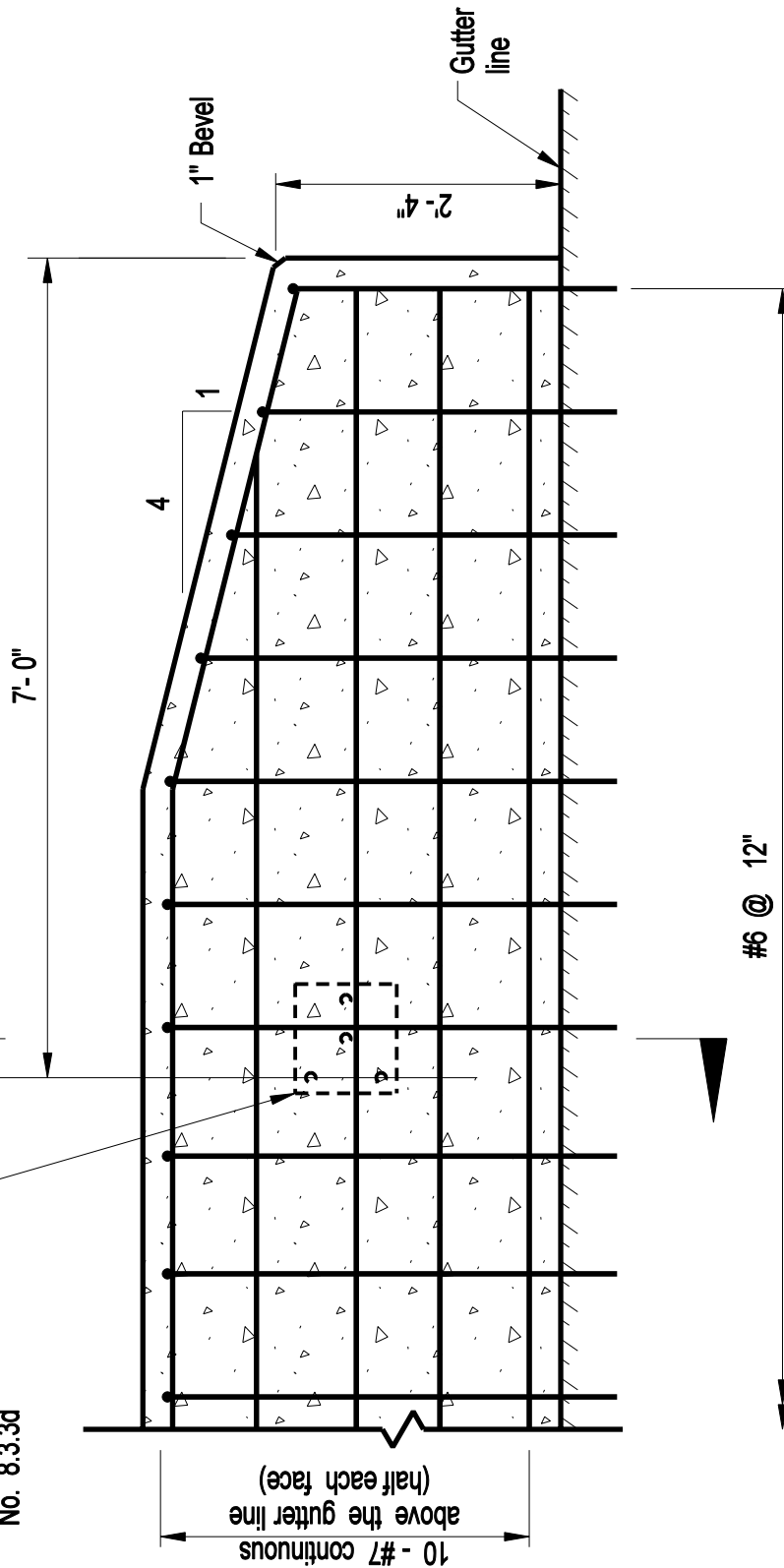
1" * pipe shall conform to ASTM A53 Gr. B or ASTM A501 and shall be galvanized in accordance with the requirements of ASTM - A123.

DESIGN INFORMATION:



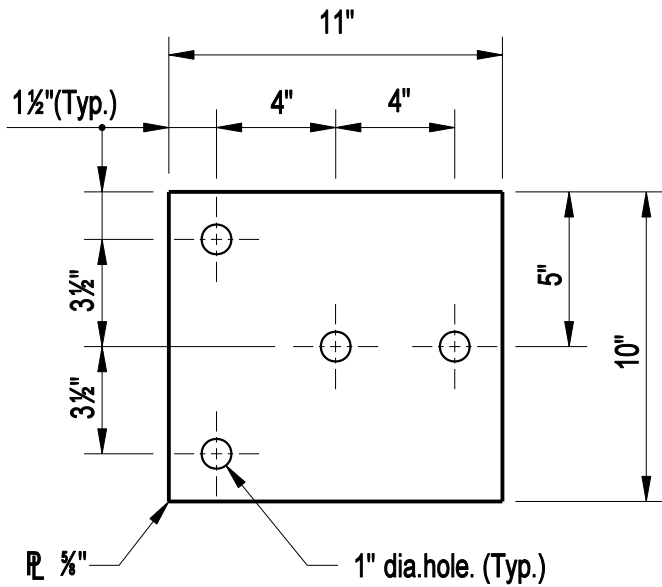


Anchor Plate for Metal
Beam Rail attachment,
leading end. See Plate
No. 8.3.3d

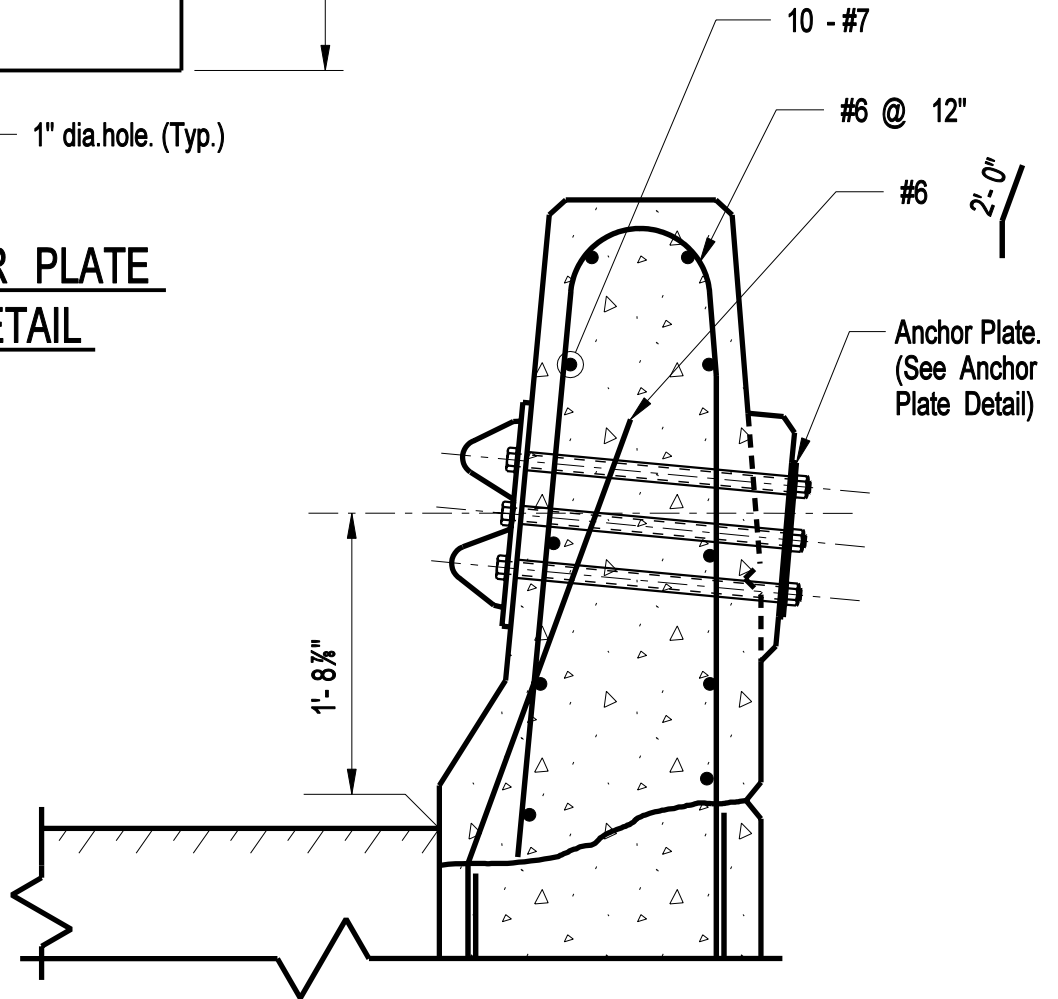


Note: See Plate 3.4.4 for typical parapet reinforcing

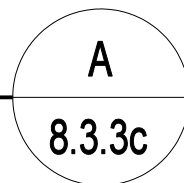
ELEVATION
PARAPET REINFORCEMENT AT LEADING END

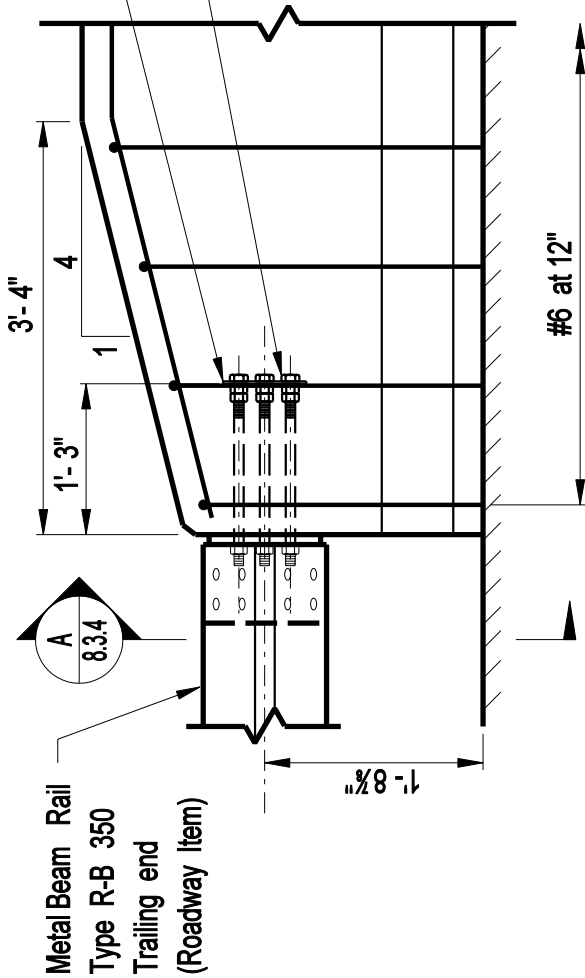


ANCHOR PLATE
DETAIL

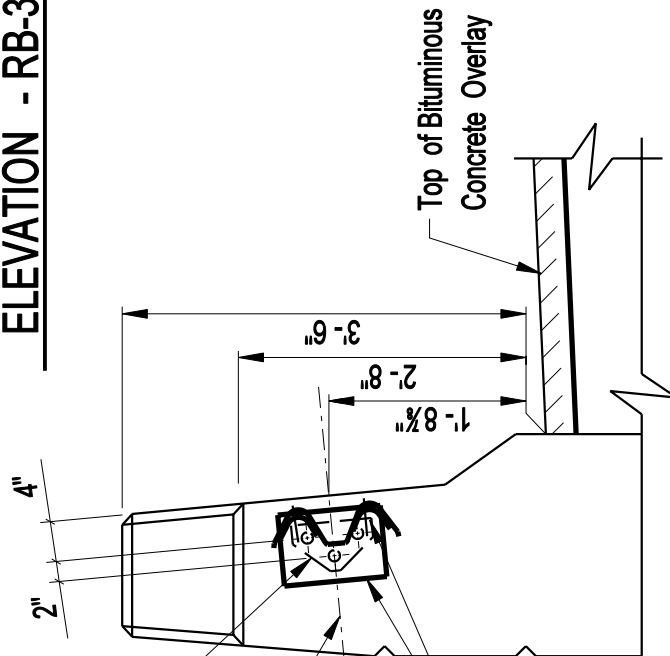


Section





ELEVATION - RB-350 RAIL



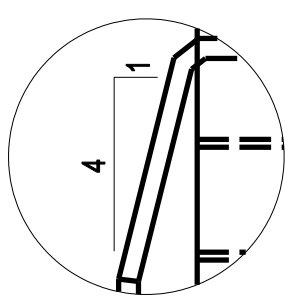
**DETAIL
ANCHORAGE PLATE**

1/2" anchorage plate. See Anchorage Plate Detail
 Anchorage plate is to be set perpendicular to front parapet face.
 Connection Plates See Roadway Dwgs.

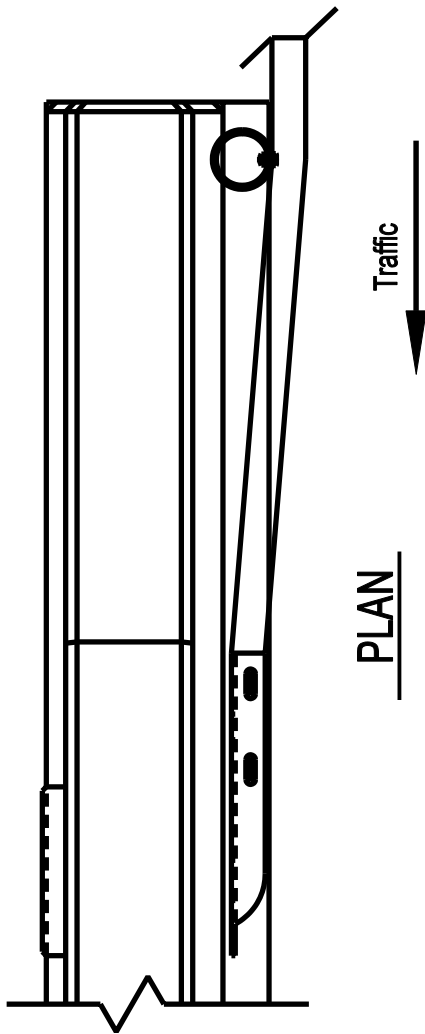
DESIGN INFORMATION:
This detail to be used at trailing ends on uni-directional roadways only.

VIEW A 8.3.4

TRAILING END R-B 350 RAIL ATTACHMENT



DETAIL **B**
8.3.5a



B
8.3.5a

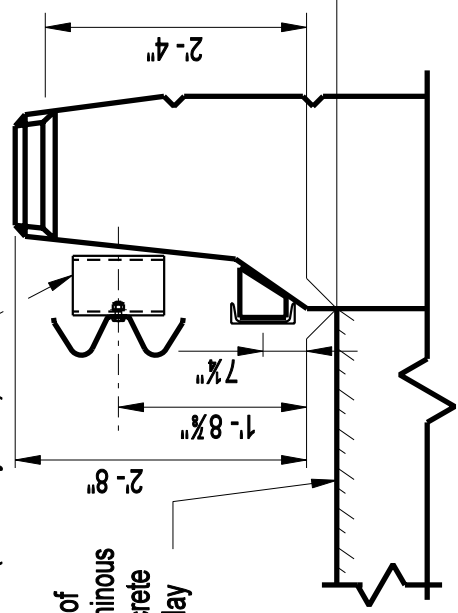
A
8.3.5a

Metal Beam Rail
RB-350 Terminal Connector
(Roadway Item)

C6 x 8.2 Rubrail
(Roadway Item)

Spacer tube
(Roadway Item)

Top of
Bituminous
Concrete
Overlay



VIEW **A**
8.3.5a

Rub rail attachment. Three 5/8" x 6" chemically anchored bolts with washers. Max bolt projection shall be 1/2". (Roadway Item)

4'-0"

5/8" ϕ bolts with washers.

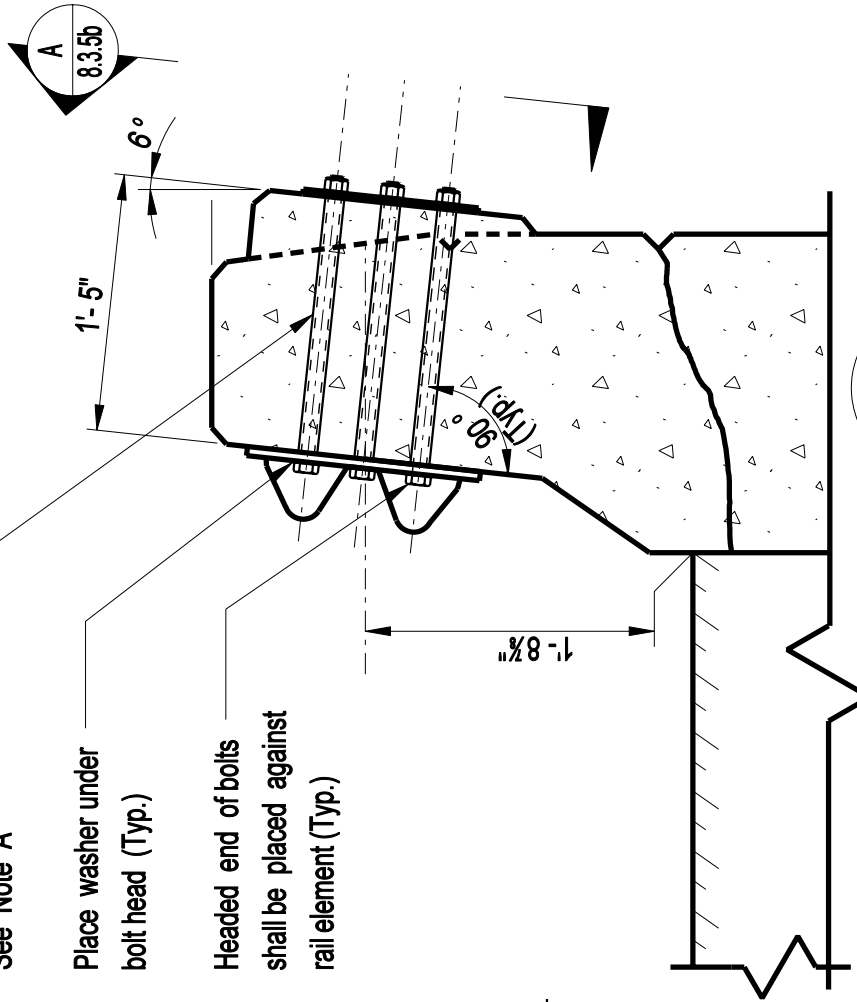
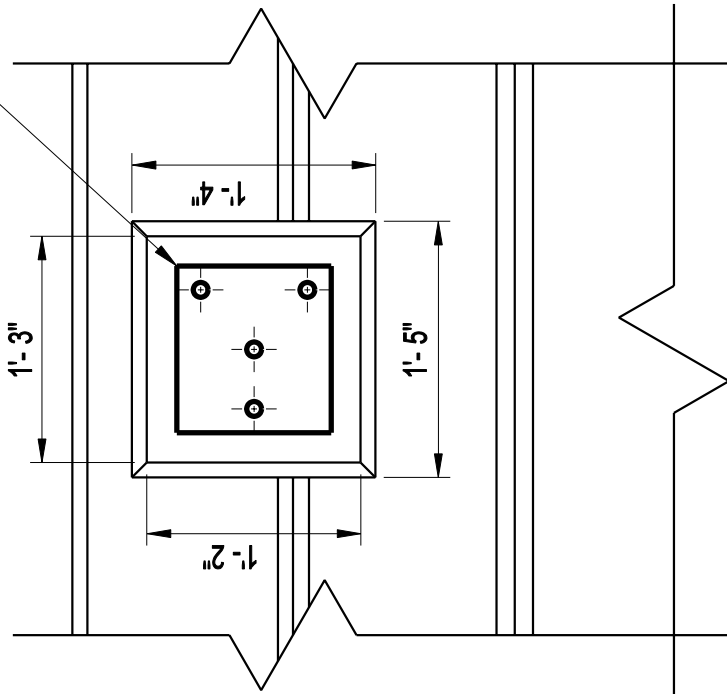
B
8.3.5b

DESIGN INFORMATION: For parapet reinforcement within these limits, see plate 8.3.5c. This detail to be used at both ends on bi-directional roadways.

LEADING END R-B 350 RAIL ATTACHMENT

See Plate 8.3.5d
"Anchor Plate Detail"

1" *Standard
pipe sleeve (Typ.)
See Note A
Place washer under
bolt head (Typ.)
Headed end of bolts
shall be placed against
rail element (Typ.)



NOTE A

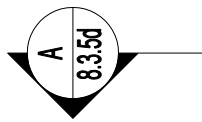
1" *pipe shall conform to ASTM A53 Gr. B or ASTM A501 and shall be galvanized in accordance with the requirements of ASTM - A123.

DESIGN INFORMATION:

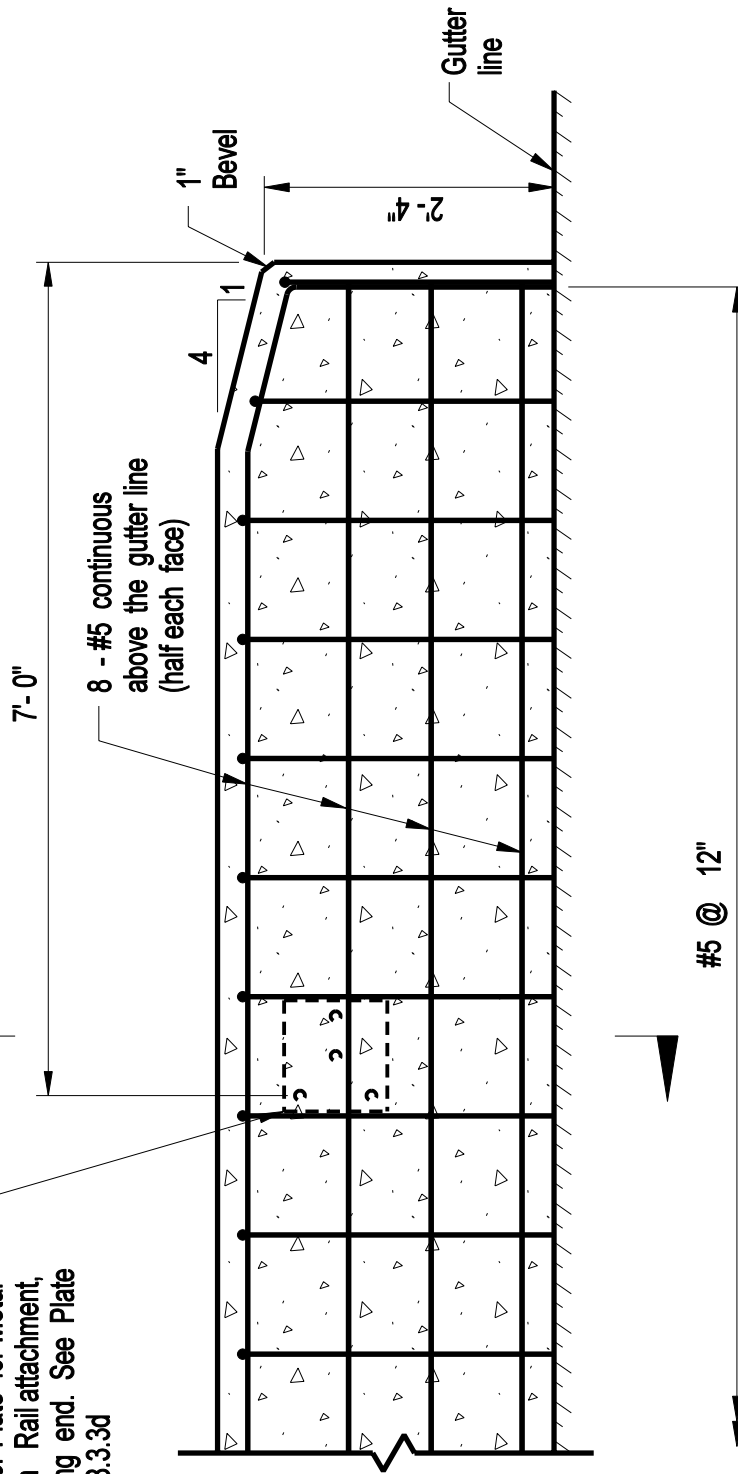
*For reinforcement not shown, see plate 8.3.5d
For parapet dimensions not shown, see plate 3.4.3*

*Dimension taken from top of parapet to intersection of anchor bolt Q and face of buildout.

LEADING END R-B 350 RAIL ATTACHMENT

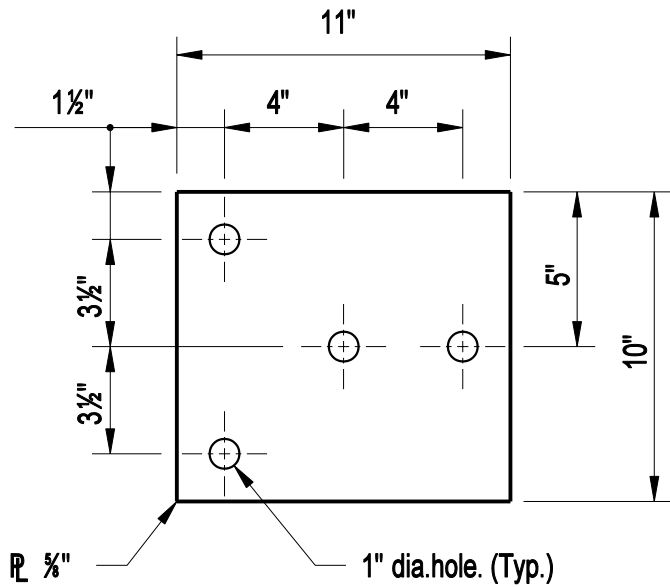


Anchor Plate for Metal
Beam Rail attachment,
leading end. See Plate
No. 8.3.3d

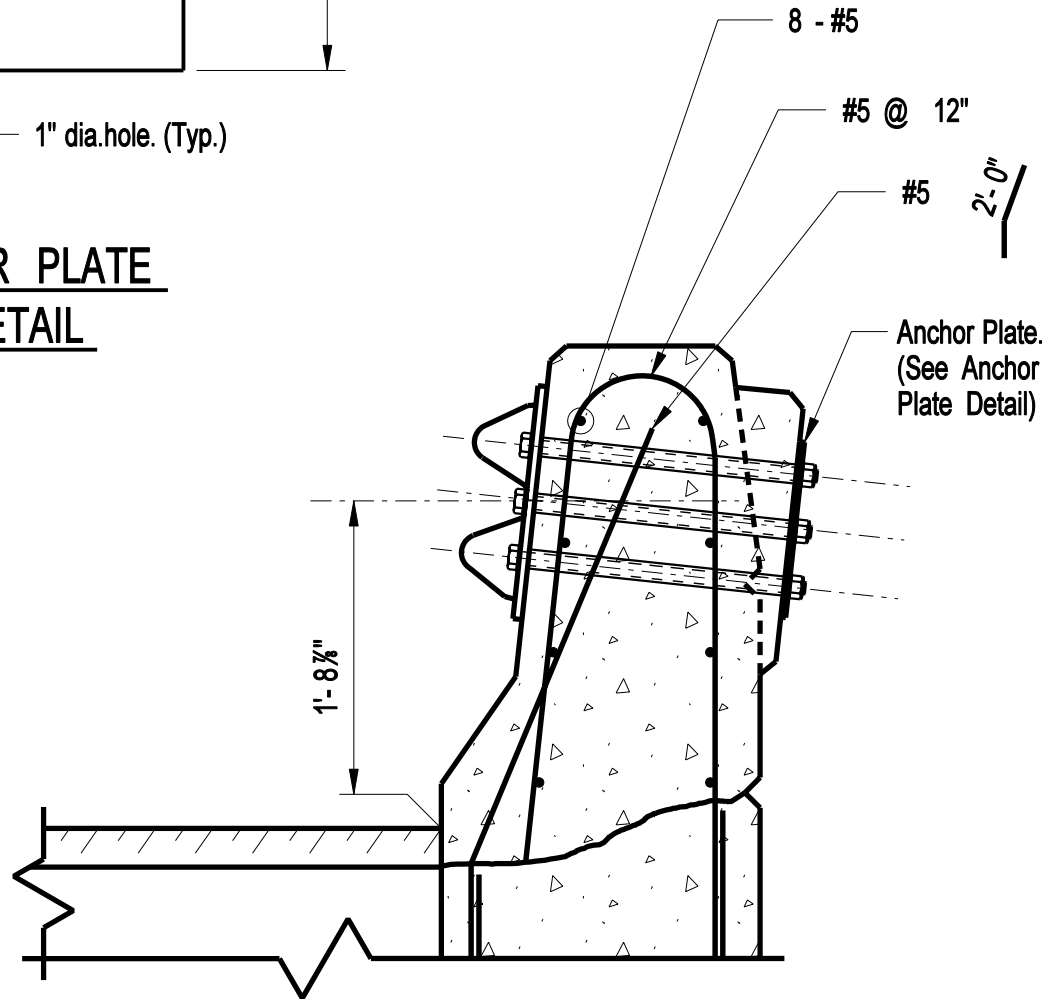


Note: See Plate 3.4.3 for typical parapet reinforcing

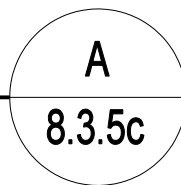
ELEVATION
PARAPET REINFORCEMENT AT LEADING END



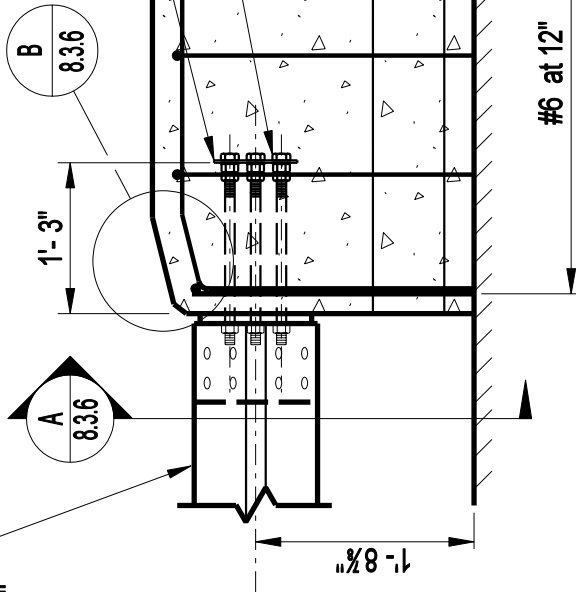
ANCHOR PLATE
DETAIL



SECTION

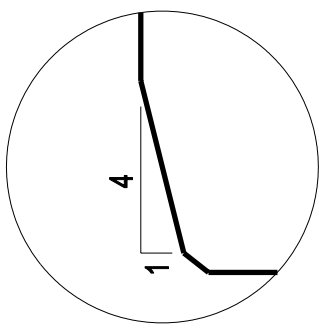


Metal Beam Rail
Type R-B 350
Trailing end
(Roadway Item)



5/8" anchorage plate

1" dia. x 1'-8" long
anchor bolts with 4 nuts
and washers (Typ.)



DETAIL B 8.3.6

ELEVATION - RB-350 RAIL

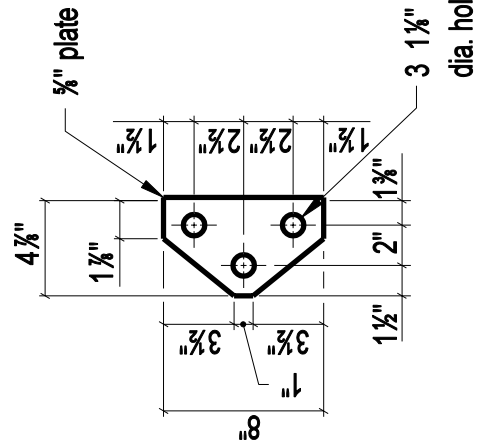
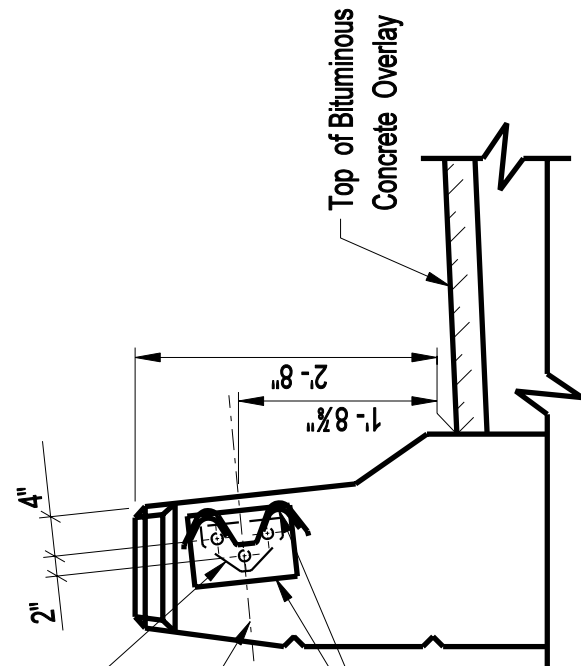
5/8" anchorage plate.
See Anchorage Plate
Detail

⊥ Anchorage plate is to
be set perpendicular to
front parapet face.

Connection Plates
See Roadway Dwgs.

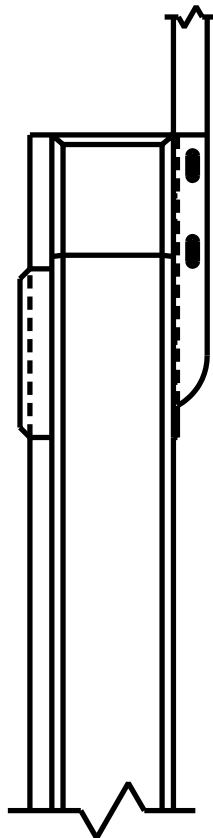
DESIGN INFORMATION:

*This detail to be used at
trailing ends on uni-directional
roadways only.*



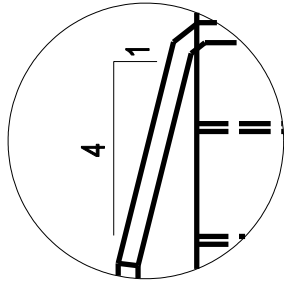
**ANCHORAGE PLATE
DETAIL**

TRAILING END R-B 350 RAIL ATTACHMENT



PLAN

Traffic →



DETAIL B

A
8.3.7a

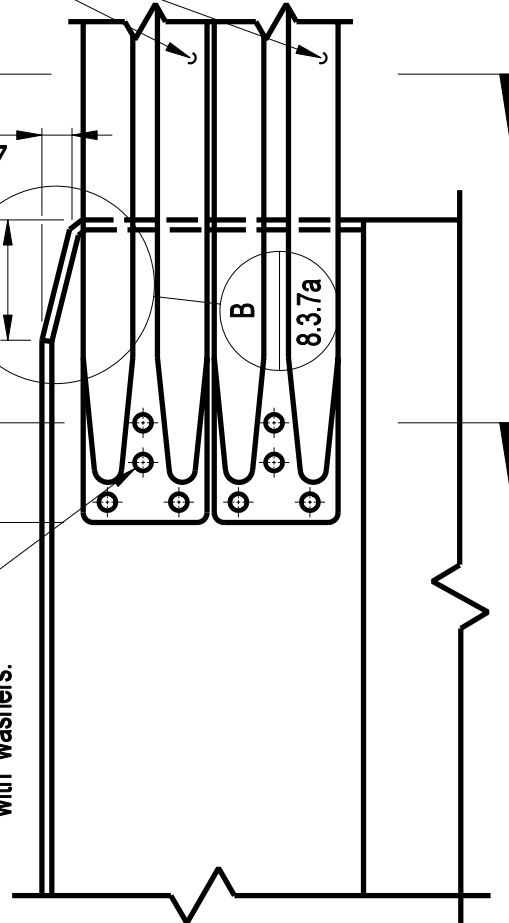
B
8.3.7b

2'-6"

$\frac{3}{8}$ " ϕ bolts
with washers.

1'-4"

$\frac{1}{4}$ "



Metal Beam Rail
RB-350 Terminal Connector
(Roadway Item)

Top of
Sidewalk

2'-8"

1'-8 $\frac{1}{2}$ "

2'-3"

1'-1"

A
8.3.7a

VIEW

DESIGN INFORMATION:
*For parapet reinforcement within these limits, see plate 8.3.7c.
This detail to be used at both ends on bi-directional roadways.*

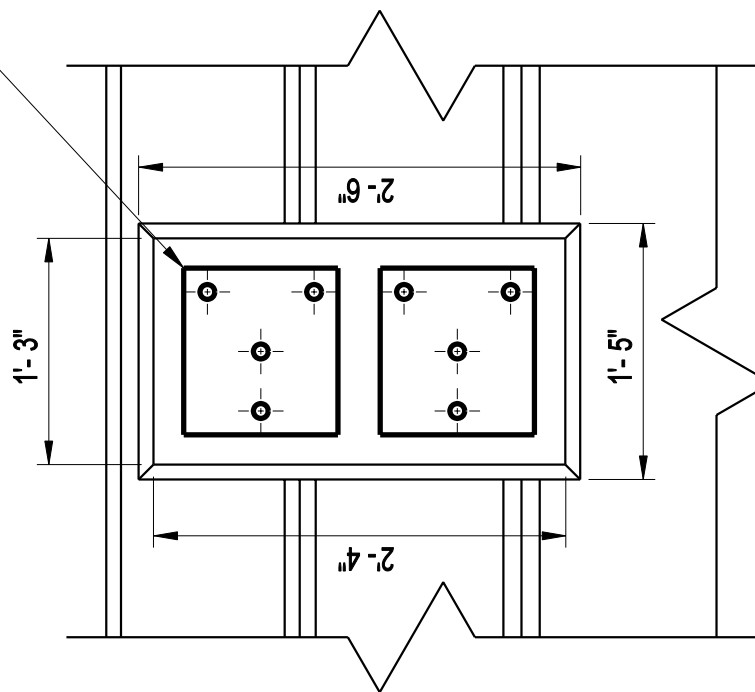
LEADING END R-B 350 RAIL ATTACHMENT

See Plate 8.3.7d
"Anchor Plate Detail"

1" * Standard
pipe sleeve (Typ.)
See Note A

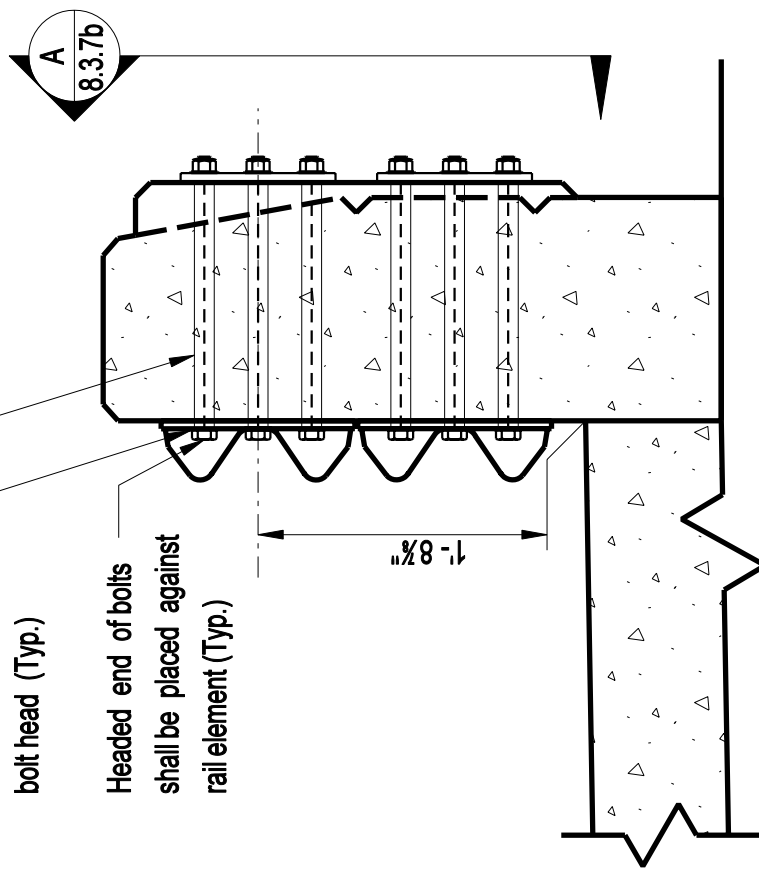
Place washer under
bolt head (Typ.)

Headed end of bolts
shall be placed against
rail element (Typ.)



View

A
8.3.7b



SECTION

B

8.3.7a

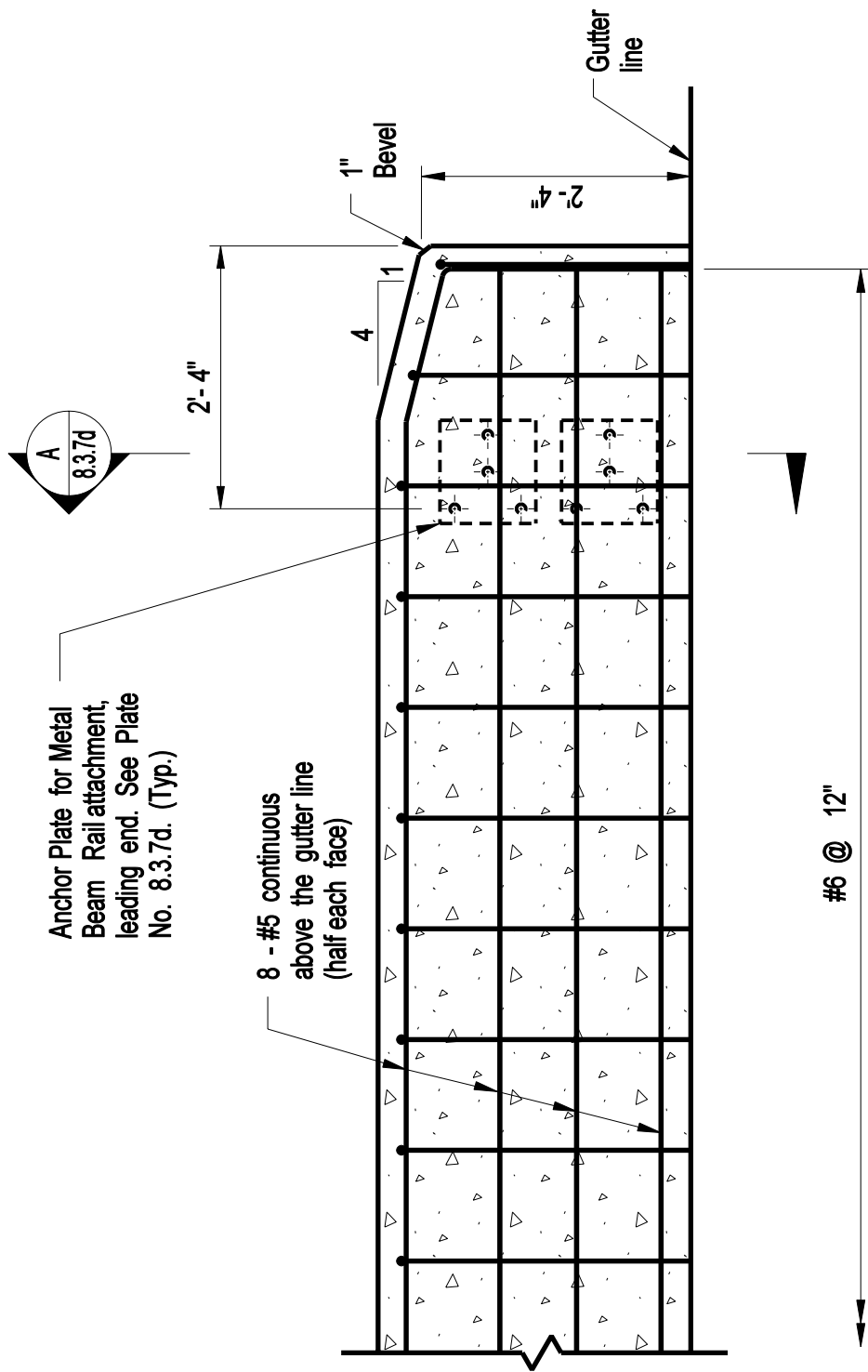
NOTE A

1" * pipe shall conform to ASTM A53 Gr. B or ASTM A501 and shall be galvanized in accordance with the requirements of ASTM A123.

DESIGN INFORMATION:

*For reinforcement not shown, see plate 8.3.7d.
For parapet dimensions not shown, see plate 3.4.6.*

LEADING END R-B 350 RAIL ATTACHMENT



Anchor Plate for Metal
Beam Rail attachment,
leading end. See Plate
No. 8.3.7d. (Typ.)

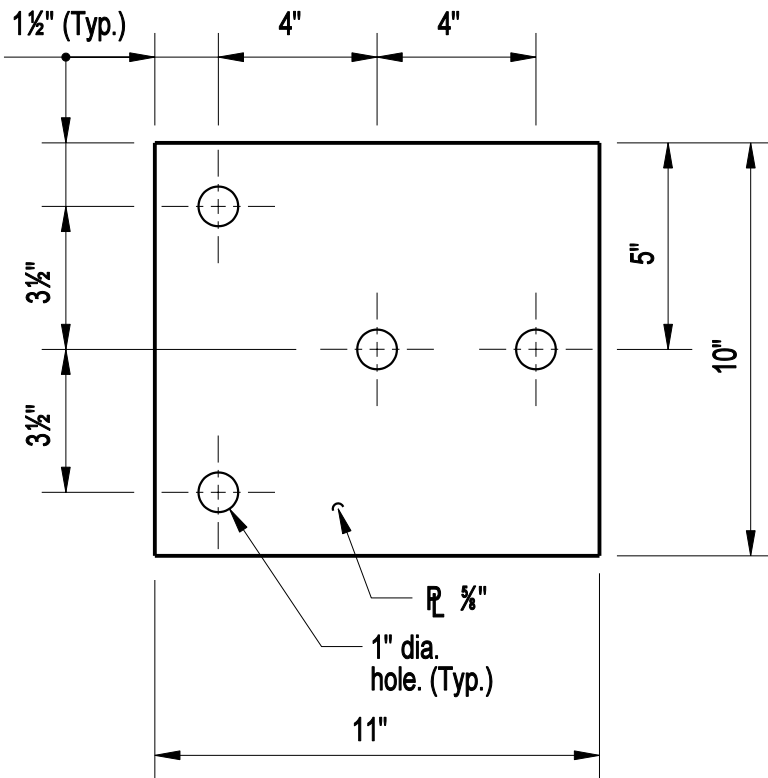
8 - #5 continuous
above the gutter line
(half each face)

#6 @ 12"

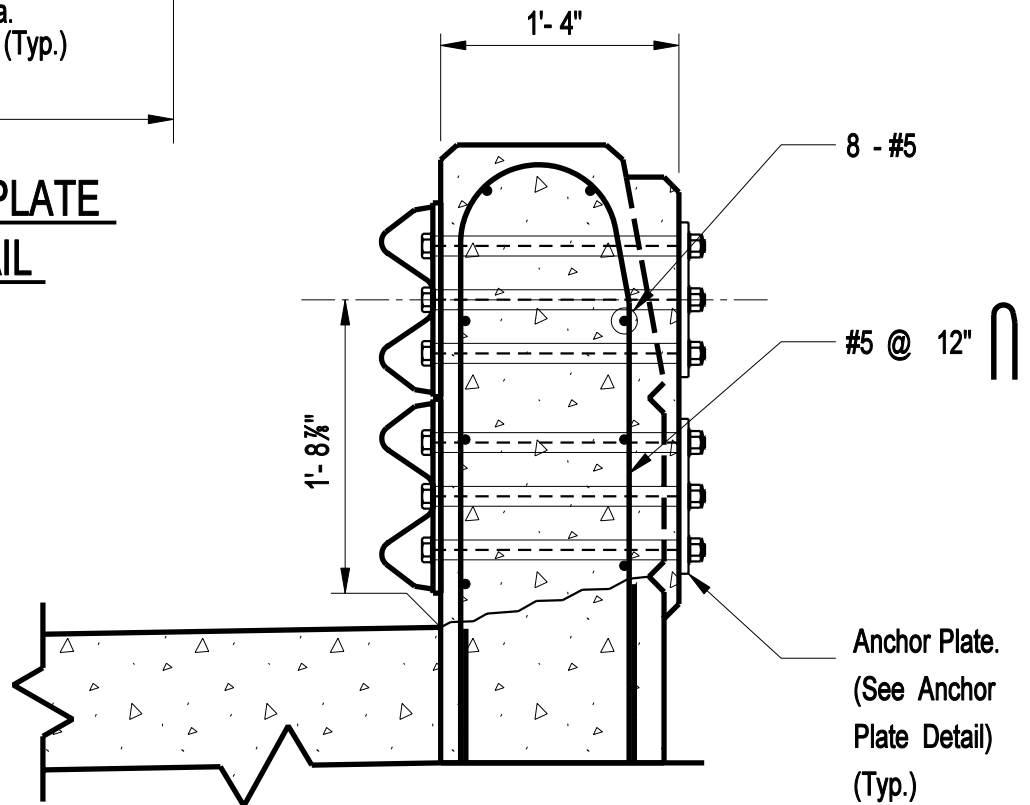
Note: See Plate 3.4.6 for typical parapet reinforcing

ELEVATION
PARAPET REINFORCEMENT AT LEADING END

Issue Date:	10/03
Revision Date:	
Plate Number:	8.3.7c



**ANCHOR PLATE
DETAIL**



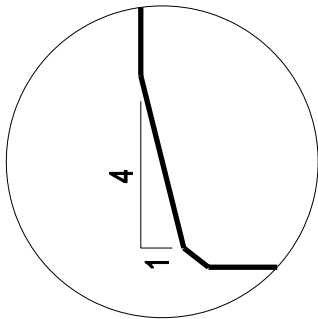
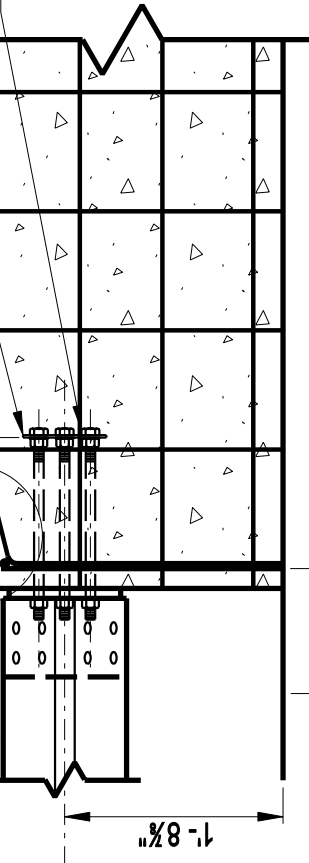
SECTION A
8.3.7c

Metal Beam Rail
Type R-B 350
Trailing end
(Roadway Item)

A 8.3.8
1'-3"

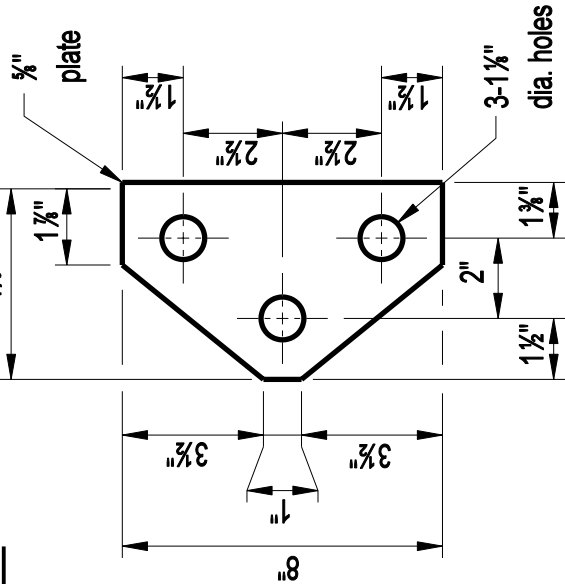
5/8" anchorage plate

1" dia. x 1'-8" long
anchor bolts with 4 nuts
and washers (Typ.)



DETAIL
B 8.3.8

ELEVATION - RB-350 RAIL



ANCHORAGE PLATE
DETAIL

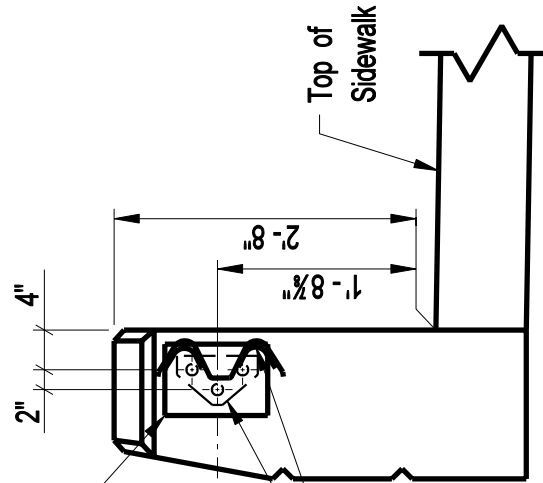
5/8" anchorage plate.
See Anchorage Plate
Detail

⊥ Anchorage plate is to
be set perpendicular to
front parapet face.

Connection Plates
See Roadway Dwgs.

DESIGN INFORMATION:

*This detail to be used at
trailing ends on uni-directional
roadways only.*



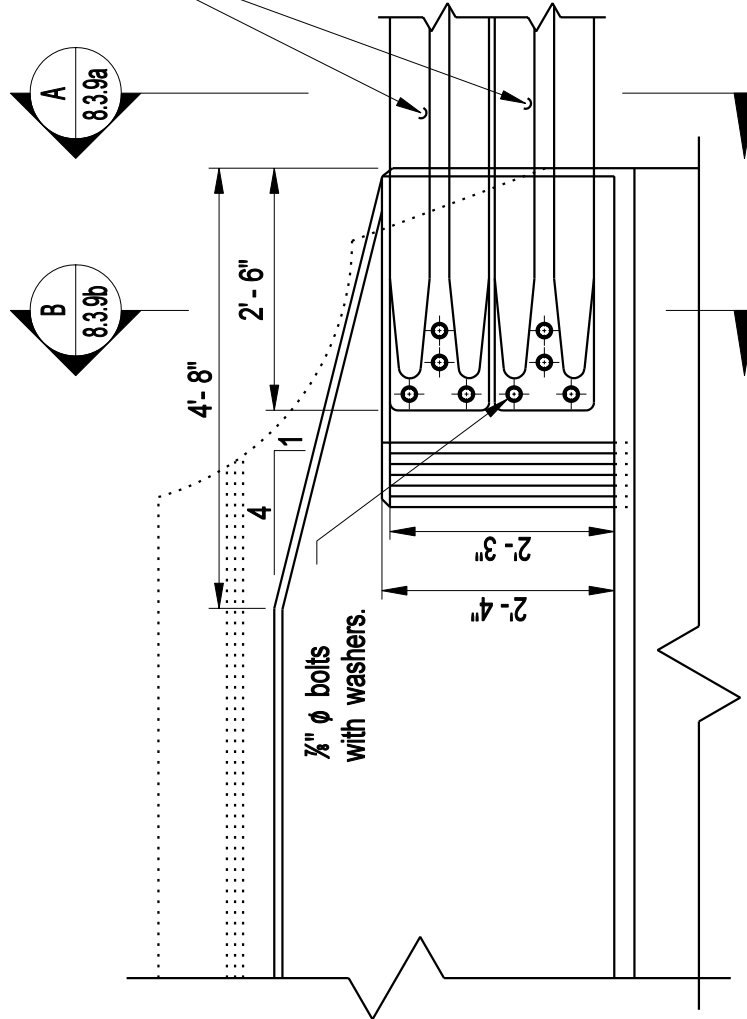
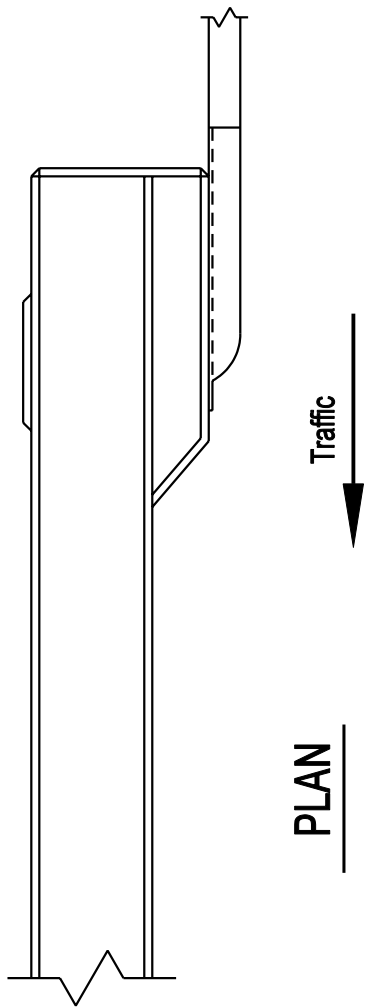
TRAILING END R-B 350 RAIL ATTACHMENT

PLAN NOTES:

1. Steel plates shall conform to the requirements of ASTM A36. The steel plates shall be hot-dip galvanized in accordance with the requirements of ASTM A123.
2. Anchor bolts shall conform to the requirements of ASTM A325, mechanically galvanized.
3. 1" ϕ pipe shall conform to ASTM A53 Grade B or ASTM A501 and shall be galvanized in accordance with the requirements of ASTM A123.
4. Railway elements shall be paid for under the applicable Roadway items.
5. All rail anchorage material required for end attachments shall be paid for under the applicable Roadway items.

DESIGN INFORMATION

- 1. Beam rail notes to be included on construction plans with all beam rail attachment details.***



Metal Beam Rail
RB-350 Terminal Connector
(Roadway Item)

VIEW A
8.3.9a

DESIGN INFORMATION:
*For parapet reinforcement within these limits, see plate 8.3.7c.
This detail to be used at both ends on bi-directional roadways.*

LEADING END R-B 350 RAIL ATTACHMENT

See Plate 8.3.9d
"Anchor Plate Detail"

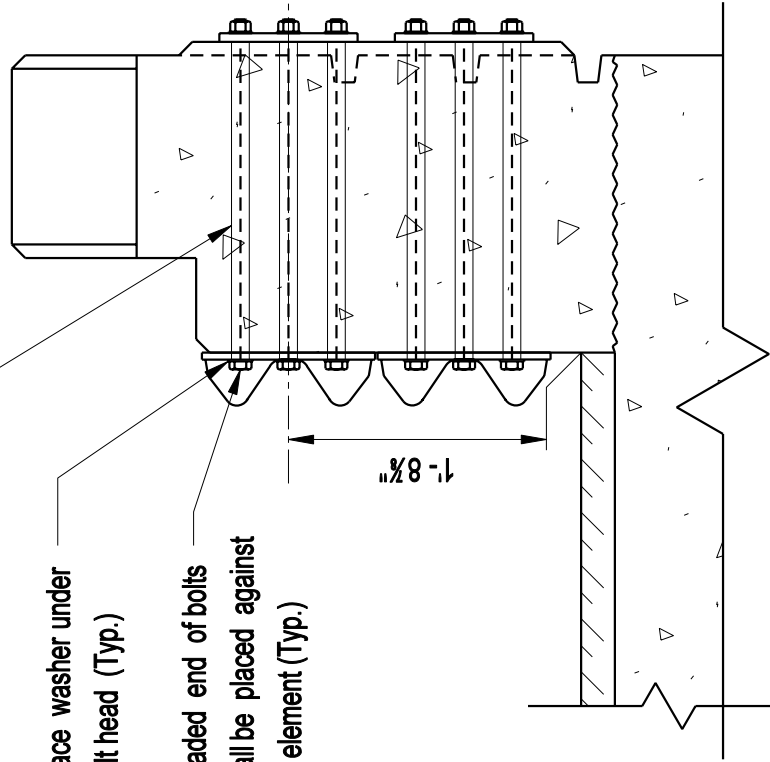
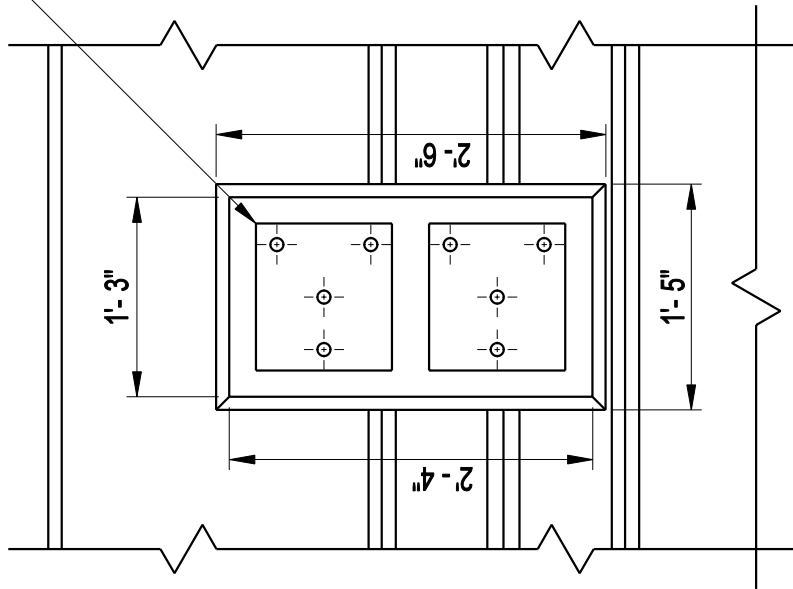
1" * Standard

pipe sleeve (Typ.)

See Note A

Place washer under
bolt head (Typ.)

Headed end of bolts
shall be placed against
rail element (Typ.)



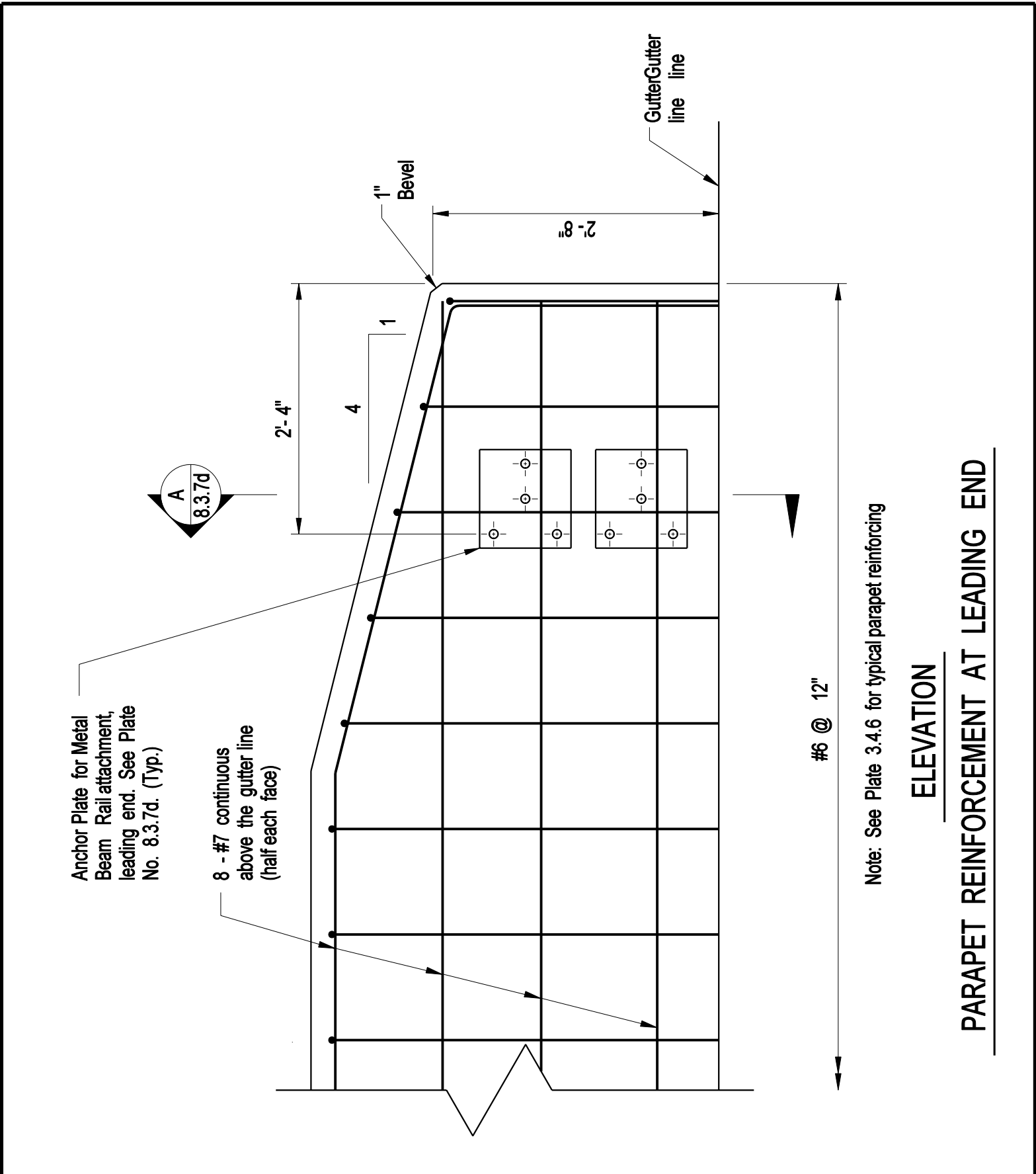
NOTE A

1" * pipe shall conform to ASTM A53 Gr. B or ASTM A501 and shall be galvanized in accordance with the requirements of ASTM A123.

DESIGN INFORMATION:

*For reinforcement not shown, see plate 8.3.9d.
For parapet dimensions not shown, see plate 3.4.6.*

LEADING END R-B 350 RAIL ATTACHMENT

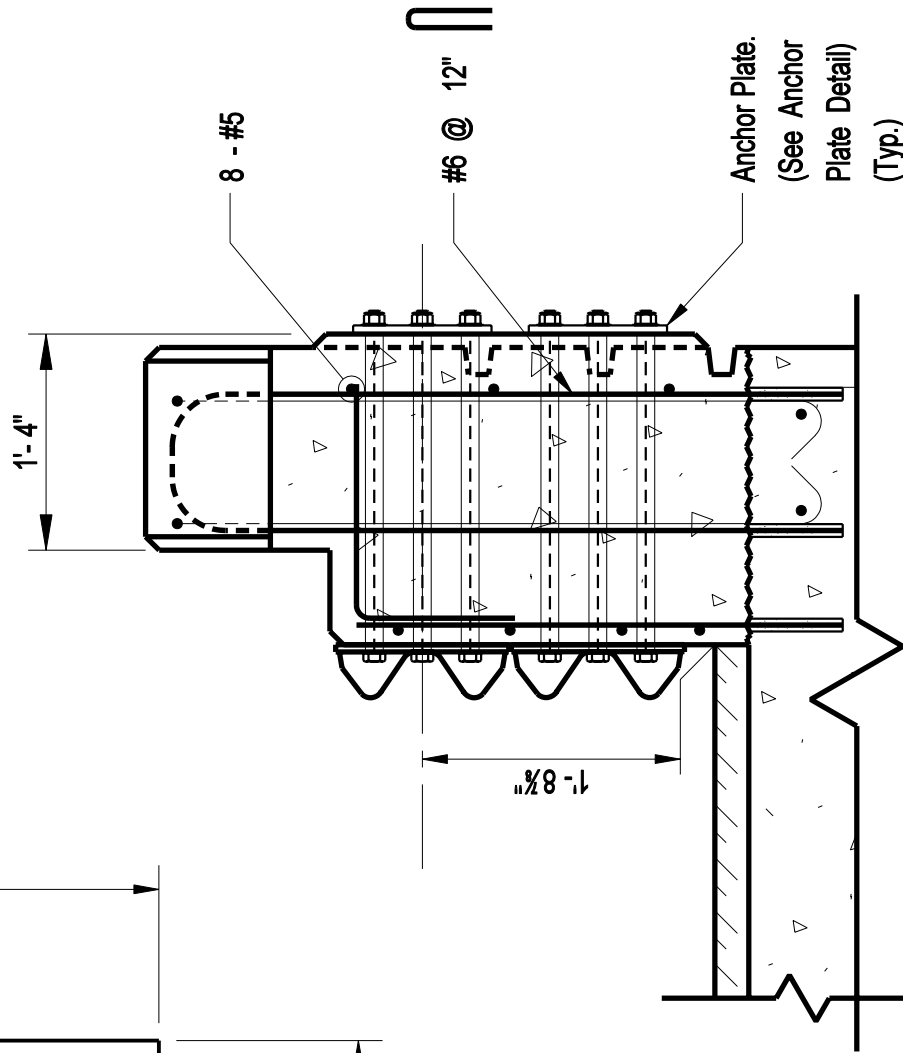
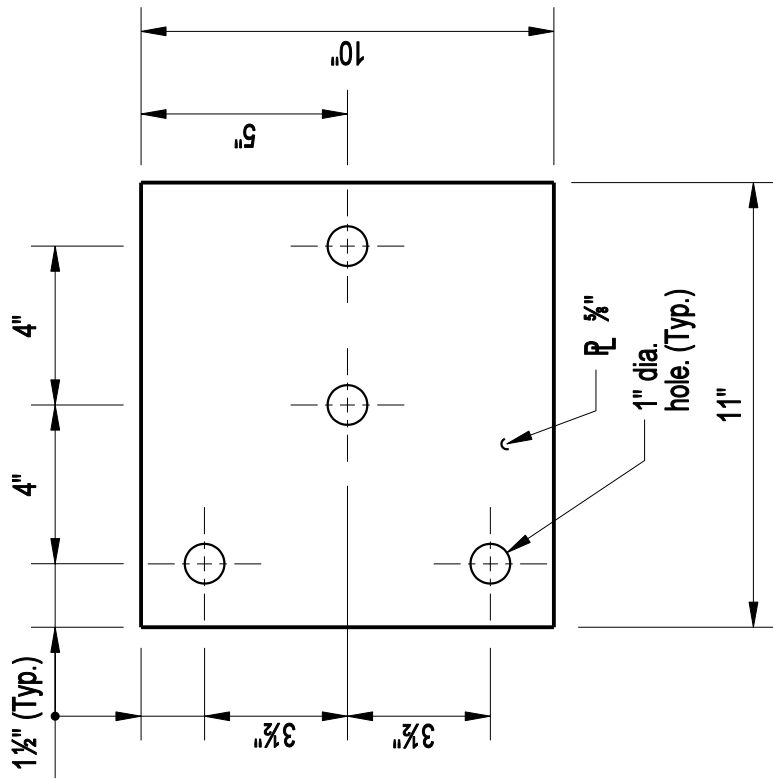


Anchor Plate for Metal Beam Rail attachment, leading end. See Plate No. 8.3.7d. (Typ.)

8 - #7 continuous above the gutter line (half each face)

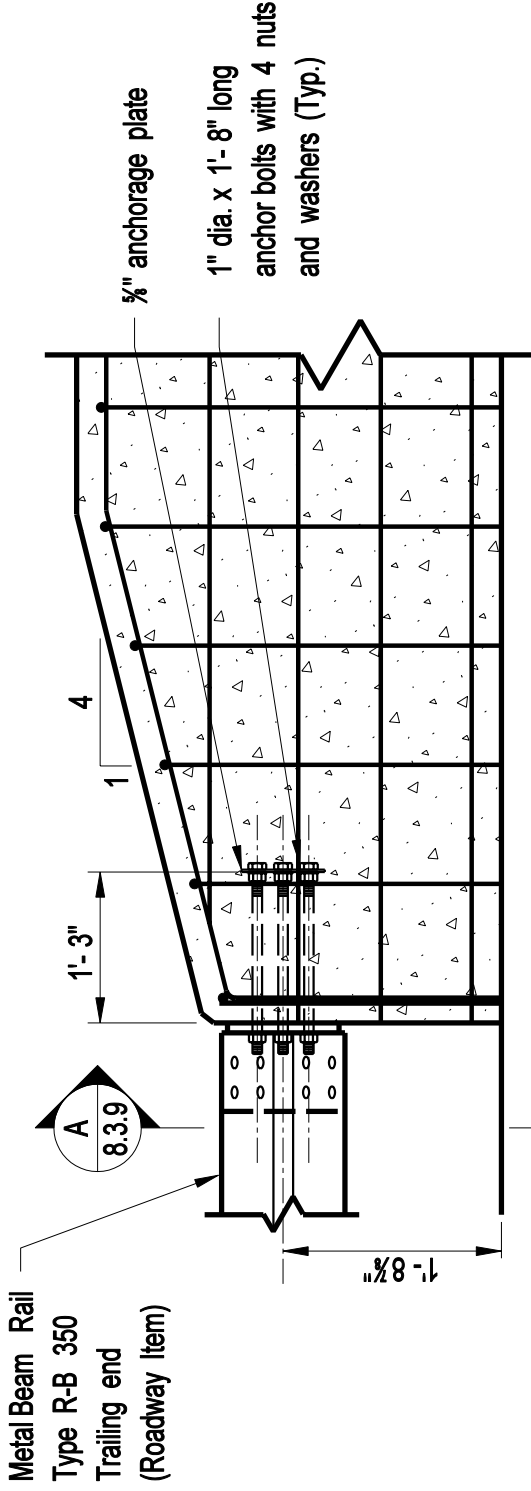
Note: See Plate 3.4.6 for typical parapet reinforcing

PARAPET REINFORCEMENT AT LEADING END
ELEVATION

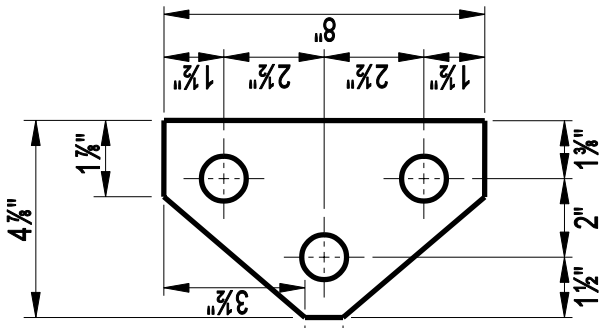


**ANCHOR PLATE
DETAIL**

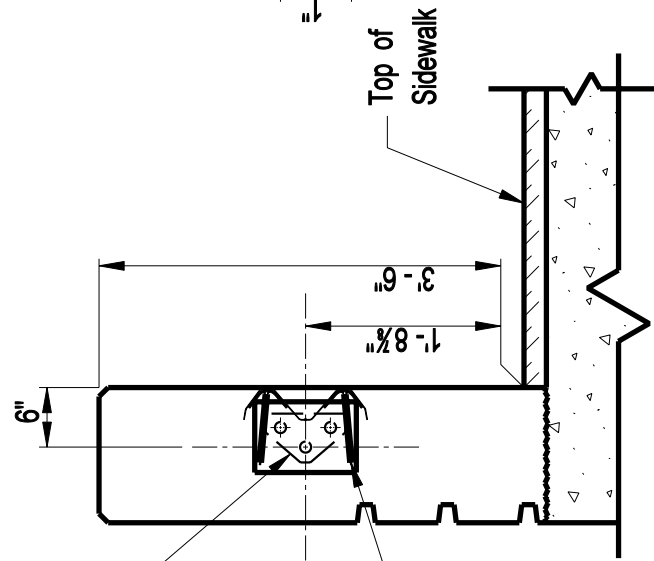
**SECTION
A
8.3.9c**



ELEVATION



**ANCHORAGE PLATE
DETAIL**



SECTION B

Metal Beam Rail
Type R-B 350
Trailing end
(Roadway Item)

3/8" anchorage plate
1" dia. x 1'-8" long
anchor bolts with 4 nuts
and washers (Typ.)

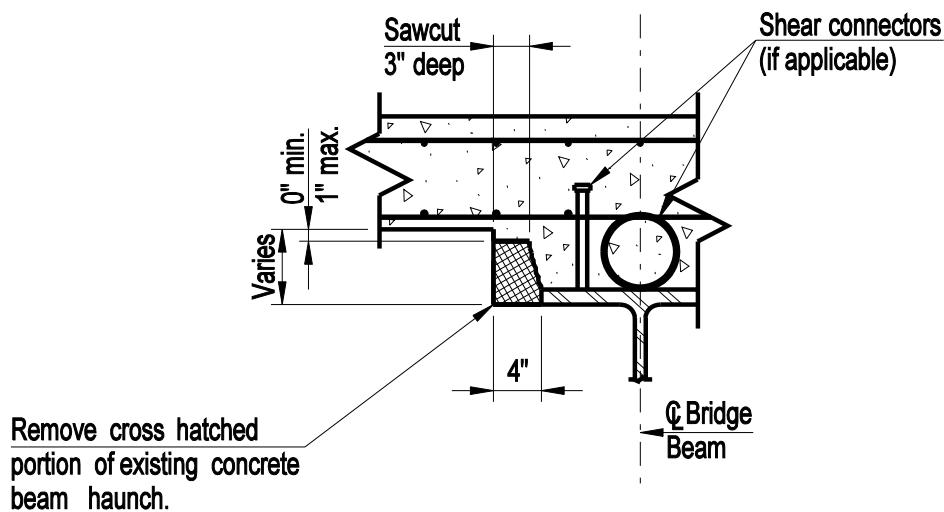
3/8" anchorage plate.
See Anchorage Plate
Detail

⊥ Anchorage plate is to
be set perpendicular to
front parapet face.

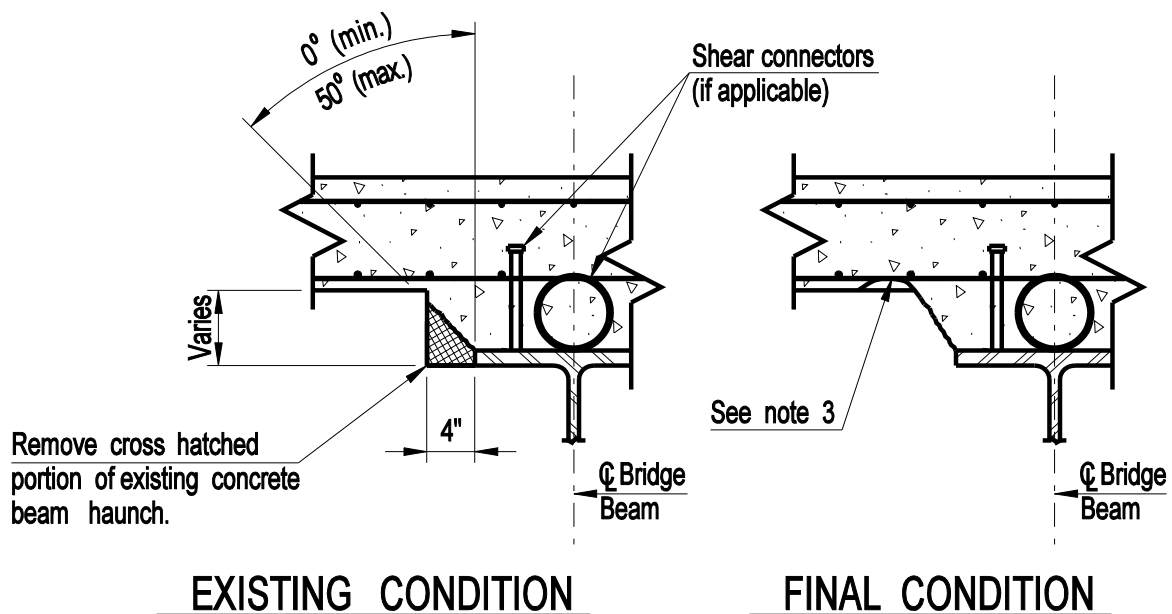
Connection Plates
See Roadway Dwgs.

DESIGN INFORMATION:

*This detail to be used at
trailing ends on uni-directional
roadways only.*



DETAILS FOR CONCRETE HAUNCH REMOVAL



DETAILS FOR CONCRETE HAUNCH REMOVAL - INACCESSIBLE LOCATIONS*

* See Note 2

For notes and design information, see Plate 9.1.2.

NOTES:

1. The removal of the portion of the concrete haunch shown shall be paid for at the contract unit price per linear foot for "Concrete Haunch Removal"
2. This method to be used only in those areas having insufficient clearance for saw-cutting equipment such as above some diaphragms as ordered by the Engineer.
3. If over-removal results, apply two coats of epoxy resin to deck reinforcing steel exposed during haunch removal. All reasonable precautions shall be taken to avoid this condition.

DESIGN INFORMATION:

This detail is to be included on contract plans for all existing bridges having this condition that pass over limited access highways within project limits. Other bridge applications such as limited access highway bridges over local roads and parking areas may be warranted but must be approved on a case-by-case basis.

The Designer shall indicate the limits of removal on the plans which will include all areas of haunches directly over travelways, shoulders and when approved, sidewalks and parking areas. Removal of haunches not over these areas will not be included regardless of their condition.

Quantities shall be computed separately for each beam edge.

Some fascia beams will require haunch removal on the inside face only, depending upon the design details of the existing conditions.

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

DETAILS FOR REMOVAL OF PORTION
OF EXISTING CONCRETE HAUNCH
NOTES

Issue Date: 01/05

Revision Date:

Plate Number:

9.1.2

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

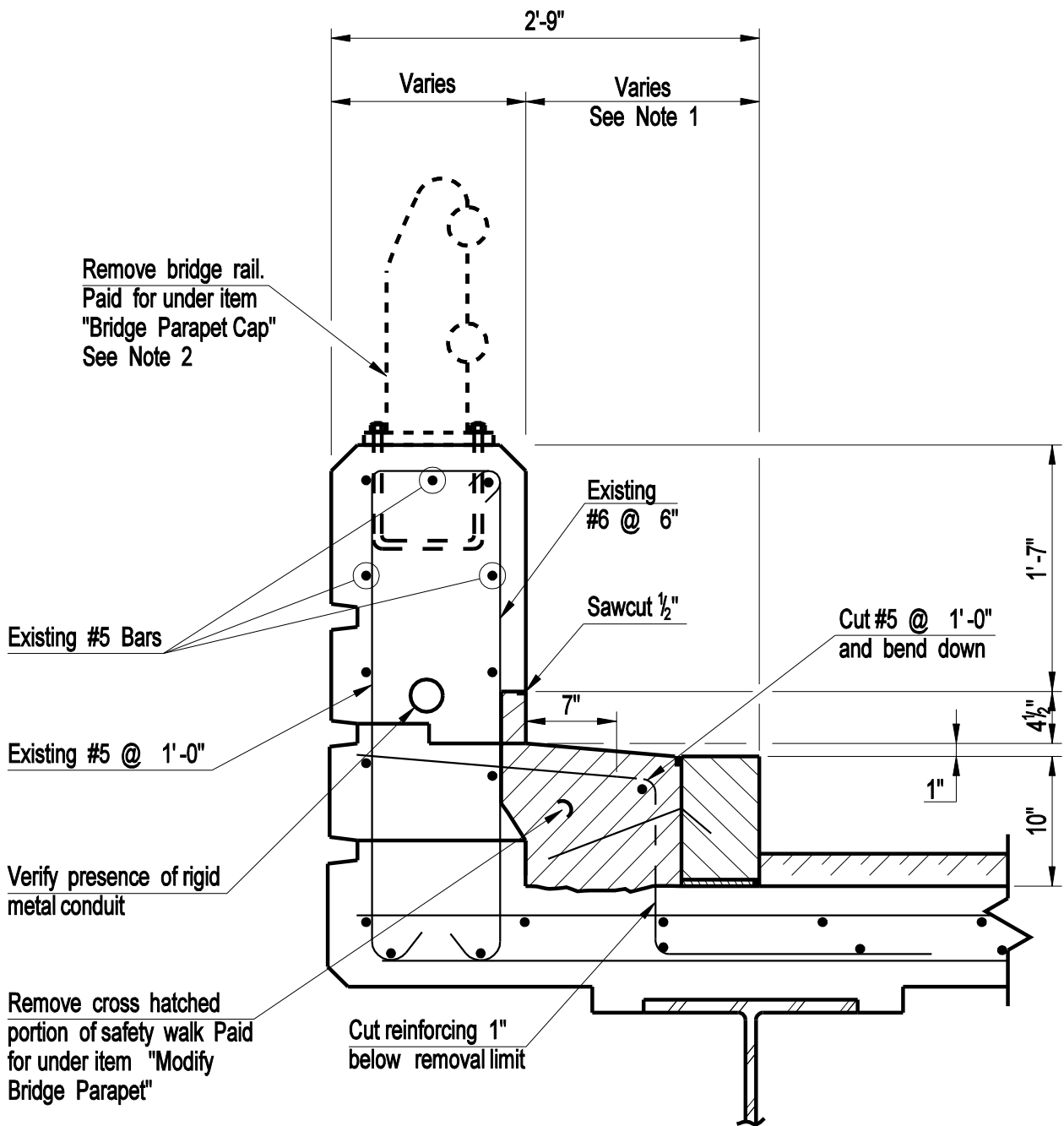
VACANT

Issue Date:

Revision Date:

Plate Number:

9.2.1



PLAN NOTES:

1. The concrete for the parapet modifications shall be a portland cement concrete with a minimum $f'_c = 4000$ psi, and shall be designed by the contractor
2. The reinforcement shall be uncoated and shall conform to ASTM A615, Grade 60.
3. Joints shall be formed in the sloped curb and the parapet cap at the joints between the bridge deck and wingwall parapets, at expansion joints in the bridge deck, at the expansion and contraction joints in the wingwalls. The joint width shall match that of the existing adjacent joint. No reinforcement shall pass through expansion or contraction joints.
4. The removal of the concrete safety curb, drilling and grouting dowels, furnishing and placing reinforcement and placing and finishing concrete for the reconstructed curbs shall be paid for under the item "Modify Bridge Parapet"
5. The removal and salvage of metal bridge rail (if specified for salvage), drilling and grouting dowels into the top of concrete parapets, furnishing and placing of reinforcement and placing concrete for the reconstructed parapet caps shall be paid for under the item "Bridge Parapet Cap".
6. Diameter of the drilled holes shall be per the chemical anchor manufacturer's instructions.
7. Removal of any existing curb plates in the safety walk shall be paid for under the item "Modify Bridge Parapet"

DESIGN INFORMATION:

- 1. Parapet curb modifications are to be done where safety walk or brush curb width exceeds 6". Brush curbs with width 6" or less shall not be modified.**
- 2. Metal bridge rails are to be replaced with concrete parapet caps on limited access highways only. On non-limited access roads, deteriorated metal bridge rails are to be replaced with appropriate new metal bridge rail.**
- 3. New "Bridge Parapet Cap" to match the width of existing parapet. Rustication depth is to match the dimension of existing chamfer at top of parapet.**

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

VACANT

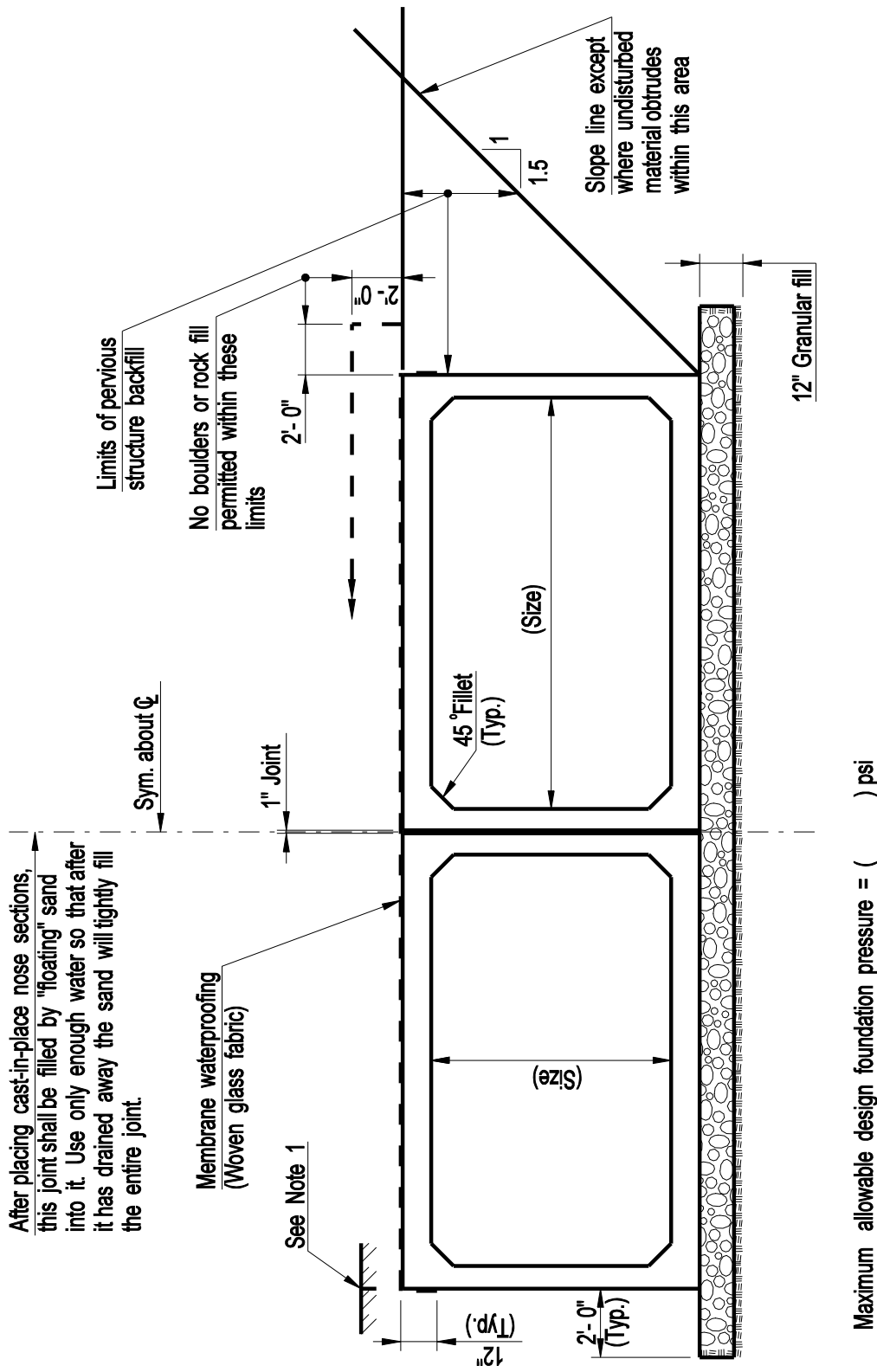
Issue Date:

Revision Date:

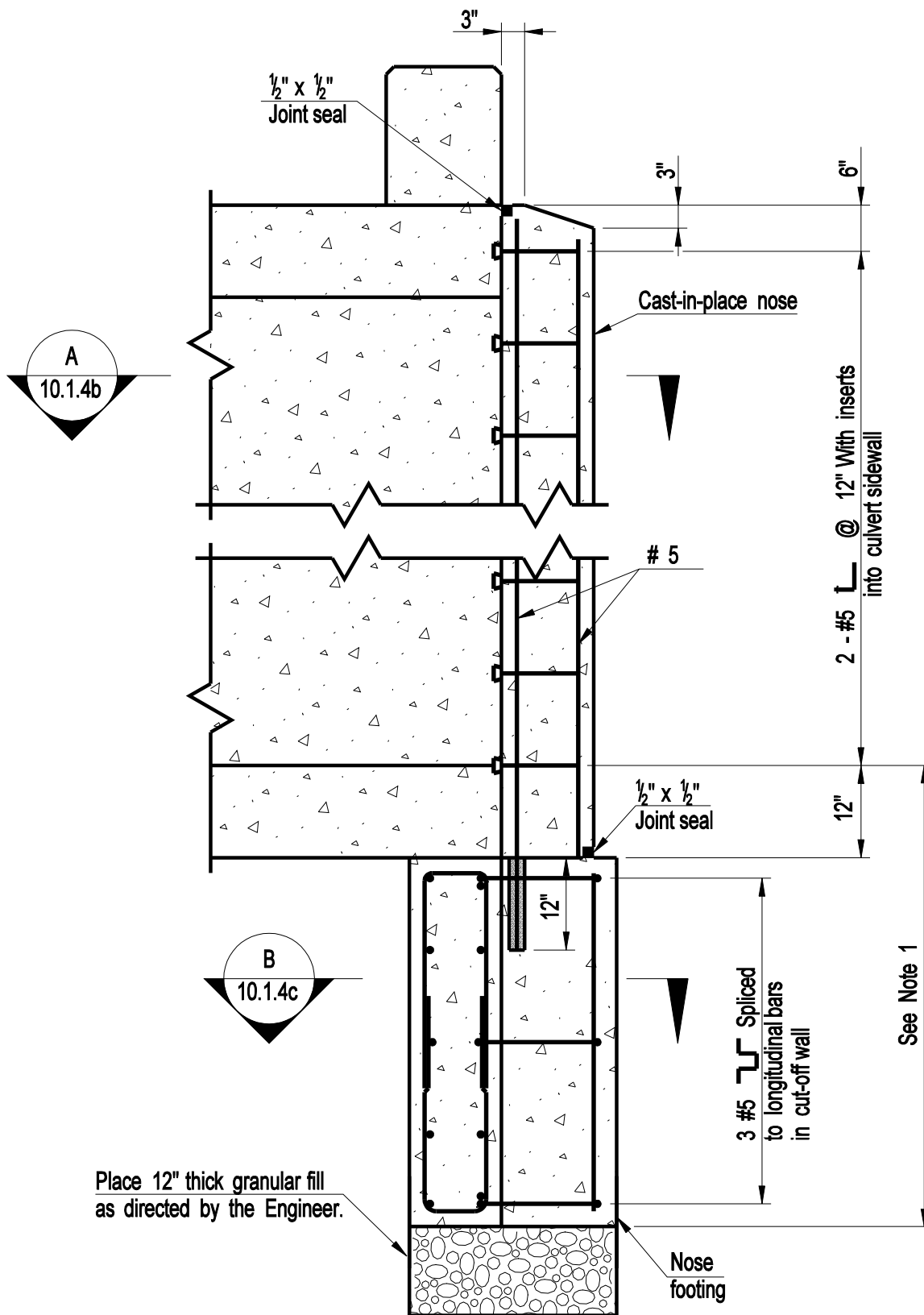
Plate Number:
10.1.1

**PRECAST BOX CULVERT
TYPICAL SECTION**

Issue Date:	10/03
Revision Date:	
Plate Number:	10.1.2

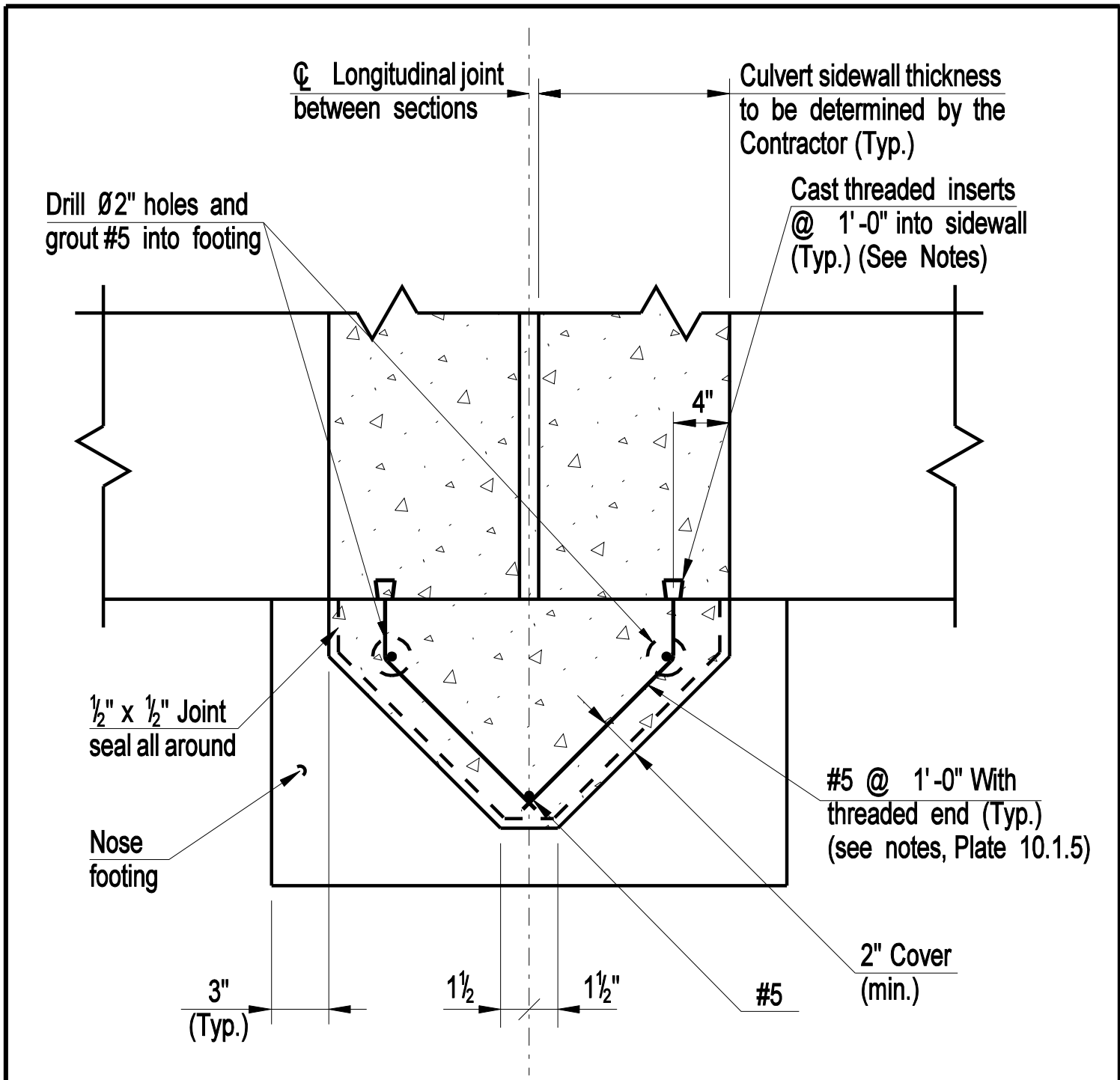


- NOTE:**
1. Cut overlay with a $\frac{3}{8}$ " x $1\frac{3}{4}$ " deep kerf and fill with a pourable sealant when cover is less than 2'-0" (from top of box to wearing surface). Cost of cutting and sealing to be paid for at the contact unit price for "Sawing and Sealing Joints".

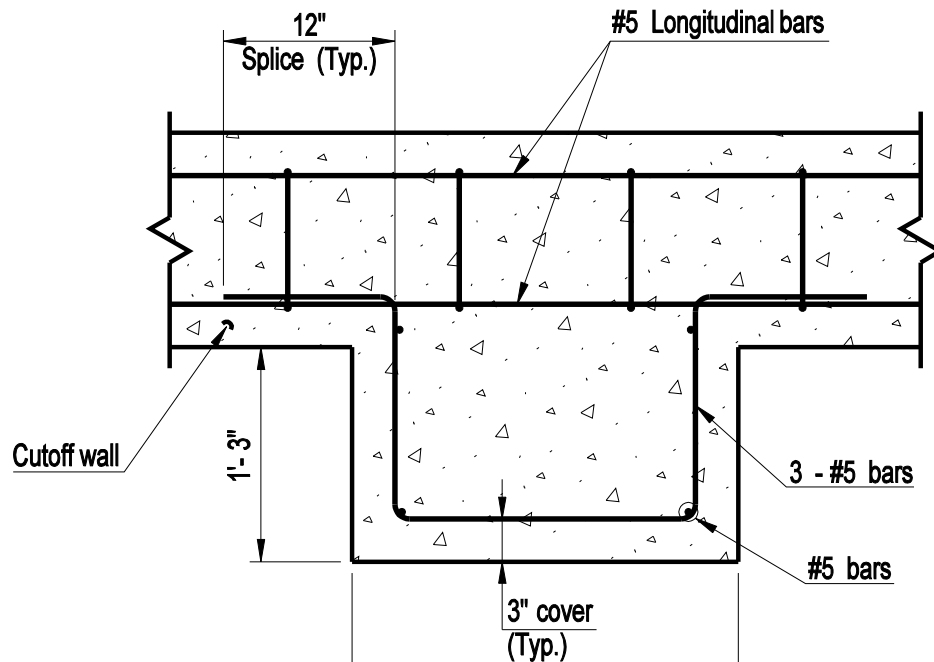


NOTES:

1. Bottom of cutoff wall and return walls shall be a minimum of 4'-0" below stream bed or 2'-0" below the bottom of culvert, whichever is greater.



SECTION A
10.1.4a



Build-out width to be determined by the Contractor. Provide dimensions for reinforcing on shop plans.

SECTION B
10.1.4a

**CONNECTICUT
BRIDGE DESIGN
MANUAL**

PRECAST BOX CULVERT
CAST-IN-PLACE
NOSE FOOTING SECTION

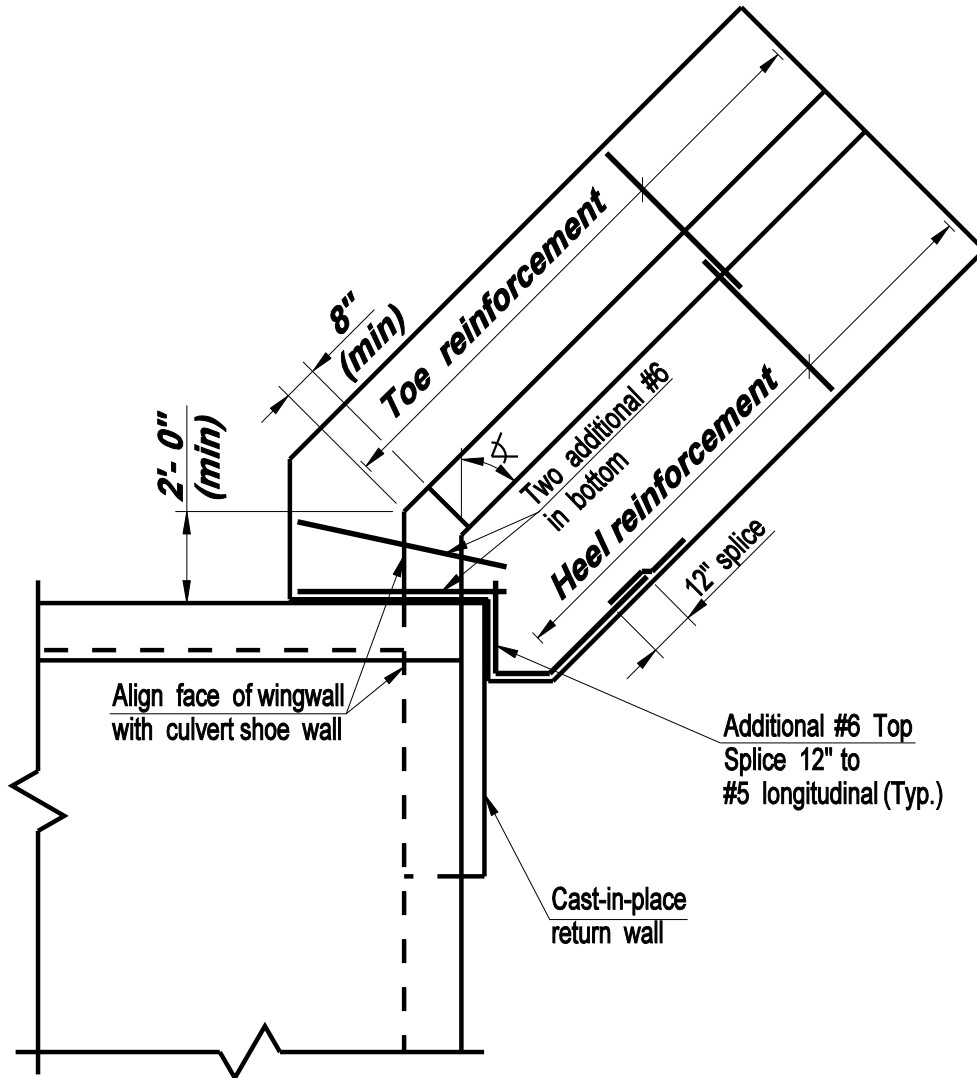
Issue Date: 10/03

Revision Date:

Plate Number:
10.1.4c

Notes:

1. The Contractor shall design, manufacture and construct Precast Box Culvert in accordance with the special provisions for "Precast Concrete Box Culvert" and the inside dimensions, length and details shown on these plans.
2. All inserts or holes cast into the culvert sections for the sole purpose of handling and setting the units shall be grouted over to a smooth finish upon completion of the work.
3. Non-shrink grout shall be used to grout the reinforcement.
4. The cost of furnishing and installing inserts shall be included in the item "11'- 0" x 9'- 0" Precast Concrete Box Culvert" and shall be one of the following:
 1. Star Expansion Industries Corp. Type P-35-T
 2. Richmond Screw Anchor Co. Type LF
 3. Dayton Superior Corp. Type F-57All inserts shall have a corrosive resistant coating.
5. The #5 bars with threaded end shall be compatible with the threaded inserts (see note 4). Threads shall be long enough to fully engage the inserts. The threaded bars shall conform to the requirements of ASTM A615, Grade 60.
6. All reinforcement to have 2" cover unless otherwise noted.



**CONNECTICUT
BRIDGE DESIGN
MANUAL**

VACANT

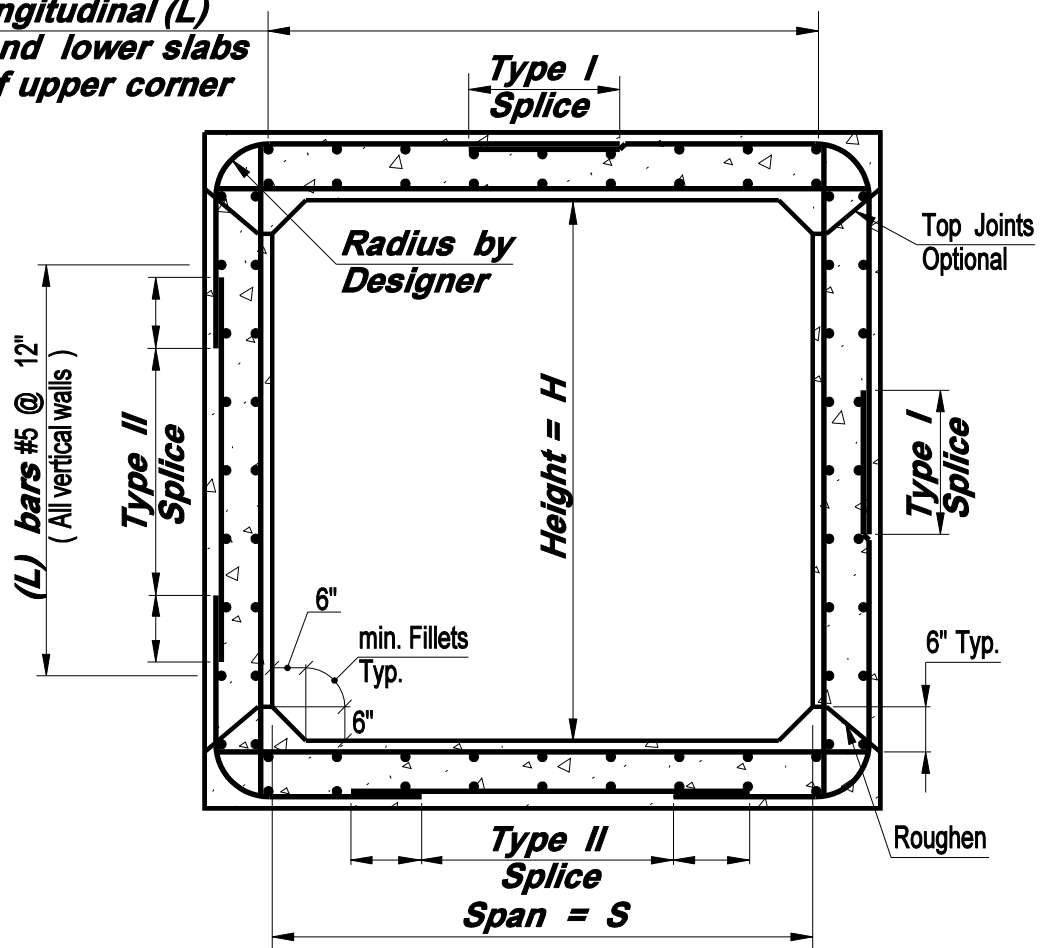
Issue Date:

Revision Date:

Plate Number:

10.1.7

NOTE: Outer longitudinal (L) bars in upper and lower slabs shall be 35% of upper corner steel.



DESIGN INFORMATION:

Minimum thickness of top and bottom slab and sidewalls to be 12".

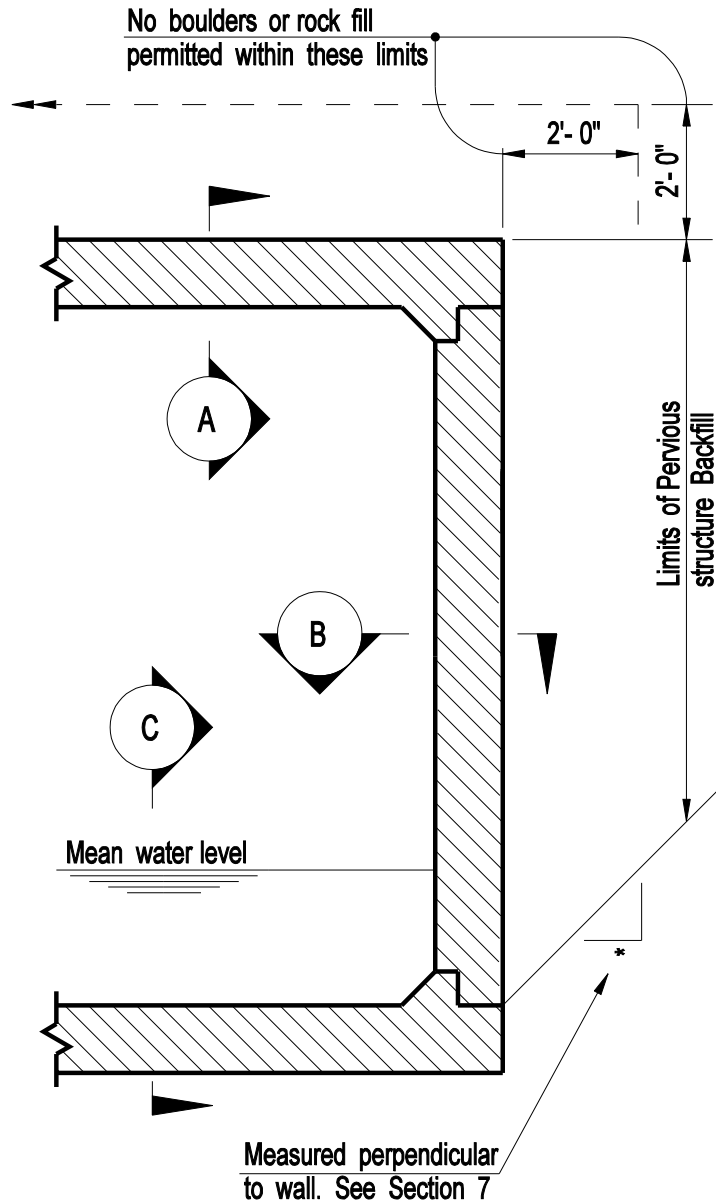
All bars shall have 2" cover except at bottom of lower slab where cover shall be 3". Where structure is exposed to the action of salt water, all cover shall be 4".

Minimum bar requirements shall be #5 at 12".

Location of lap splices shall conform to either type (Type I or Type II) shown above. Lapped splices and development lengths shall be determined by the designer in accordance with latest AASHTO design criteria.

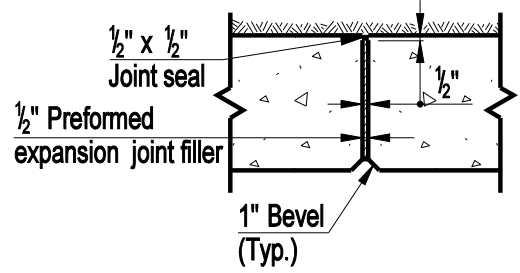
When the fill on the box is less than 2'- 0", the longitudinal (L) bars in the lower face of the top slab shall be a percentage of the main reinforcing steel required for positive moments as given in the latest AASHTO design criteria.

Provisions for fishway may be required in bottom slab.

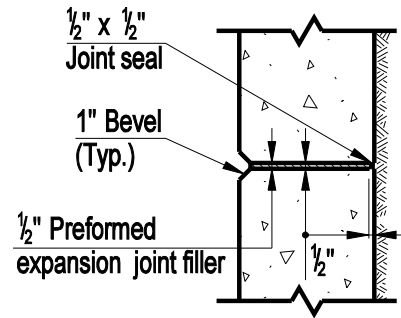


 = Indicates 1/2" preformed expansion joint filler

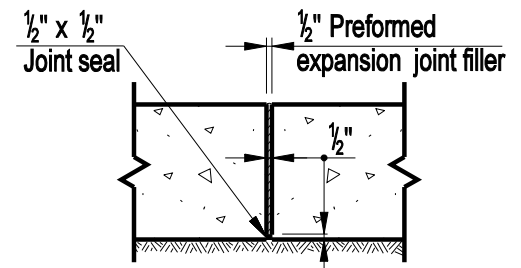
PARTIAL SECTION THRU CULVERT AT EXPANSION JOINT



SECTION A



SECTION B



SECTION C

DESIGN INFORMATION:

The spacing of expansion joints in the culvert shall not exceed 30'-0".