Structures Manual

State of Vermont
Agency of Transportation

STRUCTURES MANUAL

Vermont
Agency of
Transportation

Structures Manual

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State of Vermont
Agency of Transportation

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Introduction

This manual was written as a guide for use by design personnel in the Vermont Agency of Transportation Structures Section. The designer shall use the procedures and standards in the manual in designing all new and rehabilitated bridges. This includes the administrating, designing and preparing plans. Emphasis is on the design and communication necessary to perform the above functions to provide safe, convenient projects that meet with public approval.

This manual covers the design responsibilities of the Section. It does not cover other functions that are a part of the Structures Section responsibilities. Excluded functions include bridge inventory and inspection, administrative supervision, the use of computers for structures design, and personnel policies and procedures.

The manual is organized to follow the normal flow of work within project development and design. It implements System International Units (SI) by including them in parentheses after the English system units.

Part I covers the general administrative and production related duties. It addresses how the Structures Section operates within the Vermont State government. It describes the resources available to Section personnel.

Part II outlines the process from project initiation through the post-construction duties performed by the Section. The Section actively participates in the step system that the Agency has adopted. Each Chapter in this part of the manual describes a particular step and the duties of the designer in completing that step. To further assist the designer, this part of the Manual is organized in chronological order.

Part III contains the design criteria that the Section has adopted. This Section is organized in the same order as the AASHTO Standard Specification for Highway Bridges. As with AASHTO, this part includes topics such as general design criteria, concrete design, steel design and more.

Part IV will be valuable in the final steps of the project. It describes how the Section calculates and quantifies project quantities. In addition, it describes the process for developing estimates.

Page replacements will be provided when modifications to the manual are needed.

Part I

Structures Section Information and Organization

Use this part to familiarize yourself with information and the organization of the Structures Section.

Chapter One

Organization

1.1 STRUCTURES SECTION

The Structures Section is responsible for certain activities concerning the construction or rehabilitation of highway bridges and structural plate culverts, throughout the State. These activities include the planning, design and preparation of plans. Additional responsibilities include the following:

- Design of structures on State-owned railways and airports.
- Review of supports for overhead signs and luminaries, designed by fabricator.
- Inspection, inventory and load rating of bridges.
- Shop inspection of the fabrication of structural steel, bearing devices, expansion joints, bridge rail and overhead sign supports.
- Special structure designs, such as dams, at the request of other State agencies.

1.2 ORGANIZATION CHART

Organizational charts for the Structures Section, for the Project Development Division and for other area of the Agency of Transportation can be found on the Agency of Transportation web site, and in the Engineering Operations Manual.

1.3 OPERATIONS

See the Vermont Agency of Transportation Policy and Procedures Manual for information not in this manual.

1.4 JOB DESCRIPTIONS

Copies of Structures Section personnel job descriptions are available in Human Resources Office.

Chapter Two

Relations with Others

2.1 VERMONT AGENCY OF TRANSPORTATION

2.1.1 Traffic and Safety Section

The Structures Section provides the Traffic Section with the structural analysis of supports for overhead signs, traffic signals, and luminaries. The Traffic Section assists the Structures Section in layout, detailing, and estimating the costs of all traffic control systems [temporary and permanent] involved in the construction or repair of structures. Design Section will complete traffic control sheets, when they are the lead section on a project. Structures will complete traffic control sheets, and Traffic & Safety will review the details, when Structures is the lead section.

2.1.2 Technical Services Division

2.1.2.1 Project Definition Team [PDT]

The Structures Program Manager or a delegate serves as a member of the Project Definition Team to review projects as necessary.

2.1.2.2 Hydraulics Unit

The Hydraulics Unit furnishes the Structures Section with preliminary hydraulic data. The data includes acceptable optional structure types, channel size, and minimum elevation for bottom of beam or slab, minimum waterway area [for buried structures], for the requested bridge location.

Based on the Structures Section's bridge or culvert type selection and proposed details, the Hydraulics Unit develops final hydraulic data, including recommended channel protection and temporary bridge requirements.

The Hydraulics Unit works with the Structures Section to develop acceptable environmental mitigation details.

2.1.2.3 Right-of-Way Unit

The Structures Section provides plans to the Right-of-Way Unit showing anticipated project construction limits for Federally-funded projects.

The Right-of-Way Unit provides existing ROW information for Federally-funded project to the Structures Section .

The Right-of-Way Unit prepares plans showing existing ROW limits, proposed taking lines, channel and slope rights, construction easements, etc.

The Structures Section reviews the proposed take lines and channel rights next to structures, and submits comments and recommendations to the Right-of-Way Unit. The Structures Section also furnishes information to Right-of-Way Unit concerning the estimated costs of specific features contemplated during the negotiations.

The Right-of-Way Unit is responsible for securing the necessary property rights, or easements, for all federally funded bridge work managed by the Agency.

2.1.2.4 Utilities Unit

The Structures Section furnishes the Utilities Unit with project plans depicting the scope of the work to determine if any conflict with utilities exists. Structures provide provisions for incorporating utilities as necessary. The Utilities Unit handles all correspondence and required permits between the VAOT and the utility companies.

The Structures Section acts in a consulting capacity and advises the Utilities Unit regarding bridge engineering matters, such as attachment of utility lines to structures.

2.1.2.5 Environmental Unit

The Environmental Unit will determine and delineate wetlands, determine archaeological sites and determine historic bridges and buildings on all projects.

The Environmental Unit will obtain Corp. of Engineer's and Agency of Natural Resources permits and Categorical Exclusions.

2.1.2.6 Traffic Research Unit

The Traffic Research Unit provides traffic data to the Structures Section upon request. The Traffic Research Unit also provides incentive/disincentive figures for use on projects.

2.1.2.7 Agency of Natural Resources via the Environmental Unit

Stream crossings are subject to the review of the Agency of Natural Resources through the Stream Alteration Permit process.

The Environmental Unit prepares Standard Form HD-2-0040 for Structures, "Permission to Change the Course of a Stream or Remove Material from a Stream Bed," for review and concurrence of these departments.

2.1.2.8 Agency of Development and Community Affairs Division for Historic Preservation via the Environmental Unit

The Structures Section follows procedures as outlined in Public Act 109, dated April 30, 1975, Title 4.22 V.S.A., Chapter 14, and cooperates with the Vermont Historical Sites Commission in the planning and conducting of specific undertakings affecting historic properties.

Additionally, on all bridge projects, the Structures Section complies with Section 106 of the National Historic Preservation Act.

The activities required to meet the above obligations are coordinated and conducted by the Environmental Unit .

2.2 OTHERS IN VAOT

2.2.1 Policy and Planning Division

The Policy and Planning Division is responsible for managing the Agency's Statewide Transportation Improvement Program [STIP]. They handle developing this document, the approval process, and adding all amendments as necessary.

The Structures Section makes recommendations to the Planning Division regarding projects to be added to the Capital program.

Before submitting to the FHWA, the Structures Section should review the Agency's STIP for any major discrepancies. The section should also work with Programming by reviewing the listing of projects, the Agency plans to obligate during the Federal Fiscal Year.

2.2.1.3 Programming

The Structures Section and Programming work closely in several areas. The Structures Section provides Programming with the necessary information to load new Town Highway Bridge projects into PPMS and STARS. The Structures Section also asks Programming to request Federal PE authorization on Town Highway Bridge projects that have Federal funding.

These Sections work together annually in developing the Agency's Capital Program for inclusion into the Budget submitted to the General Assembly. The Structures Section provides Programming with an expenditure estimate on a project by project basis. The section then works with Programming to refine the Capital Program once a draft has been prepared.

The Structures Section is responsible for maintaining the PPMS fields allocated to the section. This system provides up-to-date data and information that is necessary for project scheduling. The Structures Section and Programming should work closely to insure the schedule dates on Structure related projects are reasonable. If necessary, these sections should make adjustments to PPMS to correct any problems.

2.2.2 Materials and Research Section

The Structures Section cooperates with the Materials Section in preparing specifications for materials involved in the design of various structures. The Materials Section through its Research Unit, is involved in the testing and approval of alternate materials for bridge projects.

The Structures Section submits requests for subsurface investigations and borings at specified locations to the Materials Section. The Geotechnical Engineer will submit a foundation report for all projects that have subsurface investigations. [See chapter 8, preliminary plans, for foundation report requirements.]

The Structures Section provides personnel to serve on the Research Advisory Committee [RAC] and input into state administered research projects.

Upon request, the Research Unit performs corrosion surveys and takes deck cores on existing structures. Structures can use this information as a guide in determining the type and extent of rehabilitation to be done on the deck.

2.2.3 Construction Section

The Structures Section serves in a consulting capacity to the Construction Section when field conditions encountered differ from conditions shown on the plans. The Construction Section may request that a representative of the Structures Section assist in the inspection of a structure before, during or on completion of a project. The Structures Section participates in preconstruction conferences and final inspections.

The contractor requirement for working drawings shall be in accordance with the specification for the individual pay item and subsection 105.03 of the Vermont Standard Specifications.

2.2.4 Contract Administration Section

The Structures Section forwards contract plans, estimates and drafts of special provisions and specifications for bridge projects to the Contract Administration Section.

The Structures Section also coordinates with the Contract Administration Section in the preparation and review of railroad, right-of-way, and finance and maintenance agreements that involve structures. This also includes the preparation of contracts for shop inspection, special bridge inspections and consultant design.

The Structures Section provides one member to serve on each of the following committees:

- Prequalification
- Specifications

2.2.5 Assistant Attorney General

The Structures Section provides assistance to the Assistant Attorney General regarding project necessity hearings and court claims against the State involving the Structures Section.

2.2.6 District Transportation Administrators

The Structures Section acts in a consulting capacity to the District Transportation Administrators regarding bridge engineering matters. The Structures Section forwards bridge inspection reports and critical maintenance letters to the District Transportation Administrators, recommending critical repairs, for state owned structures.

2.2.7 Department of Motor Vehicles

The Structures Section acts in an advisory capacity to the Department of Motor Vehicles regarding the issuance of Highway Overload Permits. The Structures Section works with the Department of Motor Vehicles regarding proposed legislation involving vehicle weight limitations.

2.2.8 Automated Services Section

The Automated Services Section maintains and inventories computer hardware and most software authorized for use by the Structures Section.

2.2.9 Rail, Air, Public Transportation [RAPT] Division

The Structures Section coordinates through the RAPT Division, with the railroad companies on all railroad grade separation structures. This includes both new structures and the rehabilitation of existing structures.

The Structures Section furnishes the engineering when requested on structures on the State-owned rail systems.

2.3 OTHERS OUTSIDE VAOT

2.3.1 U.S. Department of Transportation—Federal Highway Administration [FHWA]

The U.S. Department of Transportation is concerned with all projects that involve Federal money. The FHWA must approve the complete set of plans, Specifications, and Estimates [PS&E Submittal] for all Interstate projects and N.H.S. projects with construction estimates over $1,000,000.

The FHWA mandates and continually monitors the bridge inventory and inspection program of the Structures Section. The FHWA's regional and local division office reviews the Structures Section program each year.

The Environmental Unit of Technical Services prepares the categorical exclusions applications for FHWA approval.

2.3.2 Agency of Natural Resources-Department of Fish & Wildlife

The application for a Storm Water Discharge Permit is prepared by the Environmental Permitting section of the Technical Services Division and submitted to the Department of Fish and Wildlife, at the request of the Structures Section.

2.3.3 Contractors—Fabricators

The Structures Section answers questions and works with fabricators regarding clarification of, and conformance with, plans and specifications.

The Structures Section, in coordination with the Construction Section, consults with Contractors on questions connected with bridge projects.

Chapter Three

Files, References and Publications

3.1 FILES KEPT BY STRUCTURES SECTION OFFICE

3.1.1 Letter Files

The following is a list of letter files maintained by the Structures Section office:

- General Correspondence—Filed by subject
- Project Files—Filed by project
- Town Files—Filed by Town
- Town Highway applications File
- Computer Progress Reports—see program control
- Technical Information File—by Subject [library]
- Shop Drawings for Active Projects
- Temporary Bridge Plans

3.1.2 Electronic Files

- Bid Results, by Item - available is Microsoft Excel and Access formats
- Submittal Forms

3.2 REFERENCE LIBRARY—STRUCTURES SECTION

3.2.1 Resource Guideline

Where there is a conflict between material presented in the publications listed in the Structures Section Manual and the AASHTO Specifications, the AASHTO Specifications will govern on highways. The same applies to the AREA Specifications on railroads. In all cases the modifications, to technical publications, presented in the Structures Section Manual, will govern the design.

3.2.2 Library Contents

The Structures Section Library contains the following resources:

- AASHTO Specifications—Testing Procedures
- AASHTO, “Guide Specifications for Bridge Railings”–1989
- AASHTO, “Guide Specifications for Seismic Isolation Design”–1991
- AASHTO, “Guide Specifications for Horizontally Curved Highway Bridges”–1993
- AASHTO, “Roadside Design Guide”
- AASHTO & AISC Specifications—Previous Editions
- AISC Old Beam Books
- AASHTO & American Society for Testing and Materials [ASTM]—Materials [Part I-Specifications, Part II—Testing]
- FHWA, “Design Guide for Reinforced Steep Slopes”
- FHWA, Reports
- FHWA, “Seismic Design and Retrofit Manual for Highway Bridges”
- FHWA, “Manual on Design and Construction of Driven Pile Foundations and Spread Footings”
- FHWA, “Manual on Uniform Traffic Control Devices for Streets and Highways [MUTCD]”
- FHWA, “Region 3 Structure Committee for Economical Fabrication—High Load Multi-Rotational Bearing”
- NCHRP Reports
- Standard Specifications of the American Railway Engineering Association [AREA]—Chapter 15
- Concrete Reinforcing Steel Institute [CRSI] Design Handbook
- Reinforced Concrete Design Handbook [American Concrete Institute]
- Timber Construction Manual—American Institute of Timber Construction [AITC]
- USDA Forest Service, “Timber Bridges, Design, Construction, Inspection and Maintenance”
- “National Design Specifications for Wood Construction” [National Forest Products Assoc.]
- Other Publications Approved by AASHTO
- VAOT Policy and Procedures Manual
- VAOT Manuals from other Sections
- VAOT Specifications
- Bridge Manuals from other States
- Other Technical Information
- Town and County Maps
- Route Logs
- Shared Software Manuals
- State of Vermont Long Range Transportation Plan
- USGS Topographic Maps of Vermont

3.3 FILES MAINTAINED BY UNITS

3.3.1 Project Files

Each unit will maintain each of these files:

- Active Project File—Correspondence and Computations Folder
- Active Project Plans
- Design Memos
- Staff Meeting Reports

3.3.2 Reference Material

The following material is available in each unit :

- American Association of State Highway and Transportation Officials [AASHTO], "Standard Specifications for Highway Bridges" Current Edition and Interims
- Bridge Welding Code ANSI/AASHTO/AWS D1.5-96 [Metric]
- AASHTO "Green Book," "A Policy on Geometric Design of Highways and Streets" 1994 [Metric]
- Vermont State Standards
- General Special Provisions
- American Institute of Steel Construction [AISC] Steel Construction Manual
- Computer Item Listing
- Latest Unit Price Figures
- VAOT half size set of Standards
- Inroads Manual
- Computer Hardware and Software Manuals
- Plate Pipe Tables & Design Information
- Dictionary
- Book of standard CADD "Cells"

3.4 FILES MAINTAINED BY BRIDGE INSPECTION UNIT

- Inventory file for each bridge over 20 feet *(6.1 m)* in length including latest inspection report [Hard copy only]
- Inventory file for each state owned short structure 6 feet *(1.8 m)* to 20 feet *(6.1 m)* in length
- Inventory file for each town owned short structure 6 feet *(1.8 m)* to 20 feet *(6.1 m)* in length
- Critical maintenance request log for state-owned bridges
- "Bad bridge" letters to towns
- Overload permits
- Annual Federal report [establishes sufficiency ratings], back to 1975
- Covered Bridge reports and Metal Truss bridge reports for Historical bridges

3.5 INDIVIDUAL REFERENCE

3.5.1 Engineers

Engineers in the Structures Section should have the following reference material:

- Structures Section Manual
- State of Vermont Agency of Transportation Standard Specifications for Construction, 1990 and *(1995 Metric)* Editions
- Supplemental Specifications
- General Special Provisions
- Concrete Design Book
- Foundation Design Book
- Structural Design Book

- Other appropriate design aids
- “Policy on Preparation of Design Exception” [VAOT Engineering]

3.5.2 Technicians

Technicians in the Structures Section should have the following reference materials:

- State of Vermont Agency of Transportation Standard Specifications for Construction
- Other appropriate design aids
- Structures Section Manual
- CADD Technical Reference Information

Chapter Four

Technical Resources

4.1 DESCRIPTION OF SPECIFICATIONS BY THE STATE OF VERMONT

4.1.1 State of Vermont, AOT, Standard Specification for Construction

- The VAOT adopted these specifications in 1990, *(1995)* according to Sections 5, 7 and 10 of Title 19, Vermont Statutes Annotated. The provisions of these specifications shall apply on all construction contracts entered into by the Vermont Agency of Transportation. Agency projects are designed in accordance with these specifications except as provided by the Supplemental Specifications, Standards, General Special Provisions, Detail Plans, or Special Provisions included in the specific contract.
- Plans and estimates are approved by the Director of Project Development. This is done with the understanding that the work covered by such plans and estimates is to be performed or contracted according to these Specifications and any Supplemental Specifications, General Special Provisions, or Project Special Provisions included in the contract.

4.1.2 Supplemental Specifications

- These specifications cover unique items that are generally not incorporated into the Standard Specifications. These items are either infrequently used or they change frequently. Check with Contract Administration for the most recent version.

4.1.3 General Special Provisions

- The General Special Provisions are changes to the Standard Specifications, adopted since publication of the current issue of the Standard Specifications. These general special provisions are published for inclusion on all projects. Check with Contract Administration for most recent version.

4.1.4 Special Provisions

- Special Provisions are applicable to the particular project for which they are written. Among the principal functions of the Special Provisions are the following:

- Alter the requirements of the Standard Specification and/or Supplemental Specifications where such requirements are not appropriate for the work on the proposed project.
- Call the bidder's attention to any unusual conditions, regulations or laws affecting the work, construction schedule/completion date, work in stream, and maintenance of traffic, etc.

4.2 EQUIPMENT OWNED BY THE STRUCTURES SECTION

4.2.1 Computer Equipment

4.2.1.1 Hardware

- IBM Compatible Desktop Personal Computers ["PC's"] and Laptop PC's
- Technical Desktop Computers ["TD's"]
- Plan Size Color/B&W Plotter
- Laser Printers

4.2.1.2 Software

- MicroStation—The standard 2D/3D Computer Aided Drafting and Design [CADD] used by the Structures Section.
- Inroads—Used to model existing 3D ground and new roadways. It is also used for cutting sections. Use this software package inside MicroStation.
- Coordinate Geometry [COGO]—Used to calculate coordinate geometry for project. Use COGO commands in either 2D or 3D to layout the project alinement, substructures, superstructures, framing plans, etc.
- Darwin—Used for flexible pavement design.
- Structural Analysis And Design [STAAD3]—Used for general structural analysis.
- Merlin-DASH—Used for steel beam and girder design.
- "H" Programs—Used for a variety of projects.
- Bridge Rating and Analysis of Structural Systems [BRASS]—Use this group of programs for a variety of projects.
- CONSYS/CONSPAN—Used for prestress concrete design.
- Estimator—For use in project estimates.
- Descus —Curved girder design.
- Microsoft Word—Used for in-house design spreadsheets.
- Microsoft Word—Used for correspondence. In association with Microsoft Word, there are forms available on the Agency's Server that can be used during the various steps in a project progression.

4.2.2 Other Equipment

- Cameras
- Dictaphones and Transcribers
- Light Table
- Basic Surveying Equipment
- French Curves
- Miscellaneous Office Supplies
- Set of Roadway Curves
- Planimeter

4.2.3 Individual Equipment

The Structures Section supplies to classified Structures employees, the basic equipment necessary to perform their duties.

4.3 TECHNICAL RESOURCES

4.3.1 CADD Standard Cells

The Structures Section stores many details in CADD cell libraries. Use these cells to meet the requirements of a particular project. Each Design Unit should have a current listing of available cells.

4.3.2 Previous Design and CADD Drawings

Bridge Design drawings are archived electronically. The plans can be retrieved for use on projects which are similar in nature. It may be advantageous to use a previous design and its drawings to save drawing time. An example would be using a previously designed and drawn substructure unit that was conservative in height.

4.3.3 On-line Resources

The Vermont Agency of Transportation has made available to In-house and consultant designers an electronic on-line “manual”. This resource contains CADD related information as well as a variety of other services and documentation. The designer can find cell libraries and standard details used by the Agency. Contact the Agency’s CADD technical support personnel to get the current procedures to gain access to this resource.

Part II
Project Development

Plans at the various design steps will be submitted for review according to the procedures provided in this part. This part organizes the entire project development and submittal process into chapters that specifically outline the procedure for each step. The chapters are organized in a chronological order from a project's inception to the Section's construction duties.

Chapter Five

Project Inception

5.1 PROJECT CATEGORIES

The Vermont Agency of Transportation [VTrans] classifies projects into two basic categories.

5.1.1 State System Projects

The Agency conducts a State System project on a bridge or highway owned and maintained by the State. These projects are usually funded with a combination of state and federal funds. The following list contains the various types of highways that can be included.

- Interstate
- National Highway System [N.H.S]
- State Owned Arterials
- State Owned Collectors

5.1.2 Municipal System Projects

The Agency conducts a Municipal System project on a bridge or highway owned and maintained by a local community. These projects are usually funded with a combination of federal, state and local funds. The following Town Highways are included in this category.

- Town Owned Arterials
- Town Owned Collectors
- Town Owned Local Roads

5.2 PROJECT ESTABLISHMENT

5.2.1 State System Projects

The Planning Division establishes State System projects from the following criteria:

- Existing road/structure conditions [bridge sufficiency ratings]
- Available funding [Federal, State and Local]
- Regional Planning requests
- A legislative mandate
- Accident frequency records

5.2.2 Municipal System Projects

The municipality sends requests through the District Transportation Administrator to the State for assistance in the planning, designing, constructing and funding of town highway bridges. The Structures Section establishes funding and priority via a process known as the Town Highway Bridge Program.

5.2.2.1 Developing Town Highway Bridge Program

- The Structures Section develops a preliminary list to match available funding. This list must have preliminary approval from the Agency Secretary and Town's desire to enter the program.
- The Structures Section sends the preliminary list to the District Transportation Administrator, Regional Planning Coordinators and Regional Planning Commissions.
- The list of Town approved projects are then sent to the Agency Secretary for final approval. This list becomes the approved Town Highway Bridge Program for the respective fiscal year.
- Structures then sends the Program Action Request [PAR] Form and a request for an expenditure account [EA] to be set up, to Programming.

Projects are sometimes initially funded for preliminary engineering using state and local funds only. Projects that are federally eligible are often reprogrammed for federal funds, and then receive new project numbers.

5.2.2.2 Project Types

- Federally ineligible, Town Highway Projects - small to medium sized projects of minor complexity.
  - Rehabilitation funding is 95% State, 5% Town.
  - Replacement funding is 90% State, 10% Town.
- Federally Funded Projects - medium to large projects, over 20' in span length.
  - Rehabilitation funding is 80% Federal, 15% State, 5% Town.
  - Replacement funding is 80% Federal, 10% State, 10% Town.

Note: For a very limited number of structures, on which there is a preservation easement, if major rehabilitation is needed, no local share will be assessed.

5.2.3 Rehabilitation Projects

Rehabilitation projects include the following types of projects:

- Deck repairs such as installing an overlay, applying waterproofing membrane and paving.
- Partial or complete cleaning and coating with grease.
- Strengthening individual members as necessary to obtain an increased load capacity.
- Replacing selected components in kind, such as individual truss members.
- Replacing the steel floor support system on a truss.
- Replacing an existing deck with a new timber, concrete, or other type of deck.
- Installation of new bearing devices.
- Necessary substructure repairs.
- Placing a new superstructure on all existing substructure units, either as is or widened as necessary.
- Widening an existing superstructure by adding more beams and extending the deck and substructure.
- Replacement of bridge railing.

Typical prefixes associated with projects are as shown in Table 5.1.

5.2.4 Project Assignment

The Structures Program Manager makes individual project assignments to Structures Section Project Managers with the following objectives:

- Equal distribution of the work load
- Optimum use of personnel's experience and expertise
- By districts

5.2.5 Consultant Design

The Structures Section administers the activities of consultant engineering firms for designs when the program work load exceeds the Structures Section capabilities. All such designs are to be done according to the Structures Manual.

5.2.6 Pre-construction Project Management System [PPMS]

The Pre-construction Project Management System is a computer data system administered by the Policy and Planning Division. Data contributed from various divisions of the Agency provides current status information on projects at all stages of development.

- Project Manager provides input for project status reports.

Project Manager updates project PPMS file for bridge projects assigned to this division.

Figure 5.1. Project Prefixes

Prefix	Description
BHF†	Bridge Rehabilitation - Federal - Primary, On System. These are being programmed only on current Federal-aid
BHM	Bridge Rehabilitation - Federal - Urban
BHS	Bridge Rehabilitation - Federal - Secondary
BRZ, BRO†	Bridge Rehabilitation - Federal - Off System
BRF†	Bridge Replacement - Federal - Primary, On System. These are being programmed only on current Federal-aid
BRM	Bridge Replacement - Federal - Urban
BRS	Bridge Replacement - Federal - Secondary
BHZ, BHO†	Bridge Replacement - Federal - Off System
BST	Bridge 2000 - State System
BTN	Bridge 2000 - Town System
F	Federal - Aid Primary
F-EGC	Federal - Aid Primary - Economic Growth Center
HDP	Highway Demonstration Project
IM†	Interstate Maintenance
IR	Interstate 4R
M-EGC	Urban - Economic Growth Center
STP†	Surface Transportation Program
DSR†	Damage Survey Report
NH†	National Highway System
HES	Hazard Elimination Project
CM†	Congestion Mitigation and Air Quality Projects
TH	Town Highway Bridge, State and Local Funds Only

Chapter Six

Project Scoping

6.1 SCOPING PROCESS

It is the responsibility of the Structures Section to develop alternatives and a cost for each alternative. These alternatives will be reviewed by:

- Municipal System.
  - Municipality.
  - Appropriate Planning Commission.
  - Environmental Services.
- State System
  - Municipality
  - Appropriate Planning Commission
  - FHWA
  - Environmental Services

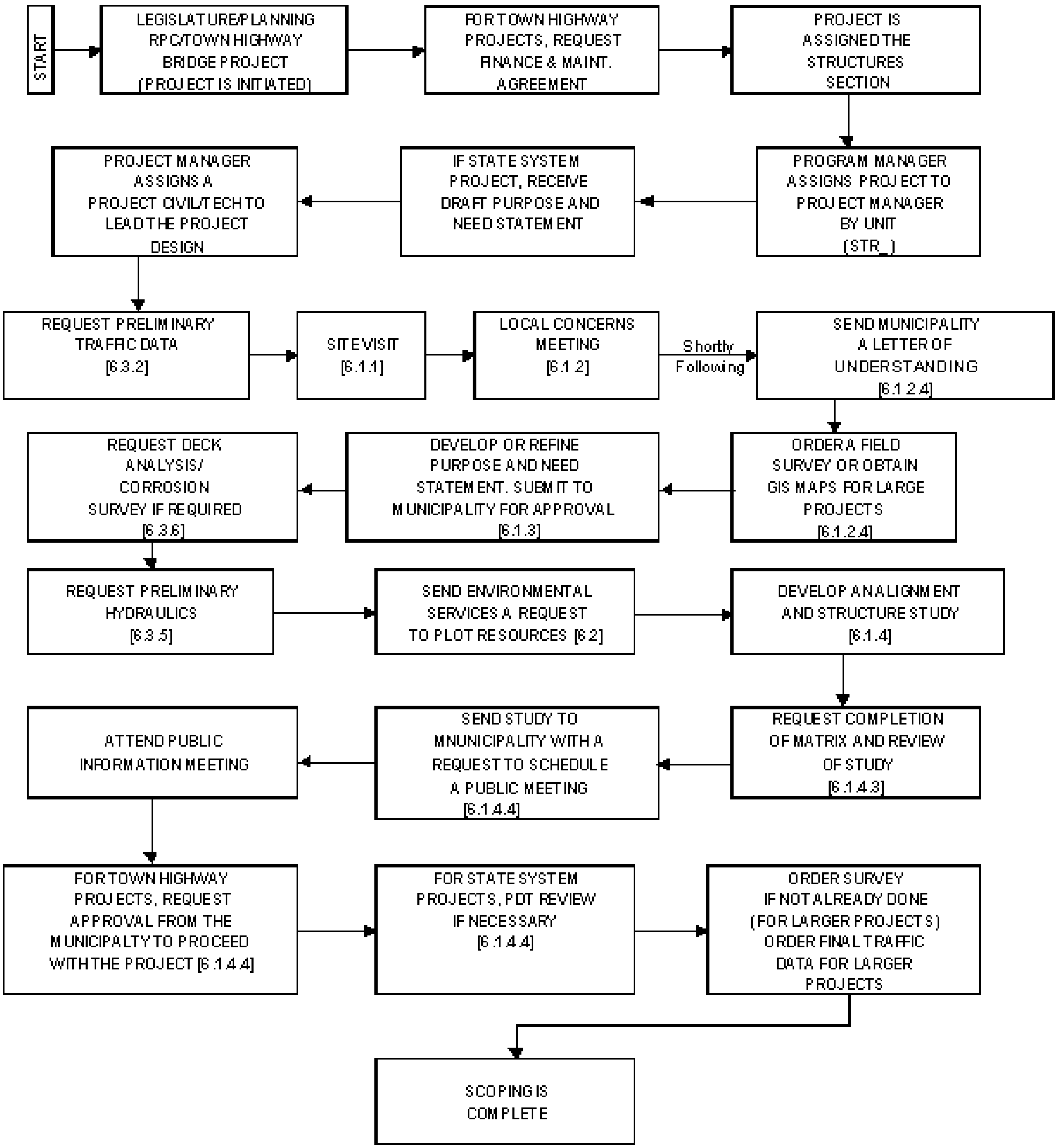
The intent of this process is to provide adequate information so that an alternative can be selected. The Project Manager should define alternatives prior to the Conceptual Plans submittal. Once an alternative has been selected, the Project Manager will develop Conceptual Plans for that alternative.

The Project Manager shall refer to the Agency's "Project Development Process" for a more comprehensive description of duties required for scoping a project. The Project Manager may delegate duties to others in the design unit.

Refer to figure 6.1 for the process outline.

Figure 6.1

Scoping Process



6.1.1 Initial Site Visit

6.1.1.1 Preparation

The Project Manager must complete the following, prior to the site visit:

- Obtain a draft purpose and need statement plus any other information or comments from the local Regional Planning Commission for state system projects. [See 6.3.1]
- Request traffic data from Traffic Research [see 6.3.2]. For large State System Projects this request may be preliminary, in which case the request will be made a second time once alignments have been fully studied [see 6.3.2].
- Check available funding at the federal, state and local levels.
- Review any information provided by the local regional planning commission.
- Obtain existing structure record plans, when available.
- Obtain current Bridge Inspection reports and photos.
- View video logs of the project's vicinity if available.
- Obtain comments from District Transportation Administrator [the District Transportation Administrator should be consulted and invited to attend the site visit]
- Review the Regional Planning Commission Documents for the area including the project.

6.1.1.2 Site Investigation

The Structures Project Manager shall organize and attend the initial site visit to view the site and surrounding area. The Project Manager should consider inviting appropriate individuals to attend this visit such as the District Transportation Administrator, Hydraulics Engineer, etc. The Project Manager shall use experience and judgement while examining the site for the following factors:

- Geometric Constraints. Obvious Environmental and Social Concerns
- Obvious Historic Preservation concerns
- Areas within or near a project that contain hazardous wastes. [See "VTrans Procedures for Identification, Handling and Disposal of Petroleum Contaminated Soils."] Complete Hazardous Waste Assessment Sheet on every project, and place in the project design file.
- Condition of existing structure and roadway alignment. Take photographs and measurements as appropriate.
- Consider the best location for temporary bridge, or available detours.
- Note utilities - power, phone, water, sewer, gas, etc.
- Note streambed material - gravel, ledge, boulders, silt, etc.
- Note posted speed limits and other signs.
- Note possible begin and end points of the project.

- Note any side road or drives that fall in the project area and make note of use.

The Project Manager should consider bringing of the following to the site visit for reference:

- The latest Bridge inspection report
- Comments from the District Transportation Administrator
- The Draft Purpose and Need Statement from the Regional Planning Commission and any other comments from the town and regional planning commission if the project is in the state system
- The traffic study results
- Plans of the existing structure
- Camera
- Field measuring devices
- Notebook
- Site visit checklist and CE analysis sheet [Appendix A&B from the VTrans "Project Development Process Manual"]

Complete this visit as early as possible. Consider the information gathered as preliminary, pending local input and evaluation of impact on environmental, historic and archeological resources.

6.1.2 Local Concerns Meeting

6.1.2.1 Notification

Once a site visit has occurred and findings have been compiled, Structures will work with the Municipality to set up a meeting to gather local input on the project. The town should be reminded to duly warn the public and to notify the Project Manager and adjacent property owners in writing at least four weeks in advance, of this meeting.

When a date has been set, Structures will notify the appropriate Planning Commissions, the District Transportation Administrator, and Environmental Services of the meeting, it's location, date and time. Include with this notification, a map with the project location marked.

6.1.2.2 Site Visit

Prior to the Local Concerns meeting, Structures shall organize a site meeting with the Municipality, the Regional Planning Commission and Environmental Services. For convenience, this meeting may be scheduled earlier on the same day. The purpose of this meeting is to investigate some of the issues presented in section 6.1.2.3 on the project site. Parties involved with the site meeting may point out areas of concern. A record of this meeting shall be put in the design book.

6.1.2.3 Meeting Agenda

The first part of the local concerns meeting the Agency will discuss the project developing process and funding. During the meeting the Agency will initiate discussion on the following points:

- Alignment[s]
- Close road vs. Temporary Bridge
- Existing rights of way
- Which existing bridge components should be kept
- Sidewalk
- Posted Speed
- Special site specific design considerations
- Aesthetic considerations
- Temporary foot bridge during construction
- History of Flooding
- Hazardous Material Sites
- Historic and other resource issue
- Width of Bridge
- Purpose and Need Statement

6.1.2.4 Duties following Meeting

The person attending the meeting shall request from the municipality, a copy of the minutes from the local concerns meeting.

The following must be completed directly after the Local Concerns Meeting has occurred:

- Send a letter to the Municipality summarizing the meeting and reporting our understanding of how we should proceed with the project. Request that the Municipality respond with their concurrence and/or comments.
- After receipt of a concurrence letter from the Municipality, request a field survey. If the project is large or has the potential of becoming large, the designer may choose to obtain GIS maps of the project area. Once the project is defined, the designer may then request a more complete survey. [See 6.3.3]

Once the survey has been received:

- Request that Environmental Services prepare a plot of all existing resources. Refer to Section 6.3 in this manual for detailed information concerning this request. Include as-built plans, if available, with this request, to help establish areas of prior construction.

- Request preliminary hydraulics. [See 6.3.5]

6.1.3 Purpose and Need Statement

6.1.3.1 Definition of Purpose and Need Statement

The intention of the Purpose and Need Statement is to state, define and justify the problem in a concise manner. A Purpose and Need Statement shall include two parts.

The first part shall define the purpose. This purpose cannot include a solution such as "The purpose of this project is to replace the bridge..." The purpose may be "...to improve safety..."; "...to improve structural capacity..."; "...to enhance mobility..."; etc. The statement may include multiple purposes, in which case each purpose shall be clearly defined.

The second part shall define the need for the project. This requires stating the problems that are present and providing substance to why something should or should not be done. Such a need could be "The structural capacity of the bridge is severely diminished due to the significant deterioration of the stringers." The project may have multiple needs and each should be spelled out clearly. The needs for the project must be conclusively shown to prove the project is justifiable and warrants the expenditure of public funds.

The Purpose and Need sections of the statement shall not include methods, ideas or solutions to correct any problem defined. The statement must be kept to the definition of the problems and reasons for the project.

6.1.3.2 Development of Purpose and Need Statement

Once the survey has been received and the Municipality and Structures have a common understanding of the issues, the following shall be done:

Develop and/or refine the Purpose and Need Statement. This may require making refinements to the draft Purpose and Needs Statement by the Regional Planning Commission in the case of a State System project. Refer to the previous section of this manual for a definition of this statement, and to VTrans' "Project Development Process" for more information on the content of this statement.

Send the Purpose and Need Statement to the Municipality for approval on Town Highway Projects or for comments on State System Projects. This may result in further refinements as requested or suggested by the Municipality.

6.1.4 Alignment and Structure Study

When preliminary hydraulics and resource plots are received by Structures along with the approved Purpose and Need Statement, the following must be done:

- Determine alternate alignments, including the existing alignment as an alternative.
- Determine the minimum design criteria for each alternative.
- Identify necessary design exceptions.

- Develop a typical section for each alternative. These will likely be the same, but in the case where different design speeds will be used for alternatives, they may differ slightly. With these typicals establish rough construction limits and cross sections.
- A summary of the different criterion for each alternative shall be placed in the design file. [See 13.2.1]
- The designer should consider the "do nothing" alternative.

6.1.4.1 Structure Type and Length

For wet crossings, the preliminary hydraulics report will supply a minimum required horizontal and vertical clearance with the horizontal clearance given normal to flow. This hydraulic clearance, along with the horizontal and vertical alignments, shall be used to determine the structure length.

For dry crossings, the typical section of the feature crossed, minimum vertical clearance, clear zones, and horizontal and vertical alignments shall be used to determine the structure length.

The designer may consider increasing the length of the bridge if that will decrease overall costs by reducing the substructure size. Increasing the length of a bridge may require deeper sections or piers; therefore the designer shall keep vertical clearances and in-stream construction in mind when making this choice.

It may be appropriate to develop a range of bridge types [buried structure, bridge, arch, etc.] and subtypes [prestressed concrete, timber, steel and concrete.] Refer to section 6.3 for bridge type definitions. Use some of the following factors when selecting the desired types:

- Economics
- Maintenance assumptions
- Hydraulic Considerations
- Traffic Control During Construction
- Construction Time Required
- Safety
- Elimination of Joints
- Environmental Concerns [wetlands, archaeological and historic]
- Aesthetics
- Subsurface Conditions
- Local Concerns
- Availability of Materials

While economy is generally the best substantiation for selection of type, other factors may combine to outweigh differences in initial cost, for example, a buried structure could have first preference due to reduced maintenance costs.

Always document the reasons for selecting bridge types in the design folder.

6.1.4.2 Developing the Alternative Matrix and the Advantage/Disadvantage Matrix

Create a matrix showing cost comparisons, design criteria, problems addressed and impacts between project alternatives. Some of the items may include the following:

- Cost
  - Estimated costs [Construction costs, Construction & Engineering and Contingencies, Right-of-way, and Preliminary Engineering]
    - Preliminary Engineering costs should be broken down into resource identification and investigation, engineering and permitting.
  - Construction costs should be broken down to Structure, Roadway, Temporary and Traffic & Safety.
- Engineering
  - Typical Section Summary [i.e. 2-11-11-2] *(0.6-3.4-3.4-0.6)*
  - Alignment Change
  - Bicycle Access
  - Hydraulic Performance
  - Utility impacts
  - Future use of bridge and roadway
  - Maintain traffic during construction
  - Right-of-way required
  - Vermont State Standards compliance
  - Existing structural condition
- Impacts
  - Construction impacts
  - Agriculture impacts
  - Archeological impacts
  - Historic Structures, Sites and Districts
  - Hazardous Materials
  - Floodplain impacts
  - Water Body and Wildlife impacts
  - Rare, Threatened and Endangered Species

  - Public Lands Section 4[f]
  - LWCF Section 6[f]
  - Noise
  - Wetland impacts
- Local and Regional Issues
  - Concerns
  - Community Character
  - Economic Impacts
  - Conformance to Regional Transportation Plan
  - Satisfies the Purpose and Need Statement
- Permits
  - Act 250
  - Water Quality [401]
  - Corps of Engineers Permit [404]
  - Stream Alteration
  - Conditional Use Determination
  - Lakes and Ponds
  - T & E Species
  - State Historical Preservation Organization [SHPO]

Create another matrix listing the advantages and disadvantages for each alternative. Both matrices shall clearly designate the recommended alternative.

6.1.4.3 Alignment and Structure Report

Develop an Alignment and Structure Report. The report shall be preceded by a summary that identifies the preferred alternative, provides a brief bridge and roadway location and summarizes other major issues. This summary is usually limited to one paragraph. Begin the body of the report with a detailed description of the project location and the project background. This will include information gathered from site visits and the Local Concerns Meeting plus any other information from the Municipality, the appropriate planning commission, and the District. Include the Purpose and Need Statement, then elaborate on the problem and reasons for the project if required. The report must include a description of each alternative studied with a summary of the impacts involved. A conclusion statement shall explain the preferred alternative and how that alternative satisfies the Purpose and Need. The author may include supporting documentation as listed in section 6.1.4.2 to help define the purpose and need. The report shall include the matrices described in section 6.1.4.2 in an appendix.

- Send the draft Alignment and Structure Report to Environmental Services for review and comment with a request to complete any necessary areas of the matrices.

6.1.4.4 Completion of Project Scoping

Once Structures and Environmental Services agree on the scope of the project, the following steps must be completed to finalize the scoping process. Refer to the Agency's "Project Development Process" for more detailed information.

- Send the Alignment and Structure Report to the Municipality and request a public information meeting with appropriate warning and recording. The participants at this meeting will discuss the report, including impacts on resources, for the various alternatives.
- Distribute the final version of the Alignment and Structure Report to Environmental Permitting Unit, the local Regional Planning Commission and appropriate environmental agencies affected by the various alternatives, with notification of meeting place and time.
- Finalize the Report as required from the comments from the public information meeting, indicating the alternative chosen.
- Send the Final Report to the Municipality with a request for the Municipality to provide written authorization to proceed with Conceptual Plans for the chosen alternative. The Municipality acts in an advisory role, if project is on the State System.

6.1.4.5 No Consensus

At times consensus may be difficult to achieve. If this occurs, the following steps apply:

- For Municipal System Projects:
  - The town has the option to terminate the project. In this case, the Agency will reimburse the town for all expenses charged. The Agency will remove the project from the program. Even though the Agency terminated the project, keep the project work on file for future reference.
- For State System Projects:
  - At the Project Manager's discretion, the Project Definition Team may be called upon to review the project. Refer to the Project Development Process for more information.

6.1.4.6 Consensus Reached

- Request a survey and a traffic study of the project area if they were not ordered earlier.
- For State System Projects, the Project Definition Team may need to be called upon. Refer to the "Project Development Process" for more information.

6.2 RESOURCE DELINEATION

Prior to developing an Alignment and Structure Study, Structures must receive a resource plot from Environmental Services. Refer to Section 6.1 in this manual for information on the Scoping Process.

6.2.1 Environmental Services Resource Plotting

Environmental Services will gather and plot the following information:

- Class I, II and III wetlands.
- Areas that may be archaeologically important.
- Other resources such as Historic Districts, Agriculture and locations of Endangered species. Refer to 6.1.4.2 for a list of possible impacts listed in the alternate matrix.

Environmental Services will communicate with Structures to identify areas of concern. At the completion of each phase of any activity Environmental Services will send a report of their findings to the Structures Section. On Town Highway projects, the Structures Section will forward a copy of this report to the Municipality.

Archaeological work is divided into three phases, investigation, test pits and data recovery. If Phase I archaeological work is necessary, Environmental Services will provide a cost estimate with separate costs for primary and secondary areas. No additional work past Phase I will begin until the Project Manager has given written authorization to do so.

6.2.2 Resource Delineation Review

The Structures Section will review the resource plot mentioned in section 6.2.2 and consider options.

- If an area is of concern, the Structures Section will decide to satisfy the concern through avoidance or to continue with Phase I and/or wetland mitigation as necessary.
- The Structures Section will send all information regarding those areas needing further study to Environmental Services, along with approval to continue.
- If Environmental Services determines that a Phase II archaeological study is required, Structures will request a written cost estimate of that study. The Project Manager will then decide either to continue with the study or to avoid the area. Avoidance is often preferable due to the time and costs associated with Phase II archaeological research.

6.2.3 Additional Work

Comply with the following throughout the design process for the project:

- When changes are made that would require construction outside the previously defined area of involvement, notify Environmental Services and discuss with them the possible impacts.
- It may be necessary to delineate any areas adjacent to construction limits that are not to be disturbed.

6.3 INFORMATION TO REQUEST FROM OTHERS

6.3.1 Regional Planning Commissions

The Regional Planning Commissions are responsible for the following:

- Drafting a Purpose and Need Statement for State System projects. [See 6.1.1.1]
- Consulting with the Agency as to how the project fits in the regional plan.

6.3.2 Traffic Section

Prior to a site visit, make a request for a Traffic Study. The request includes the following:

- The construction year.
- The design year.
- 20 and 40 year ESALs
- A town map.
- Note any known traffic generating conditions related to the site.

For large projects that may include multiple roads, obtain a preliminary Traffic Study. This may be an estimate that could be done in house without requiring a costly traffic study to be done. This information will be finalized at a later point once the project scope has been defined.

6.3.3 Survey Section

After concurrence from the Local Concerns Meeting, order a field survey. The survey request letter shall include the following information:

- A town map with the project site shown.
- A description of the extent of the survey:
  - Requirements concerning the existing structure
  - Area along the roadway.
  - Area along the channel.
  - Include a sketch of the area to be surveyed.

Make sure that the survey crew has consulted with the District Transportation Administrator before the survey.

The Structures Section receives a form from the Survey Section saying the survey is complete. This form will describe the location of the existing ground model and other files to be used for plan preparation.

For very large projects, request GIS maps of the vicinity of the project from technical services. These maps will aid in developing alternates without performing a costly survey. Once an alignment has been selected, order a survey of the area that the project will effect.

6.3.4 Environmental Services

Environmental Services will assist Structures in the following to help define the scope of the project:

- Help identify and plot resources [see 6.2]
- Accompany Structures to the initial meetings with the Municipality
- Review all documents that define the scope of the project.
- Other duties as described in section 6.2 of this manual.

It is very important to maintain an open dialog between Structures and Environmental Services. The work accomplished early in this process will save time in the design phase of the project.

6.3.5 Hydraulics Section

After field survey is received, request preliminary hydraulics. The Preliminary Hydraulic request shall include the following:

- The structure location
- The bridge number
- The Town Highway number
- The stream name
- Plotted Survey and Sections [if available]

6.3.6 Materials and Research Section

Once concurrence from the Local Concerns Meeting has been achieved, request a deck analysis and corrosion survey, if required. This may be required for deck rehabilitation projects.

6.4 STRUCTURE DEFINITIONS

6.4.1 Bridge

A bridge is a structure erected over a depression or an obstruction, such as water, highway, or railway. A bridge has a track or passageway for carrying traffic or other moving loads. Federal guidelines designate a bridge as a structure having a clear span of 20' *(6100 mm)* or more. The clear span is measured along the center of the roadway between abutments, spring lines of arches or the extreme ends of openings for multiple boxes. A bridge may include multiple pipes where the clear distance between each opening is less than half the smaller contiguous openings.

VTrans designates any structure with a span of 6’ *(1800 mm)* or more a bridge. Structures with spans of less than 6’ *(1800 mm)* are not bridges. These are designated as drainage structures.

6.4.1.1 Simple Span Bridges

A bridge that has two supporting substructure units. One support is fixed while the other is allowed to expand. Usually the expansion support is at the higher elevation. If one of the substructure units is founded on ledge, the fixed support will be located there regardless of elevation.

6.4.1.2 Multiple Span Bridges

A bridge that has more than one span. These bridges require at least one pier. Some major types of Multiple Span bridges include:

- Continuous Composite Girder:
  - All shear and moment effects are transferred between spans. The girder is one continuous entity from the beginning abutment, through all piers, to the ending abutment. Engineering judgment will be required when determining expansion or fixed supports. Length of spans, abutment or pier bearing elevations, underlying material and the number of spans will contribute to the location of expansion supports.
- Multiple Simple Span Bridges:
  - Each span along the bridge is a simple span. Shear and Moment effects are isolated between spans. At each pier, two sets of supports are used. Multiple simple span bridges require higher degree of maintenance and are discouraged for new construction.
- Three-Span Continuous Cantilever:
  - Advantages of this type structure include:
    - Elimination of a pier in the center portion of the stream that may be objectionable hydraulically or expensive due to cofferdam requirements
    - Economy in structural steel sections due to balance of positive and negative moments
    - Short construction time requirements due to rapidity of substructure construction
    - Elimination of open construction joints
    - Limitations: not to be used on curved alignment or skews more than 15° skew
    - This type of structure is limited to a composite steel girder [or spliced girder] with a concrete deck. A slanted leg rigid frame shares some similarities with this type of bridge.

6.4.1.3 Jointless or Bridges with Integral Abutments

A bridge without expansion joints. The superstructure is integrally constructed with the sub-structure. Flexible piling and relief joints at the ends of the approach slabs accommodate all longitudinal movement [creep, shrinkage and temperature effects].

6.4.1.4 Trusses

A bridge made up of structural members joined at their ends by riveted or bolted connections or pins to form a stable framework. A triangle can be considered the simplest of trusses. Simple Span Trusses have one expansion and one fixed bearing. Multiple-span trusses exist but are typically comprised of multiple simple span configurations. Trusses can either be through trusses, pony trusses or deck trusses. Refer to appendix H for the different types of trusses.

6.4.1.5 Covered Bridges

Typically a timber truss housed inside a timber shell used to protect the truss. Covered Bridges may have simple spans, multiple simple spans or continuous timber trusses. Bearing for covered bridges typically are hardwood blocks set upon each abutment.

6.4.1.6 Concrete rigid frames and arches

A bridge consisting of abutments and a deck integrally constructed. Typically these bridges are short in length, 50 ft *(15 200 mm)* or less. Frames can be constructed with cast-in-place or precast/prestressed concrete.

6.4.1.7 Segmental

A bridge constructed with similar precast/prestressed sectional units, post-tensioned together. These bridge types can span long distances and can typically be constructed from the bridge rather than impacting large tracks of land. Segmental bridges typically are multiple span bridges and by virtue of the post-tensioning, are continuous.

6.4.1.8 Suspension or Cable Stay Bridges

A bridge with its deck suspended by cables attached to towers at each pier.

6.4.2 Drainage and other non-bridge Structures

Drainage structures include short structures [spans less then 6' *(1800 mm)*], culverts, catch basins, drop inlets, manholes, head walls, sewers, service pipes and drains, foundation drains, and other drainage features that are not classified as a bridge [see 6.4.1].

Non-bridge structures include retaining walls, cribbing, stairs, buildings and any other feature that are not classified as a drainage component or a bridge.

6.4.3 Buried Structures

A buried structure can be structural plate pipes, pipe arches, and arches. A buried structure can be a reinforced concrete box or a rigid frame as well. These structures typically are covered with gravel prior to the wearing surface being placed.

6.4.4 Materials

Bridges may be constructed with a variety of materials or combinations of materials

6.4.4.1 Steel

Steel is the most widely used material in Vermont Bridges. Steel can be used in almost every component in a bridge and is usually found in some form in every bridge in Vermont.

6.4.4.2 Concrete

Concrete is a versatile material in bridge construction. Concrete components may either be cast-in-place, precast and/or prestressed. Concrete is primarily used in substructure components of a bridge and typically used for the bridge's deck.

6.4.4.3 Timber

The use of timber as a structural material is limited to the following applications:

- Guard Rail posts and offset blocks
- Temporary bridges
- Decking material on short span municipal system structures
- Laminated deck panels on deck rehabilitations of some steel truss structures, as a means of dead load reduction
- Occasional use as pedestrian bridges for aesthetic purposes
- Treated timber curbs
- Stressed timber slabs
- Covered bridge rehabilitation
- Pre-manufactured or prefabricated superstructures
- Binwalls

6.5 SCOPING CHECK LIST

Figure 6.2 shows what is required for the scoping process.

Figure 6.2 Scoping Check List

Form number or type	Description
3	Request preliminary traffic data
Hazwaste *	Hazardous waste assessment
Inttwnmt*	Request to Municipality to schedule a local concerns meeting
✍	Request to Environmental Services to set up local concerns meeting.
✍	Send letter of understanding to town
survey*	Order field survey, if appropriate
✍	Distribute Purpose and Need Statement
2	Request Preliminary hydraulics
✍	Request deck analysis/corrosion survey if required.
2a	Request to Environmental Services to plot resources
✍	Request to Municipality to schedule a public information meeting
✍	Request from the municipality to proceed with the project.
✍	Request PDT approval if necessary
✍	Distribute final Alignment and structure study report

✍- This submittal requires a letter to be drafted.

D = Design Division Lead

FF = Federally Funded

NFF = Non-Federally Funded

Chapter Seven

Conceptual Plans

7.1 ENGINEERING FOR CONCEPTUAL PLANS

The purpose of Conceptual Plans is to provide enough information to allow the town and any other reviewing agencies to have a reasonable idea of the project without providing specific details.

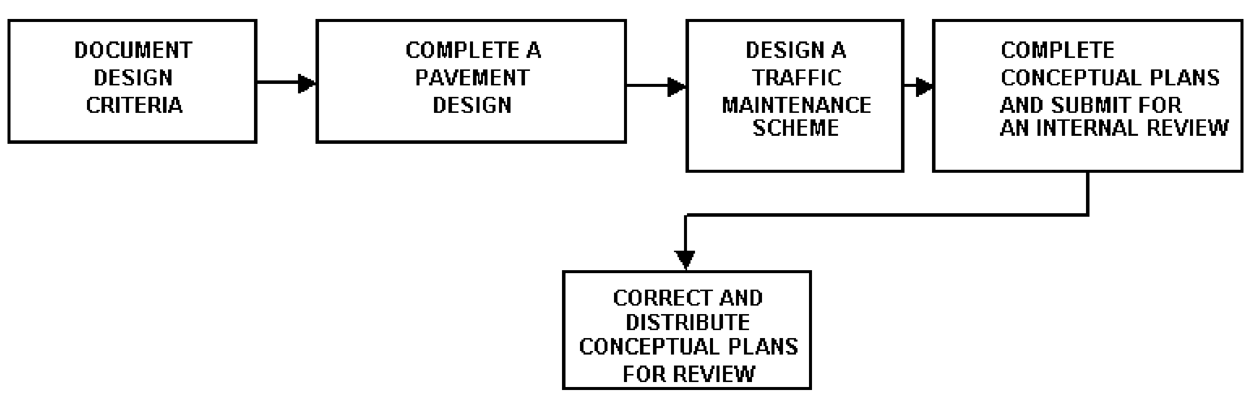
Prior to developing the Conceptual Plans, involve the Municipality and various other entities through the scoping process as described in Chapter 6.

7.1.1 Conceptual Plan Development Flow-Chart.

Refer to figure 7.1 for a flow chart describing the duties that must be completed on a project.

Figure 7.1

Conceptual Plan Submittal



7.2 DESIGN CRITERIA

Document the Design Criteria in a standard form as described in 13.2.1.

7.2.1 Design Exceptions

Exceptions to the criteria described in 13.2.1 shall receive a design exception according to VTrans publication, "A Policy on Preparation of Design Exceptions." January 2, 1998, see 13.2.2.

7.3 PROJECT GEOMETRIC CONTROL

7.3.1 Horizontal Control

Establish the horizontal control by showing the following:

- The centerline of the roadway and major chord [if applicable].
- Angles between the centerline and working lines [see figures 13.1 to 13.5].
- Stations at the centerline roadway where the layout lines cross.
- Direction of stationing and direction of stream flow.
- The ties to key points on the horizontal alignment.

7.3.2 Vertical Control

Establish the vertical control by showing the following:

- Grades for all lines: mainline, sidelines, channel lines [if pipe or box]
- Minimum clearances
- Ground lines [existing and proposed]
- Bench Marks

7.4 RIGHT OF WAY PROCESS

7.4.1 Town Highway Bridge Projects [No Federal Participation]

It is the policy of VTrans to require each Municipality to acquire all necessary right-of-way for Town Highway Bridge Projects within the respective Municipalities when no federal funds are involved.

Conceptual plans will be submitted to the Municipality by Structures or it's design consultant, upon acceptance of the Alignment/Structure study report.

7.4.2 Town Highway and State System Bridge Projects [Federal Participation]

After Conceptual plans are submitted, Property Administration will determine the existing Right-of-Way limits and add to the electronic files.

7.5 CONCEPTUAL PLANS

The Structures Section develops Conceptual Plans to portray the proposed concept of a bridge project. If something is required to make this concept clear, it should be on the plans. If it is not required, it need not be shown on the plans. This manual provides the following lists of items to assist with the development of plans that are consistent. Projects differ; therefore certain items may not be necessary on some projects. The sheet contents will change at each step of the project's development. Each chapter in this part of the manual will address the changes or additions necessary for each step.

Project sheets shall appear in the same order as listed below.

7.5.1 Title Sheet

7.5.1.1 Plan View

- Existing edges of roads [dashed] with directions to adjacent towns labeled.
- Existing Highway/Route names and/or numbers.
- Existing edges of river with river name and flow direction.
- Existing building outlines.
- Existing bridge or structure [dashed].
- Proposed centerline with mainline stations only, no subtangents.
- Begin and end project stations.
- Begin and end bridge stations.
- North arrow.
- Bar scale.

7.5.1.2 Horizontal and vertical datum

7.5.1.3 Project information

- Town, County, Route No. [show class if a town highway], Bridge No.
- Project Location [same as shown on the Finance & Maintenance Agreement].
- Project Description [same as shown on the Finance & Maintenance Agreement].
- Length of Structure, Length of Roadway, Length of Project.

7.5.1.4 Location map

- Large enough to be legible when reduced to half size.
- Identifiable features [i.e., State route, or rivers] labeled.
- Project location circled and labeled with project name and number.

7.5.1.5 Title Block

- Project name and number.

7.5.2 Preliminary Information Sheet

7.5.2.1 Typical Bridge Section [As applicable for type of superstructure]

- Thickness of pavement and/or deck and height & width of curbs.
- Types and thickness of pavement lifts.
- Cross slope information.
- Width to curb, face of rail, fascia.
- Type of bridge rail, with reference to standard.
- Beam spacing and fascia overhangs.
- Girder web depth or size of rolled beams.
- Number, size and type of prestressed members including depth of overlays.
- Sheet membrane waterproofing.
- Haunch, chamfers and drip notches.
- Typical diaphragms or cross-frames.
- Centerline and location of grade.
- Scale: 3/8" = 1'-0" preferred, 1/4" = 1'-0" minimum. *(1:40 preferred, 1:50 minimum)*

7.5.2.2 Typical Roadway Section

- The following tolerances shall be shown on the Roadway Typical Section:

Figure 7-2. Material Tolerances

Material Item	Tolerance
Surface Course	
- Pavement	±1/4" (±5mm)
- Aggregate Surface Course	±1/2" (±10mm)
Base Course	±1/2" (±15mm)
Subbase	±1" (±30mm)
Sand Borrow	±1" (±30mm)
Granular Borrow	±1" (±30mm)

- Thickness of pavements, subbase and frost-free material.
- Type and thickness of pavement lifts.
- Cross slope information.
- Width of travel lanes and shoulders with and without guardrail.
- Type of guardrail with reference to Standard.
- Side slope ratios [1:2, 1:3 etc.] and ditch information.
- Grade point and centerline.
- Additional details as required [i.e., sidewalks, curbs, under-drain, etc.].
- Scale: 3/8" = 1'-0" preferred, 1/4" = 1'-0" minimum *(1:40 preferred, 1:50 minimum)*.
- Clear Zone

7.5.2.3 Design Criteria

- Live Load.
- Design Span.
- Structural Steel Type.
- Concrete Type.
- Design Stresses for Steel and Concrete.

7.5.2.4 Traffic Maintenance

- Only fill in lines 1 and 2.

7.5.2.5 Load Rating Table

- Place an appropriate table; to be filled at a later step.

7.5.2.6 Traffic Data

- Show if available.

7.5.2.7 Title Block

- Fill everything but designed by, drawn by, checked by, and supervisor.

7.5.3 Plan Sheet

7.5.3.1 Bench Marks

- Label each benchmark with number, description, and elevation in individual boxes.

7.5.3.2 Existing topography

- Label all features used for control ties and only critical features near project area [i.e., existing structures, edge of woods, fence lines, guard rail, stone walls, power/telephone poles with numbers, existing drainage and water courses with the name and a direction-of-flow arrow.]
- Direction arrows to nearest town or route.
- Existing Highway/Route names and/or numbers.

7.5.3.3 Proposed mainline alignment

- Regular and cardinal stations.
- Face of rail/edge of shoulder line from beginning to end of the project.
- Curve data [if applicable].

7.5.3.4 Proposed channel line alignment

- Regular and cardinal stations.
- Mainline/channel line intersection labeled with stations and delta angles.

7.5.3.5 Begin/end bridge stations

- Show lines at begin and end of bridge on appropriate skew.
- Label with station and finished grade elevation.

7.5.3.6 Begin and end project stations

7.5.3.7 Existing bridge data

7.5.3.8 North arrow

7.5.3.9 Bar scale

7.5.3.10 Temporary Bridge Center Line

- Only when necessary.

7.5.4 Profile Sheet

7.5.4.1 Profile

- Existing ground along proposed line [dashed and labeled].
- Proposed vertical alignment.
- Vertical and cardinal stations and elevations.
- Tangent grades [to 4 decimal places].
- Vertical curve information [showing length, stopping sight distance and k values.]
- Begin/end project station.

- Begin/end bridge stations and finished grades.
- Lines showing back of abutments and bottom of the superstructure.
- Existing ground elevations at left of vertical grid lines to 1 decimal place *(to 2 decimal places - metric).*
- Proposed finish grade elevations at right of vertical grid lines to 2 decimal places *(to 3 decimal places - metric).*
- Title.
- Scale use 2 to 1 vertical exaggeration, 20-scale horizontal and 10-scale vertical *(2.5 to1 vertical exaggeration, 250-scale horizontal and 100-scale vertical).*

7.5.4.2 Title block

- Project name.
- Project number.
- Sheet name.

7.5.5 Roadway Cross Sections

7.5.5.1 Cross sections

- Shown at 50 foot *(10 meter)* intervals and at critical sections
- Existing ground [dashed]
- Show only “backbone” of the new surface from begin to end of the project
- Show sides slopes and ditches only on critical sections

7.5.5.2 Title block

- Project name
- Project number
- Sheet name

7.5.8 Channel Cross Sections

7.5.8.1 Cross sections

- Shown at 25 foot *(5 meter)* intervals
- Existing ground [dashed]

7.5.8.2 Title block

- Project name
- Project number

- Sheet name

7.6 DESIGN AND PLAN REVIEW

Conceptual Plans are exchanged between the Structures Design Units for the following considerations:

- Appropriateness of the basic design concepts and assumptions
- All necessary design considerations have been addressed
- An acceptable degree of uniformity in details is being maintained between the Structures Design Units

7.7 PROJECT CHECK LIST

The checklist in figure 7.3 shall be reviewed before proceeding with project plan submittals.

Figure 7.3 Conceptual Plan Check List

NFF	F	D	Form number or type	Description
✔	✔		1	Request for Finance and maintenance agreement.
✔	✔		3	Request traffic study, if necessary.
✔	✔		survey*	Request for survey, if none has been done yet.

*- This is the name of the form.
D = Design Division Lead
FF = Federally Funded
NFF = Non-Federally Funded

7.8 PROJECT SUBMITTAL

Figure 7.4 shows what the submittal process is for Conceptual Plans.

Figure 7.4 Conceptual Plan Submittal Process

NFF	F	D	Form number or type	Description	Date Designer Sent	Date Reply Recieved
✔	✔		4†	District - one set of plans.		
✔	✔		4†	Planning, two half size sets of plans marked to show the area of involvement. Exact construction limits are not required.		
	✔		4†	Property Administration - one set of plans, requesting that existing ROW be plotted.		
✔	✔		4†	Utilities - one set of plans.		
	✔		iib_town*†	Town - one set of plans.		
✔			iib_town*†	Town - one set of plans. (Request existing ROW and include a ROW procedure letter.)		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

*- This is the name of the form. Use specific form from the two choices.

D = Design Division Lead

FF = Federally Funded

NFF = Non-Federally Funded

Chapter Eight
Preliminary Plans

8.1 ENGINEERING FOR PRELIMINARY PLANS

The purpose for preliminary plans is to refine the project scope based on the information from the Town, the public and other agencies and divisions within the VAOT. The Preliminary plans should contain the final scope of the project. Upon approval, a final design could effectively be completed.

8.1.1 Preliminary Plan Development Flow Chart.

8.1.1.2 Flow Chart

Refer to Figure 8-1 for a flow chart describing the duties that must be completed on a project.

8.2 INFORMATION GATHERING

All comments from the Conceptual Plan submittal and from the public information meeting are to be collected and evaluated for inclusion into the project plans.

8.3 INFORMATION TO REQUEST FROM OTHER DIVISIONS

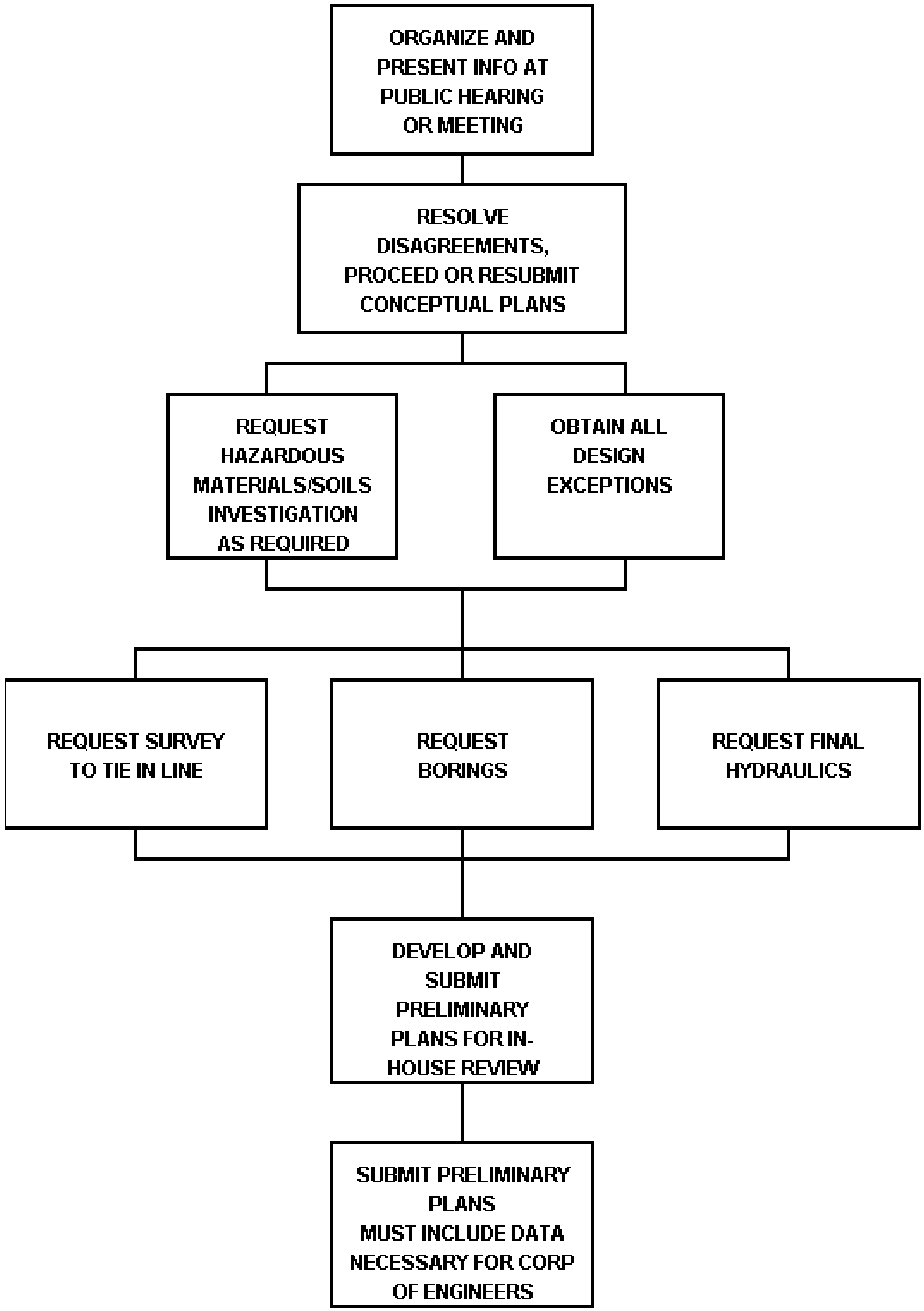
8.3.1 Hydraulics

The final Hydraulic request should include the following:

- The Title or PI sheet
- Plan and Profile sheet
- Plan and Elevation sheet
- Templated roadway and channel sections
- Low beam elevation at each substructure
- Size of temporary bridge, if required

Figure 8-1

Preliminary Plans Development Flow Chart



8.3.2 Materials & Research Section

Request borings for every project that requires the use of a cofferdam despite the size of the project. Borings are advisable on large plate pipe projects as well, and should be considered on all other projects even when the project requires no cofferdams. The number of borings to request is subject to engineering judgement. Normally, however, the number should consist of three borings at each substructure unit, as a minimum, and one boring at each plate pipe head wall as a minimum.

8.3.2.1 Boring Request

The boring request should include the following:

- Town maps with the project location shown
- Roadway layouts with desired boring locations - layouts must show horizontal and vertical control data [request and locate borings relative to surveyed alignment].
- Tabular listing of desired borings with stations and offsets from the survey line.

8.3.2.2 Boring Contents

- The information required by the Structures Section includes:
  - Proofread boring logs from CADD
  - Geologist's reports
- Recommendations from Geotechnical Engineer on moderate sized projects, to include:
  - Type of foundation to be used
  - Allowable soil bearing values
  - Type of pile if pile foundation is recommended
- Full foundation reports from the Geotechnical Engineer on major projects, to include:
  - Results of all field and laboratory testing
  - Interpretation of subsurface conditions
  - Specific recommendations for foundation design:
    - Spread footings—footing evaluation, allowable bearing value, anticipated settlement
    - Pile footings—friction or end bearing, acceptable pile types with selection criteria, requirements if down drag present
    - Construction considerations—water tables, cofferdam seals, etc.
    - Other considerations, i.e., approach embankment stability
- Foundation reports when requested

8.3.3 Survey Unit

The Structures Section shall request the Survey Unit to tie the chosen horizontal alignment in the field. Refer to this line as the survey line.

8.3.4 Traffic and Safety

Consult Traffic and Safety for assistance with traffic control, if a special governing consideration or question has risen within any particular project. This is true for both temporary and permanent cases.

8.4 HEARINGS AND INFORMATIONAL MEETINGS

8.4.1 Public Hearings [502 Hearings]

The Structures Section will be responsible for 502 hearings on State System Bridge projects.

8.4.2 Informational Meeting for Town Highway Projects

- The Structures Section requires the responsible Municipality hold a public information meeting for every project. The Municipality should schedule this meeting after the Structures Section has submitted Conceptual Plans and before work begins on Preliminary Plans.
- The Structures Section or its consultant will prepare a hearing roll for the project. The designer should color this to bring out distinguishing features on the plans.
- The Municipality will contact the adjoining property owners and will warn and conduct the meeting. The Structures Section will provide personnel to present the project and to answer questions.
- The Municipality must respond to the Structures Section in writing with any comments or changes to be considered in the development of Preliminary Plans. Any change must come through the legislative body of the Municipality, and should not be done as the result of verbal comments made at the meeting.
- The Structures representative should use judgement when asked about specific policies. Do no hesitate to respond that you need to collect additional information, and will provide a response as soon as possible.

8.5 PROJECT GEOMETRIC CONTROL

8.5.1 Horizontal Control

Further develop the horizontal control established earlier. The new items include the following:

- The centerline of bearings
- Dimensions along the major chord between centerlines of bearings
- Dimensions along centerlines of pier bearings between centerline and major chord

8.5.2 Vertical Control

Develop bottom footings, top of walls and finish grade elevations of substructures. This should include finished grade elevation for superstructures.

8.6 TEMPORARY BRIDGE REQUIREMENTS

Show a two-way bridge or a one-way bridge with traffic lights, and any other specific temporary bridge requirements, on the plans. The temporary bridge detail shall show a minimum opening sketch indicating horizontal and vertical requirements. The detail should note that all horizontal requirements are perpendicular to the stream. A note shall be added that states the contractor shall not cut existing stream banks to provide the minimum opening.

A temporary foot bridge for pedestrians may be a requirement for the project.

8.7 GUIDELINES FOR SELECTING TRAFFIC CONTROL FOR BRIDGE PROJECTS

The following information is to assist the designer in selecting the type of traffic control required during bridge deck replacement, bridge replacement, or similar type projects. This Manual does not intend to provide all of the details of design necessary for each option. View this as a means of evaluating which option may best fit a particular situation. Engineering judgement, based on site observation, is always important in making the proper selection and will supersede any guideline provision.

8.7.1 Traffic Control Criteria

The three fundamental criteria used for determining the type of option to use are:

- Safety
- Capacity
- Cost Effectiveness

Providing a two-way, temporary bridge or a detour for every bridge or deck project is not always practical or cost effective. The following guideline first explores the least complicated and least expensive option and continues to the next level of traffic control. The use of a detour is considered last, even though it may not be the most complicated or expensive option, from a construction standpoint. It may have other socioeconomic drawbacks considered important and are discussed in greater detail in that section.

8.7.2 Traffic Control Options

The four main options for traffic control for the above type of situations are:

8.7.2.1 Option 1—One-way control without traffic signals

- Low volume roads
  - ADT less than 1500
  - DHV less than 200
  - Average of 8 highest hours of an average day less than 120

- Adequate sight distance
  - The minimum site distance on both approaches should be no less than the minimum “Stopping sight distance” values in the AASHTO “Green Book.”
  - Continuously maintain the minimum sight distance until an approaching vehicle has started across the bridge.
  - Consider the sight distance restrictions caused by temporary or permanent bridge rail, concrete median barrier or other construction techniques that may obscure a driver’s view.
  - Use the alignment of the temporary bridge for the sight distance requirement when the alignment for a temporary bridge is different from the existing structure.
  - Selective thinning and trimming of trees and brush or other shoulder improvements should be considered to obtain the required sight distance before using other options.
  - Consider a higher level of traffic control, if adequate sight distance cannot be obtained, except for the special situation listed below. Always, use engineering judgement.
- Extremely low volume with less than ideal sight distance.
  - ADT, DHV—50% of above values.
  - Use same detail as above, advisory speed plaques or other additional warning signs may be necessary on a case by case basis.

8.7.2.2 Option 2—One-way Control with Traffic Signals

These values are guidelines, and if you are considering exceeding them, you should consult with the Traffic and Safety Section.

n Use this option when Option 1 is inadequate due to sight distance restrictions.

- Maximum volumes that a traffic signal can satisfy, for various bridge lengths see Figure 8-2.

Figure 8.2. Maximum Volumes that a Traffic Signal can satisfy, for various Bridge Lengths

Bridge Length	Max. DHV	Max. ADT
100 feet (15m)	830	6500
150 feet (30m)	750	5700
150 feet (45m)	700	5300
200 feet (60m)	630	4650
250 feet (75m)	580	4250

- The above ADT and DHV determination are based on the following assumptions:
  - Vehicle speeds of 20 mph *(30 km/h)* through a work zone.

- Flat terrain
- Two phase signal operations
- 60% DHV directional split
- Stop bar placement 110 feet *(34 meters)* beyond the ends of the bridge.
- ADT from “General Highway” category of VAOT Planning Divisions 1988 “Regression Analysis.”

- Minimum signal head visibility sight distance.
  - Per table 4-1 of MUTCD.
  - MUTCD allows lesser distance if the contractor posts appropriate warning signs. Use engineering judgement.

8.7.2.3 Option 3—Two-way, Temporary Bridge [Preferred]

- Use when volumes exceed the one way signal limit.
- Use when the condition cannot meet sight distance restrictions, as outlined in Option 1 and Option 2.
- Consider cost and practicability versus a detour. In some situations, building a temporary bridge without extreme expense may not be possible.
- Consider realignment of new roadway or bridge so that the contractor can use the existing bridge as the temporary bridge during construction.
- Use when time constraints do not allow for a signal design or cost of a signal and one-way bridge is greater than two-way bridge.

8.7.2.4 Option 4—Off-project Detour

- Generally use as a last resort unless a detour route is relatively short and straight forward.
- Consider the costs of additional driver delay, vehicle operating expense and road wear costs due to detour.
- Avoid detours using town highways or local roads unless the proper paper work has been done. Refer to the document relating to Title 19, dated June 20, 1979.
- Proper signing is essential to a detour and will be a part of contract plans for on-system projects.
- For off-system projects, requiring the town to sign a detour route is acceptable, with no design or participation under the contract.

8.8 PRELIMINARY PLAN CONTENTS

Before making a Preliminary Plan submittal, the plans must meet the following content criteria: [If a previous designer has already created a sheet for conceptual plans, the required information below lists modifications or additions to that sheet.]

The plan sheets shall appear in the same order as listed below.

8.8.1 Title Sheet

8.8.2 Preliminary Information Sheet

8.8.2.1 Typical Abutment Earthwork Section

- Theoretical cofferdam limits
- Excavation and Backfill limits

8.8.2.2 Typical Channel Section

- Excavation
- Stone Fill
- Grubbing Material
- Geotextile limits

8.8.2.3 Final Hydraulics Report

8.8.2.4 Design Criteria

- Fill remaining data as applicable
- If using piling, show average pile length rounded to the next 5 foot *(1500 mm)* increment for each substructure unit [use the word average for each length shown]

8.8.2.5 Traffic Maintenance

Fill remaining blanks

8.8.2.6 Traffic Data Table

Place data if not done at a previous step

8.8.2.7 Temporary Bridge Sketch

Schematic showing the horizontal and vertical requirements for size of opening

8.8.2.8 Typical Roadway Section

Show clear zones

8.8.3 Tie Sheet

8.8.3.1 Upper Section—Geodetic Control Information [if provided.]

- GPS control point name
- Northing and Easting coordinates and elevation
- Description of point location
- Swing ties to point if provided

8.8.3.2 Middle Section—Traverse Tie Information

- Swing ties shown in individual boxes with proper orientation but not necessarily to scale
- Topo and tie distances
- Description of a point
- Northing and Easting coordinates and elevation

8.8.3.3 Lower Section—New Alignment Tie Information

- Swing ties shown in individual boxes with proper orientation but not necessarily to scale
- Topo and tie distances
- Description of a point in station
- Northing and Easting coordinates
- Not necessary to have these ties before proceeding to next step

8.8.3.4 Horizontal and Vertical Datum

8.8.4 Plan Sheet [Layout Sheet]

- Horizontal alignment data with traverse points labeled as on the Tie Sheet
- Additional critical features
- Existing ROW lines
- Begin/End approach stations
- Construction item notes [ie bridge rails, guard rails, drives, etc.]
- New drainage complete with labels
- Drive and side road radii
- Approximate centerline of a temporary bridge detour with related construction limits
- Project construction limits
- Stone fill and related channel work
- Face of guard rail, guard rail flares and shoulder break lines
- The outline of new structure including deck, approach slabs, wingwalls and face of abutments [do not show footings]
- Clear zones [See section 13.1.7.1]

8.8.5 Profile Sheet

8.8.5.1 Profile

- Begin and end approach
- Abutments, including footings with bottom of footing elevations
- Approach slabs
- Do not show material transitions
- Do not show Stone Fill
- Banking diagram [may be shown here or on Roadway cross sections]

8.8.5.2 Title block

- Project name
- Project number

- Sheet name

8.8.6 Traffic Control Sheets

Traffic and Safety has provided many details for traffic control during construction. The designer may consult these for assistance in developing traffic control for a project. This sheet shall include:

- Layout of project
- General plan of temporary traffic patterns
- If there will be a detour, clearly show this detour on the plan.
- If there will be a phased traffic pattern in a bridge rehabilitation project, detail these phases on the plan. Also provide cross sections detailing the expected phases on the bridge.

8.8.7 Boring Information Sheet

Include information if available although this Step may continue without boring information.

8.8.7.1 Layout

- Existing edges of road and structure [dashed]
- A new centerline with regular stations
- North arrow
- Stream name with flow direction
- New bridge abutments outlined
- Location of bore holes marked with appropriate nomenclature
- Bore holes numbered
- Title and scale

8.8.7.2 Boring Chart

- Boring numbers
- Station
- Offset from the centerline
- Elevation of bedrock if applicable

8.8.8 Boring Log Sheet

8.8.8.1 Boring Logs

- Place logs beside one another without regard to vertical elevation
- Bottom of footing elevation applicable to each log
- Estimated pile tip elevation if applicable

8.8.9 Plan & Elevation

8.8.9.1 Plan

- Preferred scale is 1”= 10’-0” *(1:100 metric)*

- Wingwall numbers but no lengths or angles
- Abutment askew angles
- Limits and type[s] of Stone Fill
- All slope ratios [roadway and channel]
- Guard rail with flares [if within limits of drawing] and only first post off bridge
- First bridge rail post at each end of bridge [with distances to them, from the end of the bridge. If the layout detail does not show distances, refer to sheet where they may be found]
- Edge of shoulders [and pavement if applicable]
- Stream name and show direction of flow
- North arrow
- Point of minimum clearance if dry crossing [road or railroad]
- Mainline, channel line and sideline[s] with stations
- Equated stations at line intersection points with delta angles
- Substructure outlines with footings
- Cardinal stations [i.e., PC, PT, etc.] in area of bridge
- Any adjacent drainage or remaining landmarks in area of bridge
- Begin and end bridge stations, the centerline of bearing stations where applicable, and finish grades at each
- Major chord [if applicable]
- The plan need not show curve data
- Title and bar scale

8.8.9.2 Elevation View

- Drawn as if looking from the stream toward the right fascia
- Existing ground and approximate ledges [if applicable] shown and labeled
- Do not show below ground information [i.e., dashed footing, bottom of the stone fill, etc.]
- Do not show roadway percent grades or vertical curve information
- Do not show girder or beam information
- Fixed or expansion ends if applicable
- Span length[s]
- Guard rail schedule[s]

- Design “Q” or the highest “Q” that will pass under the structure
- New Stone Fill labeled with the type and thickness [shown just down to existing ground]
- New bridge rail and the length of it for each side [if the view does not show length, refer to sheet where it may be found]
- The first guard rail post off each corner
- Approach rail [may be partially shown]
- Elevation Bar Scale on each side of drawing

8.8.10 Erosion Control Sheet

8.8.10.1 Erosion Control

Refer to the erosion control procedures and measures recommended in the Erosion and Sediment Control chapter in the VAOT “Hydraulics Manual” and in the Handbook for “Soil Erosion and Sediment Control on Construction Sites” [Vermont Geological Survey, 1987].

8.8.10.2 Erosion Control Site Plan

- Use the grading of the site as a base
- Show the location of all erosion control measures [e.g., vegetation, dikes, sediment diversions, sediment basins, silt fences, etc.]
- Show a timetable chart of the sequencing of the control measures

8.8.11 Roadway Cross Sections

8.8.11.1 Cross Sections

- Fully templated with finish grades, side slopes and cross slopes labeled
- Template all material [pavement, subbase, sand borrow, etc.] but don’t label them
- Do not show begin/end stations for materials
- Label side slopes and cross slopes at least once per sheet and anytime they change
- No need to show existing drainage unless the project requires the modification
- Do not show full bridge typical section; show only backbone in bridge area
- Begin/end stations for bridge, project and approaches
- Show invert elevations for all new culverts
- Cross reference to appropriate location[s] on Drive & Culvert Cross Section Sheet

8.8.11.2 Material Transition Details

Show for both begin and end bridge and begin and end project

8.8.11.3 Banking Transition Details

If not already shown on the Profile Sheet

8.8.11.4 Drive & Culvert Cross Section Sheet[s]

- Use a separate sheet at the end of the Roadway Cross Sections

- Show drive and culvert sections and/or profiles
- Cross reference to appropriate location[s] on Roadway Cross Sections

8.8.12 Channel Cross Sections

8.8.12.1 Cross Sections

- Template with Stone Fill, Granular Backfill for Structures, Unclassified Channel Excavation and Grubbing Material
- Template new substructures with any undercut[s] and piling
- Label the begin/end stations [on both sides of the channel] for the following items:
  - Unclassified Channel Excavation
  - Stone Fill
  - Geotextile for Stone Fill
  - Grubbing Material
- Template [pattern] ledge when a substructure is founded directly on the ledge
- When a channel line cross section intersects a roadway, template only enough of the roadway to clarify any quantities involved
- Do not template any of the superstructure
- Do not show cofferdam limits
- Do not label items on x-sections unless they differ from the typical channel section

8.9 PRELIMINARY PLAN CHECK LIST

Review the check list in Figure 8-3 before proceeding with the project plan submittals.

Figure 8.3 Preliminary Plan Check List

NFF	F	Form number or type	Description
✔	✔	✍	Request any necessary design exceptions.
✔	✔	hazwaste*	Request hazardous waste assessment as required.
✔	✔	✍	Request additional survey (to run the centerline in field).
✔	✔	5	Request necessary borings. Include two sets of layouts Town maps. Make sure ties and benchmark information is on the plans.
✔	✔	6	Request final hydraulics.

*- This is the name of the form.

✍ This submittal requires a letter to be drafted.

FF = Federally Funded

NFF = Non-Federally Funded

8.10 SUBMITTAL PROCESS FOR PRELIMINARY PLANS

Figure 8-4 shows the submittal process that must be completed to do a Preliminary plan submittal.

Figure 8.4 Preliminary Plan Submittal Process

NFF	F	Form number or type	Description	Date Designer Sent	Date Reply Recieved
✔	✔	7†	District - one set with a preliminary total cost estimate.		
✔	✔	7†	District - one set with a preliminary total cost estimate.		
	✔	7†	Property Administration - One set of plans.		
	✔	7†	Design - One set of plans. (Only on projects with complex approach work)		
✔	✔	7†	Hydraulics - Two sets of plans.		
✔	✔	7†	Construction - Two sets of plans.		
✔	✔	7†	Traffic Design - One set of plans.		
	✔	iii_town*†	Town - one set of plans and estimate.		
✔		iii_town*†	Town - one set of plans and estimate. (Include ROW procedure letter and request a letter to authorize road closure if necessary.)		
✔	✔	8†	Planning - Send memo, and one full size and two half size sets of plans.		
	✔	✍†	FHWA - Plans and estimate when appropriate, by special letter.		
✔	✔	✍†	RAPT - Plans and estimate when appropriate.		
			For projects managed by Design, the following shall be done: a) Add the Final Hydraulics information to the Preliminary Information Sheet. Also develop any sheet that is particular to the structure. (ie, Pipe Sheet for large pipe culvert structures.) b) Create new layout drawings referencing the Design layout that shows the new structure or shows the modifications to the existing structure. Also show limits of channel work and stone fill. c) Add all necessary modifications to the Design cross section sheets.		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

*- This is the name of the form. Use specific form from the two choices in iii_town.

FF = Federally Funded

NFF = Non-Federally Funded

✍ This submittal requires a letter to be drafted.

Chapter Nine

Semi-Final Plans

9.1 ENGINEERING FOR SEMI-FINAL PLANS

All comments from the preliminary plan submittal and property owners' meetings have to be collected and evaluated for inclusion with the semi-final plans. The permitting process, except for the Corp of Engineer permit shall be complete before the semi-final plan submittal unless approved by the Structures Program Manager.

9.1.1 Semi-Final Plan Development and Flow Chart

9.1.1.1 Flow Chart

Refer to Figure 9-1 for the work flow for Semi-Final Plans.

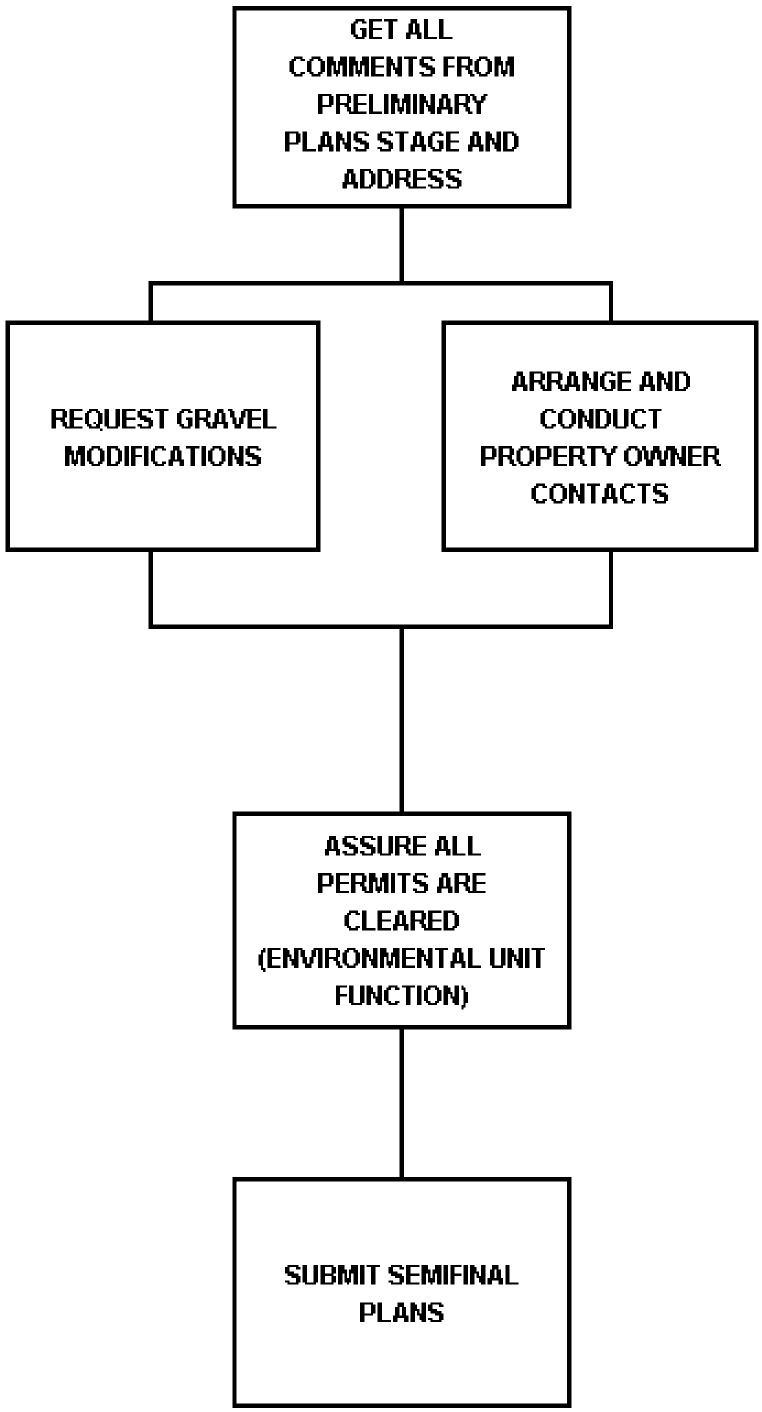
9.1.1.2 Non-Federally Funded Projects

For non-Federally funded projects, the Structures Section creates the Right-of-Way plan sheets showing the following:

- Permanent take-line
- Construction easements
- Channel rights [permanent or temporary]
- Slope rights [permanent or temporary]

Figure 9-1

Semi-Final Plan Development Flow Chart



9.2 RESPONSIBILITY OF OTHERS

9.2.1 Federally Funded Projects

For Federally funded projects, the Right-of-Way Section is responsible for producing all Right-of-Way plan and detail sheets and acquiring all necessary rights. The Structures Section shall review the Right-of-Way plans to verify the project will have adequate easements. The Structures Section shall be responsible for the semi-final plan submittal. The plans shall reflect all comments from the preliminary plan submittal and property owners' meetings.

The Structures Section shall be responsible for the semi-final plan submittal. The plans shall reflect all comments from the preliminary plan submittal and property owner's meetings.

9.2.2 Non-Federally Funded Projects

The town is responsible for acquiring all necessary rights to construct the project as shown in the plans. The town is to mark up a detail sheet showing the acquired limits if different from the limits the Structures Section determined.

The right-of-way acquisition should strive for maintaining, in fee, a 3-Rod (*15.1 m*) right-of-way from the centerline of the road.

9.3 PLAN CONTENT

The Project Civil Engineer and/or Project Manager should review plans within the Structures Design Unit before the formal Semi-Final Plans submittal.

9.3.1 Title Sheet

9.3.2 Preliminary Information Sheet

9.3.3 Right-of-Way Layout Sheets [Non-Federal Projects]

9.3.3.1 Contents

- Existing Right-of-Way
- Take lines
- Construction easements
- Rights
- Legend

9.3.4 Tie Sheet

9.3.5 Plan Sheet

9.3.6 Profile Sheet

9.3.7 Traffic Control Sheets

9.3.8 Boring Sheets

This sheet may have to be added at this step if it was not added during preliminary plans. Check to make sure that the borings have been done and added to project.

9.3.9 Plan and Elevation

9.3.10 Erosion Control Sheet

9.3.11 Roadway Cross Sections

9.3.12 Channel Cross Sections

9.4 SEMI-FINAL PLAN CHECK LIST

Review the check list in Figure 9-2 before proceeding with the project plan submittals.

Figure 9-2 Semi-Final Plan Checklist

NFF	FF	Form number or type	Description
			Request names, addresses, and phone numbers of property owners, as follows:
	✔	10	Projects for which Property Administration is responsible for obtaining right-of-way: send form to Property Administration.
✔		propname*	Projects for which the Town is responsible for obtaining right-of-way: send form to the appropriate Town.
✔	✔	propmeet*	Contact property owners to set up property owner visits, send letters via certified mail.
✔	✔	12	Request gravel modification from Materials and Research - send Title Sheet.

* This is the name of the form.

NFF = Non-Federally Funded

FF = Federally Funded

9.5 SEMI-FINAL PLAN SUBMITTAL PROCESS

Use the submittal process shown in Figure 9-3 to make a Semi-Final Plan Submittal.

Figure 9-3 Semi-Final Plan Submittal

NFF	FF	Form number or type	Description	Date Designer Sent	Date Reply Received
✔	✔	11	District- memo only		
	✔	11	Property Administration - on projects where the Agency is responsible for purchasing right-of-way: One complete set of plans plus mylar of Title Sheet and Plan and Profile Sheets, if plans are not on CADD. If plans are on CADD, send the memo only with full path names.		
✔	✔	11	Utilities - if plans were sent to Utilities at Preliminary Plan stage, send them one set of Semi-Final plans.		
✔	✔	11	Planning - memo only.		
✔		12	Contract Administration - memo only.		
	✔	iv_town*†	Town - one set of plans.l.		
✔	✔	iv_town*†	Town - one set of plans and ROW Procedure Sheet.		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

* - This is the name of the form.

NFF = Non-Federally Funded

FF = Federally Funded

Chapter Ten

Final Plans

10.1 ENGINEERING FOR FINAL PLANS

The designer has accomplished the final design for the project at this stage. This typically includes the final design of the superstructure, substructures, and other features as required. Once the design is approved, the design team will develop Final Plans by these guidelines.

10.1.1 Final Plan Development and Flow Chart

Refer to Figure 10-1 for the work flow for Final Plans.

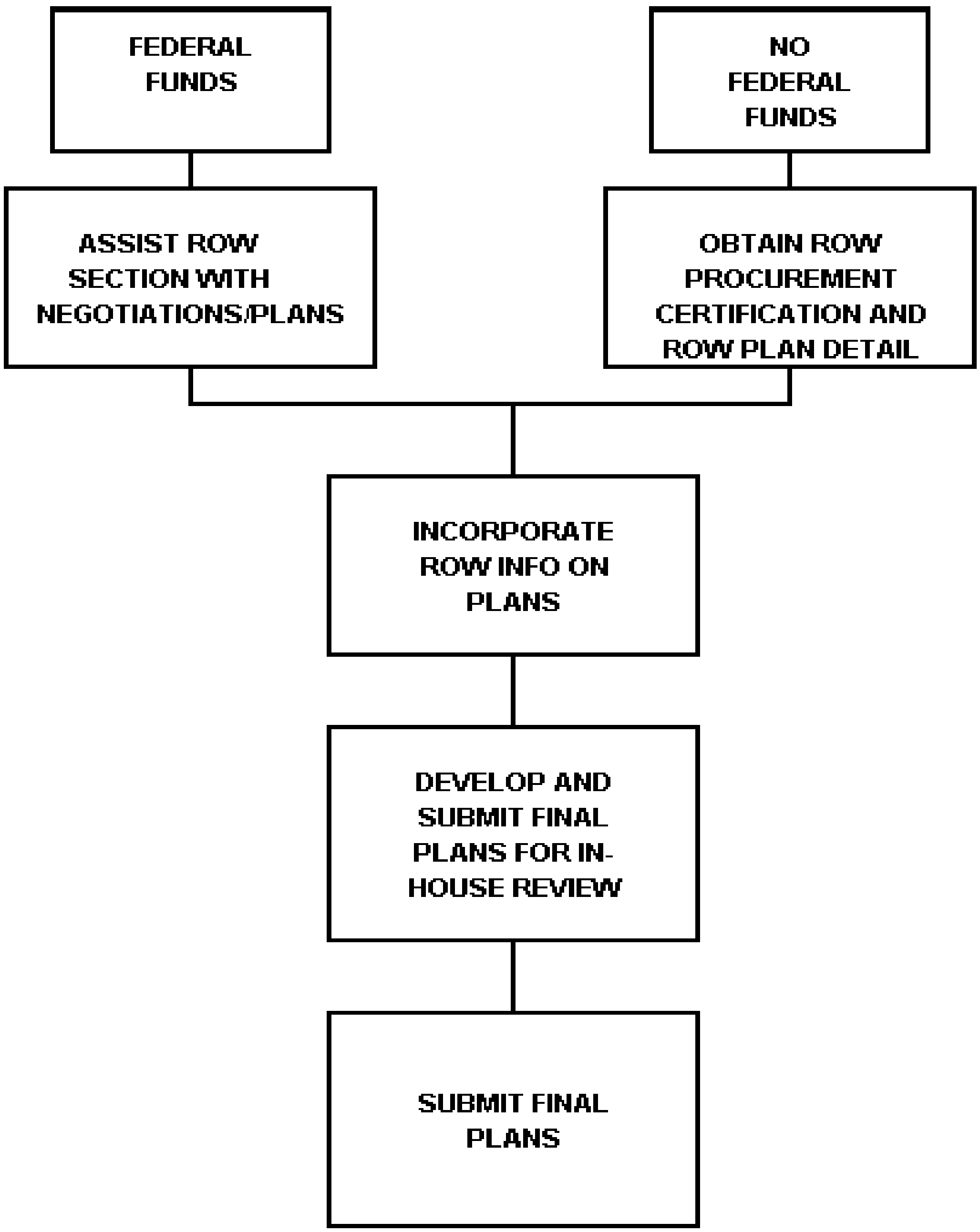
10.2 INFORMATION GATHERING

The following checklist is a guide to assist the designer in compiling all the required information:

- Final superstructure design
- Final substructure design
- Load rating
- Beam profiles
- Bearing design
- Bridge seat elevations
- A rebar schedule
- Quantity sheets
- General notes
- A final computer estimate
- Bridge railing details

Figure 10-1

Final plan development flow chart



10.3 DESIGN

Refer to Part III of this manual for criteria governing the design.

In all cases, the design computations shall be independently checked. This includes designs accomplished using a computer program.

10.4 FINAL PLAN CONTENTS

The Project Civil Engineer and Project Manager should review plans within their Design Unit. They should then forward the plans to other Project Managers for review before the formal Final Plans submittal. This review will be the most in-depth plan review made. Use the following checklists for preparation for that review:

10.4.1 Title Sheet

- Add indexes of sheets including Standards & Reference Sheets.

10.4.2 Preliminary Information Sheet

- Make any modifications to the design criteria if needed.
- Add Load Rating information to table.

10.4.3 Bridge and Roadway Quantity Sheet

10.4.3.1 Quantity Breakdown

- Quantities should be broken down and listed on the Quantity Sheet as follows:
  - Superstructure
  - Abutments
  - Approach slabs
  - Piers
  - Channel
  - Roadway
  - Utilities [participating and nonparticipating] Waterline, Sewer line, Street Lighting, Gas line
  - Erosion Control
  - Other categories, as appropriate
- Items
  - List in numerical order
  - Shear Connector—Total Number; i.e., [1322 - 7/8” X 7” *(22 mm x 180 mm)*]
  - Include Mobilization Item

10.4.3.2 Earthwork Summary

- Fill required
  - Planimetered fill [= A]

- Less factored solid rock excavation [factor is 1.3] [= B]
- Less displacement of any large buried structures [= C]
- Net planimetered fill [A - B - C = D]
- 1.15 x net planimetered fill = factored fill [1.15 x D = E]

■ Planimetered material available for fill

- Earth excavation x 1.0 [= F]
- Channel excavation 0.3 [= G]
- Structure excavation or excavation within cofferdams x 0.3 [= H]
- Total material available for fill [F + G + H = I]

■ Borrow or Waste = factored fill less total material available for fill [E - I]

10.4.3.3 Temporary Erosion Control Items

List in numerical order with quantity

10.4.4 Right-of-Way Sheets [Non-Federal Projects]

10.4.5 Tie Sheet

10.4.6 Plan Sheets

10.4.7 Profile Sheet

10.4.8 Traffic Control Sheet

10.4.9 Boring Sheets

10.4.10 Plan and Elevation Sheet

10.4.11 Erosion Control Sheet

10.4.12 General Notes

This sheet shall include notes for the contractor. Write these notes clearly. Any note requiring a pay item shall include the pay item and it’s description. Fully describe any modification to a pay item on this sheet.

10.4.13 Superstructure Details

The following details are generic and are provided for guidance. The designer is responsible for showing all necessary details for each specific project.

10.4.13.1 Bridge Typical Section

10.4.13.2 Deck or Slab Reinforcing

- Begin & End Bridge
- All necessary reinforcing details

10.4.13.3 Concrete Placement Schedule

- Show desired deck concrete placement segments and sequence for continuous spans, with direction of placement indicated, usually low to high end.
- List options, if any are available

10.4.13.4 Bridge End Detail

- Deck reinforcing shown & labeled
- Beam, end diaphragm and end haunch steel
- Pavement on and off bridge with joint detail [if required]
- PVC water stop with all curtain walls [detail curtain wall reinforcing]
- Approach Slab Bracket
  - Reinforcing, including dowels to abutment
  - Thickness of the slab
  - 1/2” X 6” *(12 mm x 150 mm)* expansion material under the edge of the slab
- Closed cell foam expansion material at the end of slab, if required
- Detail at the interface of abutment top, the back wall base and the curtain wall
- Detail the half-section elevation of the curtain wall, parallel to the centerline of bearing. Show the reinforcing configuration in this view.

10.4.13.5 Framing Plan

- Centerline bearing at abutments & piers
- Beam splice locations
- Beam/girder number, size and spacing [normal & skew]
- Member size and spacing of diaphragms
- Bridge centerline, major chord, and askew angle
- Scupper locations
- Detail locations for connection details
- Drip plate location

10.4.13.6 Beam/Girder Elevation

- Exaggerated scales [horizontal & vertical]
- Sizes of web, flanges, or beams and stiffeners, or connection plates
- Centerline bearings & splices
- Steel designation
- Shear connector details
- Charpy V-notch requirements and locations
- Girder end details, overhangs
- Cover plates with dimensions

- Drip plate location [use CADD cell for detail]

10.4.13.7 Camber Diagram and Dead Load Deflection

Detailing simple spans with only a note is allowable.

- Exaggerated scales [horizontal & vertical]
- Draw dead load deflection down, camber up
- Centerline of bearing at abutments or piers
- Numbers of spaces and spacing between ordinates, dimensions between base and curve

10.4.13.8 Beam Splice Details

- Elevation and Plan Views
- All plates with sizes
- Bolt spacing
- Bolt & hole sizes
- Detail filler plates

10.4.13.9 Bearing Device Details

- Plan View
  - Centerline girders, centerline bearing, skew angle
  - Beam flange and exposed plate dimensions
  - Anchor bolt size & hole size in plates [typical hole size is 3/8" *(10 mm)* greater than the anchor bolt diameter]
  - Bearing stiffeners
  - Face of abutment or pier
  - A temperature setting table
  - Block out plate if required
- Section normal to beam at the centerline of bearing device
  - Label bearing pad, bolts, welds, and TFE and stainless steel surfaces
  - Dimension anchor bolt spacing, overall depth of bearing, thread projection, plate thickness
- Section along the centerline of the beam

Show welds, plate thickness [including both ends of any beveled plates], washers, blockout plates and overall depth

- Notes and list of design loads, both vertical and horizontal and pertinent notes

10.4.13.10 Beam Haunch and Shear Connector Detail

- Chamfer beam haunch 1" X 1" *(30 mm x 30 mm)*
- Shear connectors designed as per AASHTO.

10.4.13.11 Bridge Joint Details

Use Vermont joint for spans 90 feet *(27 m)* and over.

10.4.13.12 Approach Slab Details

See details in chapter 18 of this manual for assistance in detailing approach slabs.

10.4.13.13 Diaphragm Details

- Design according to AASHTO.
- Detail with a 25'-0" *(7500 mm)* maximum spacing for straight girders.

10.4.13.14 Prestressed Superstructure

- Plan view of all members
- Detail a specific typical section for the prestressed member indicating:
  - A section showing a strand pattern
  - Location of the strand pattern on the span.
  - Geometric dimensions of the section.
  - Position and spacing of the deformed concrete reinforcement, including size and clearance of bars.
- Elevation view of member indicating:
  - Geometric dimensions
  - Position of the eccentricity of the strands at the ends of the member, points of tie down, or other locations of change.
- The following information shall be tabulated or noted:
  - The fabricator may submit alternate members [variation in the Section geometrics] for approval provided the overall depth and width of the typical section are no greater than that detailed.
  - Minimum concrete strength f'_c.
  - Concrete stress at transfer f'_{ci}.
  - Approximate weight of each unit.
  - Maximum live load plus impact moment and live load reaction.
  - Maximum superimposed dead load moment and dead load moment reactions and dead load and SDL.
  - Size and grade of prestressing strand used in the design.
  - Number of prestressing strands used in the design.
  - Initial prestressing force.
  - Final prestressing force.
  - Provide weep holes in bottom of all voids.
  - See standard cells for longitudinal joint connection details.

- Use minimum of 5” *(130 mm)* structural overlay with either a bare deck or with membrane and paving.
- Method of transverse tensioning

■ Plan view of overlay reinforcing

■ Appropriate end detail

10.4.14 CADD Cell Superstructure Details

Various typical superstructure details are available on CADD. Use these cells when appropriate.

10.4.15 Substructure Details

10.4.15.1 Detail Order

■ Abutments
■ Wing walls
■ Piers

10.4.15.2 Details

■ Plan views with dimensions
■ Centerline girders or beams with skews and dimensions
■ Beginning/End Bridge or centerline bearing with station & finish grades
■ Footing reinforcing plans
■ Pile plans [denote battered piles] and size, spacing, and batter
■ Elevation views
■ Reinforcing Steel
■ Weep holes
■ Elevations—beam seats, construction joint, ends of wingwalls, footings
■ Typical Sections
■ Reinforcing bars with splice lengths
■ Approximate ledge, if applicable
■ Corner detail
■ Appropriate notes

10.4.16 Other Sheets or Details

■ Curb and rail
■ Bridge railing detail sheets
■ Sign and striping details
■ Sign summary sheets
■ Drainage and Drainage layouts
■ Mailbox details

10.4.17 Reinforcing Steel Schedule

■ Avoid detailing bar lengths greater than 40’-0” *(12 000 mm)* where practical.

- Denote epoxy coated bars with the Prefix E.
- List bar groups by structural components such as superstructures, abutments, wingwall, pier, approach slabs, etc.

10.4.17.1 List Bars

List bars within a group as follows:

- Straight bars
  - #5 *(16)* bars
  - #6 *(19)* bars
  - etc.
- Bent bars
  - #5 *(16)* bars
  - #6 *(19)* bars
  - etc.

10.4.17.2 Bar Nomenclature:

- Example 1EA1105
  - 1EA denotes an epoxy coated bar for abutment 1
  - 11 denotes bar size [i.e., #11 bar.]
  - 05 denotes bar identification number [i.e., the fifth #11 bar.]
- Other Units:
  - S—deck or slab
  - AS—approach slab
  - P—pier
  - W—wingwall
  - B—barrel in R.C. box

10.4.17.3 Test Bars

- Provide extra bars for testing. Provide at least four test bar segments for every 100,000 pounds *(45 000 kg)* of each coated and uncoated bar size for each structural unit [i.e., abutments, piers, decks and approach slabs]. Each extra bar may provide a maximum of two test segments. The segments must be straight and at least 30" *(770 mm)* long.
- If there are more than 100,000 pounds *(45 000 kg)* of reinforcing required in any one size, provide additional two test bars for testing in that size.
- Avoid indicating two test bars in a line on schedule if possible. Distribute test bars evenly to get a better test sampling.
- Test bars shall be designated as one additional bar added to the number required for a detailed bar on the reinforcing bar schedule.
- The actual bar used for testing should be randomly selected from those supplied under the detail bar mark.

10.4.18 Roadway Cross Sections

10.4.19 Channel Cross Sections

10.5 SUBMITTAL PROCESS FOR FINAL PLANS

Prior to making a Final Plan submittal, an estimate must be run using Estimator Software. Electronically send a copy of the Estimator estimate along with a BAMS cover sheet to Contract Administration. Notify Contracts that the files have been sent. Contract Administration will produce a BAMS estimate using the Estimator and send copies of the BAMS output to Structures. Subsequent submittals will include BAMS estimates. The Estimator information, after the initial BAMS run has been made, is for internal Structures Section use only.

Prior to making the final plan submittal, send the finished plans and a copy of the up to date BAMS estimate to Contract Administration, along with a memo asking them to prepare the special provisions. They will prepare the special provisions and send a copy to Structures. After the special provisions have been recieved, the final plan submittal can be made.

Submit Final plans using the process shown in Figure 10-2

Figure 10-2 Final Plan Submittal

NFF	FF	Form number or type	Description	Date designer sent	Date reply recieved
✔	✔	13✦	District - one set with a detailed estimate, and a copy of the special provisions.		
✔	✔	13✦ and 14	Construction - one set with a detailed estimate, and a copy of the special provisions. (omit this submittal on a force account project). Include Form 14 to get information on field offices.		
✔	✔	13✦	Materials & Research - one set, and a copy of the special provisions.		
✔	✔	13✦	Property Administration - memo only, with a copy of the special provisions.		
✔	✔	13✦	Hydraulics - one set.		
✔	✔	13✦	Utilities - if project includes Water and Sewer or other underground items - one set, with a copy of the special provisions. If project only includes overhead utilities - Title Sheet, all layout sheets, and the special provisions.		
✔	✔	13✦	Environmental Services - a copy of memo, and a copy of the special provisions.		
✔	✔	13✦	Traffic Design - one set of plans, and a copy of the special provisions.		
✔	✔	13✦	Construction, Paving Engineer - copy of the memo only, along with a copy of the special provisions.		
✔	✔	13✦	Director of Maintenence - Memo and a copy of the special provisions.		
✔	✔	v_town❖	Town - plans.		
✔	✔	✍✦	FHWA - plans, special provisions, and estimate of the total construction costs, when appropriate, by special letter.		
✔	✔	✍✦	Rail and Air - contact Rail and Air unit to check on status of agreement and to determine if plans need to be submitted.		
	✔	15✦	Design - Plans, a detailed estimate, and a copy of the special provisions.(design led projects only)		

✦ This submittal requires a Project Sign-off Sheet. Use form called "signoff".

❖ This is the name of the form

✍ This submittal requires a letter to be drafted.

NFF = Non-Federally Funded

FF = Federally Funded

Chapter Eleven

Contract Plans

11.1 PREPARATION FOR CONTRACT PLANS

After the review period for final plans expires, contact those parties that have not responded to determine the status of all comments.

11.1.1 Contract Plan Flow Chart

Figure 11-1 shows the flow of work that must be done for Contract plans.

11.1.2 Review of Comments

Address all final plan comments and communicate any significant issues to the Project Manager. The plans and estimate shall be corrected to the full satisfaction of the designer and Project Manager. Also, review the special provisions and forward with comments to Contract Administration.

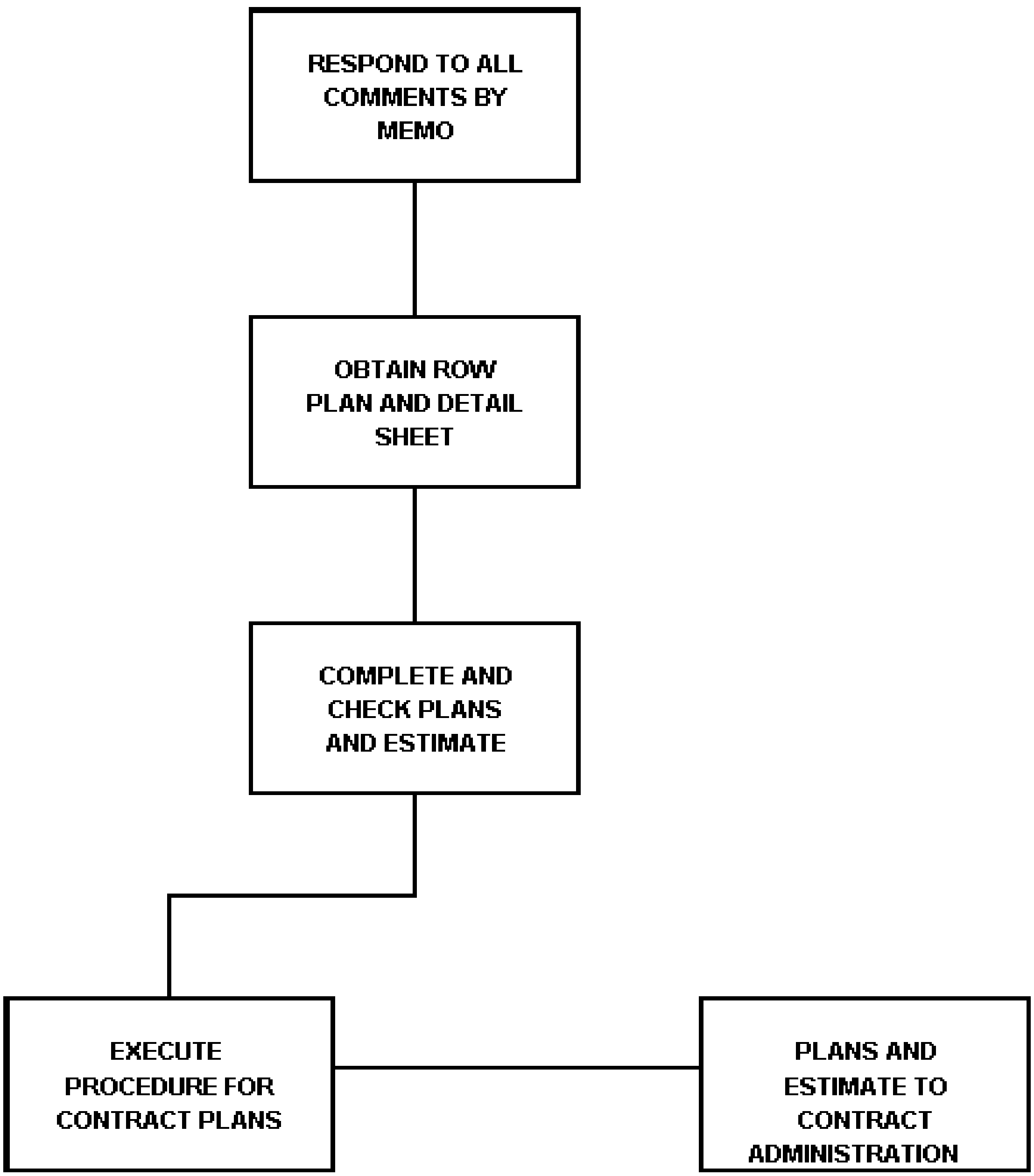
11.2 SUBMITTAL PROCEDURE

The procedure for contract plan submittal shall follow this order:

- When the plans are completed, create a print request text file listing all CADD sheets, scanned sheets and standards. Always submit a title sheet as a scanned sheet. [This will expedite the title sheet signing procedure at a later date].
- If there have been item or quantity changes since Final Plan submittal, mark up a copy of the BAMS estimate and submit it to Contract Administration. They will rerun the BAMS estimates with the latest information, and provide Structures with copies of this estimate.

Figure 11-1

Contract Plans Development Flow Chart



- Fill out a work request transmittal form, selecting “other” for type of plans and request one half size set of plans. Under “Special Instructions” make it known that this is a request for a review set of plans in preparation for Contract Plan submittal.
- Bring any sheets that will need to be scanned, along with a hard copy of the print request text file and the work request transmittal form to Reprographics. They will produce a set of half size plans for the designer’s review. The scanned sheets become the property of Reprographics and are kept in that office’s files.
- Review the half-size set of plans from Reprographics. Make any changes needed, and re-submit if necessary.
- Notify Reprographics in person that the files are now locked and request a half size set of plans for submittal to Contract Administration.
- Obtain Structures Program Manager signature on the CA52 form and the Director of Project Development’s signature on the CA52 form and on the Title sheet.
- Provide Contract Administration with the following:
  - Contract plan submittal memo
  - One half size set of plans
  - Signed CA52 form
  - A copy of the project page from the capital program report
  - Work request transmittal form [with only project name and number, EA number, and text file path name lines filled out]
  - A copy of the print request text file
  - Two copies of the BAMS estimate
  - Signed Title sheet
- Contract Administration will review the plans. If any changes are necessary, they will notify Automated Services to unlock the CADD files and the Project Manager will be notified to make the changes via a memo. Any changes to scanned sheets will be made after Contract Administration returns the originals to the Structures Section. The Project Manager returns the corrected originals to Contracts, who will then send them to Reprographics for scanning.
- Notify Contract Administration that the files are complete. They will then review and approve changes and authorize plan production.

11.3 CONTRACT PLAN STEP ACTIVITIES

Refer to Figure 11-2 for the required activities during the Contract Plan stage. Use this figure with Sections 11.2 and 11.4.

11.4 RESPONSIBILITIES OF THE STRUCTURE DIVISION

- The Project Manager shall process form CA 52 and obtain a copy of the page from the Capitol Program for which the subject project is funded. This requires signatures of the Structures Program Manager and the Director of Project Development.

- One half size set of plans and the special provisions shall be available to the design squad.

- The designer is required to complete a bid analysis detailing reasons for any significant differences between the estimate and the bid prices.

11.5 CONTRACT PLANS

The plan sheets shall follow the order shown below.

- Title Sheet
- Preliminary Information Sheet
- Bridge and Roadway Quantity Sheet
- Right-of-way Sheets
- Tie Sheet
- Plan Sheet
- Profile Sheet
- Traffic Control Sheet
- Boring Sheets
- Plan and Elevation
- Erosion Control Sheet
- General Notes
- Superstructure Details
- CADD Cell Superstructure Details
- Substructure Details
- Other Special Detail Sheets
- Reinforcing Steel Schedule
- Roadway Cross Sections
- Channel Cross Sections
- Reference Drawings
- Standards

Figure 11-2 Contract Plan Submittal

NFF	FF	Form number or type	Description	Date designer sent	Date reply recieved
✔	✔	print-request submittal	Request 1/2 size set of plans from Reprographics. This should be done through rp_iparm. The plans should be considered complete before continuing. See Section 11.2.		
		CA52❖ plus others	Once plans are complete and ready for Contract Administration, see contract plan submital process contained in Section 11.2.		
✔	✔	16(S/T)	Contract Administration - only if the project will not extend beyond the Right of Way. Send appropriate form for State(S) or Town (T).		
✔	✔	17	Director of Project Development - To request signature on Title Sheet. See section 11.2.		
✔	✔	18	Contract Administration - once Title sheet is signed.		
The following activities follow the bid advertisement.					
✔	✔	bid data sheet	Structures will attend the bid letting of the project. This person will record the awarded bid prices for later review.		
✔	✔	19	Upon reception of the bid results from Contract Administration, the project designer will analyze the results. Any Price difference between the estimated item and its corresponding bid price which exceeds 1% of the total bid price shall be studied and justified.		
		20	In-House - Square meter (Square Foot) cost survey. Use form (a) for conventional bridges and (b) for buried structures.		

❖ This is the name of the form

NFF = Non-Federally Funded

FF = Federally Funded

Chapter Twelve
Construction

12.1 PREPARATION FOR PRE-CONSTRUCTION MEETING

Construction Section will notify the Structures Section of the time and place for the pre-construction conference. The Project Manager or representative shall attend the conference. The following is a check list for Pre-Construction Meeting.

- Bring ½ size contract plans to meeting.
- Get Contractor's name.
- Get names of fabricators for structural steel, bearing devices, scuppers and down spouts, bridge railing, prestressed units, bridge joints. Remind contractors to get the shop drawings to us. Remind contractors of four week review time for first submittal, and that the work needs to be done in an approved shop.
- Get bridge contractors' name if other than the prime contractor.
- Get Resident's name and telephone number, and get Regional Engineer's name.
- Clear up any special details on plans and Special Provisions.
- Deliver beam profiles to Resident. If the profiles need more work, notify the Resident when profiles will be available.
- Caution contractors against any welding on structural steel and steel piling without approved details and procedures.
- Remind contractors to send in any temporary bridge details to the Resident for review prior to doing the work. Details must be signed by a P.E.

12.2 BEAM PROFILES

Computer generated [Program H211 or H212] beam profiles with elevations at 5 foot *(1500 mm)* intervals shall be provided to the Resident Engineer for use in determining concrete haunch depths.

- Structures that are partly on a tangent and partly on a curve, and structures that have banking transitions on them, will require special procedures to obtain beam profiles. Often several computer runs must be made, and only a part of each run is good for a specific beam.
- Beam profile computer outputs should be hand checked at various locations to verify their accuracy

12.3 FABRICATION DRAWINGS

Shop drawings are prepared by the fabricator and submitted by the contractor to the Structures Section for review and approval. The shop shall not begin fabrication prior to receiving an approved set of shop drawings and approval letters. The Project Manager shall use form "*fabltr.xxx*" when submitting an approval. This letter shall be printed on the Agency's letterhead.

12.3.1 Fabrication Drawings to be Checked

The Structures Section reviews and approves the following shop plans or drawings:

- Structural Steel†
- Prestressed Concrete Members†
- Metal, Timber, or Concrete Bin Retaining Walls†
- Temporary Bridge Details—Review by Structures Section [Review of approach details and overall approval by the Construction Section.]
- Bearing Device Assemblies†
- Expansion Devices†
- Steel Grid Flooring†
- Bridge Railing†
- Superstructure Shoring
- Field Welding Procedures†
- Shoring for Concrete Slab—Construction Engineer may request Structure Section Review
- Stay-in-Place Forms†
- Other, upon request of the Construction Section.

†Denotes shop plans or drawings that require formal approval by the Structures Section. Structures will only review the other details.

12.3.2 Extent of Review

- Shop drawings shall be checked primarily for conformance with geometrics and details given on the project plans.

- Materials specified shall be checked for conformance with specifications.
- Details and dimensions furnished by the fabricator should be "spot" checked for accuracy.
- End of girder and bearing stiffeners shall be vertical in the final erected position after all dead loads are placed on the girder.
- Welding procedures shall be checked by the shop inspector supervisor and approved prior to fabrication.
- For precast concrete, a copy of the fabricator's working drawings and concrete mix design shall be sent to the Concrete Engineer for review and comment. Materials Section is responsible for inspection of fabricators' work.

12.3.3 Responsibility

The approval by the Structures Section of shop drawings submitted by the fabricator does not relieve the fabricator of responsibility for final fit up of the structural components at the time of final assembly.

12.3.4 Extended Weights

- After fabrication is completed, the fabricator shall submit shop drawings with the weights of the structural components shown on the sheets along with a cover letter that summarizes the weights by sheet.
- Extended weights shall be checked in conformance with the method of measurement section 506 of the Vermont Standard Specifications for Construction.
- The weight of weld metal, shop bolts, and field bolts shall not be included in the extended weights, and shall be considered subsidiary to the work.
- Send a form letter to the Construction Section indicating final approval pay weight.

12.3.5 Bearing Device Shop Drawings

- Bearing device shop drawings shall be checked according to Section 531.03.
- In addition, shop drawings for components of bearing devices shall not be approved, unless all components of the device are to be from the same manufacturer or the prime fabrication company shall submit a letter assuming full responsibility for the bearing device when components are supplied by more than one manufacturer.

12.3.6 Bridge Railing Shop Drawings

- Bridge railing shop drawings shall be checked according to Section 525.03.
- The material selection shall be according to plans and specifications.
- Fit-up is the responsibility of the contractor.

Part III

Design

The main objectives of this section of the Structures Section Manual are:

- Make Structures Section personnel aware of the areas in which current section design policy or procedure deviates from AASHTO Design Specifications.
- Promote an increased uniformity of design and detail between design units in the section.
- Provide guidelines enabling consultants working for the Agency to develop plans consistent with Agency policy.

Chapter Thirteen

General Design and Details

13.1 GEOMETRIC CONSIDERATIONS

13.1.1 General

Geometrics of Design, including roadway widths, horizontal and vertical clearances, shall be according to the latest edition of The Vermont State Standards for the Design of Transportation Construction, Reconstruction and Rehabilitation on Freeways, Roads and Streets. Reference should also be made to AASHTO "A Policy on Geometric Design of Highways and Streets" [AASHTO "Green Book"] for criteria not addressed in the Vermont State Standards. The Structures Section allows minor deviations with sufficient justification and with design exceptions.

Navigational clearances for crossings over navigable waterways shall be by permit obtained from the U.S. Coast Guard.

Railroad clearance requirements per American Railway Engineering Association [AREA] Guide or as required by individual railroad involved.

13.1.2 Horizontal Alignment

Make every effort to keep the structure entirely on or entirely off horizontal curves.

13.1.3 Vertical Alignment

Make every effort to keep the structure entirely on or entirely off vertical curves. In addition, avoid placing a structure on a sag vertical curve. When this is necessary, the curve low point should be off the structure. Avoid grades of less than 1.0% if possible.

13.1.4 Cross-slopes

13.1.4.1 General Criteria

Follow these general guidelines:

- Any banking transition used on the structure must be a straight line to avoid discontinuities in the deck cross-slope. Avoid banking reversals where possible.

- On paved roads, follow the AASHTO “Green Book” banking tables, using e maximum equal to 8.0% . In urban areas, reduced or no banking may be used at the designer’s discretion.
- On gravel highways, use e_{max} = 4.0% Banking Table.
- Whether a gravel road is in a normal crown or banked, the slope used shall continue at a straight line between the centerline and the face of rail. The result will be no break at the theoretical edge of traveled way.
- Design bridge decks on a straight cross-slope, with no parabolic curve. This applies to all designs, whether on gravel or paved roads.
- For shoulders wider than 3 feet *(1.0 m),* the shoulder shall be broken with its own slope of 4.0%. This applies to the shoulder width on normal sections and if none of the structure is in transition.

13.1.4.2 Variables in Design

The designer can combine many variables to provide an acceptable design, without the need for design exceptions. As an example, consider the stop condition whenever a project is close to an intersection. Use stopping sight distance to determine the design speed range and the area of braking for the stop condition. This can positively affect the design speed.

13.1.4.3 Conditions for Elimination of Superelevation

Under certain conditions, the designer may eliminate the superelevation on designs of 30 mph *(50 km/h)* or less. Some conditions that might warrant this are as follows:

- Proximity to an intersection
- Banking amounts on existing curves on either end of the project
- Intersections of another town highway keying into the project, within the project limits

13.1.5 Maximum Grades

Refer to the Vermont State Standards, Tables 3.6, 4.5, 5.6, or 6.6, Maximum Grades, as appropriate, when selecting criteria. If a segment of road within the limits of the available survey show a grade greater than the maximum for level terrain, the terrain is either considered rolling or mountainous. The use of a lower design speed is likely in rolling or mountainous terrain, according to these tables.

13.1.6 Vertical Clearances

13.1.6.1 National Highway System [NHS]

All bridges over the National Highway System shall have a minimum vertical clearance of 16’-3” *(5000 mm).* Minimum vertical clearance on all other bridges shall be 14’-3” *(4350 mm).*

13.1.6.2 Railroads

All structures over railroads will preferably have a minimum vertical clearance of 23’-0” *(7010 mm),* or as otherwise stated in AREA Specifications. If a variance from this case is necessary, refer to 5 V.S.A. § 3670.

5 V.S.A. § 3670 (b): Subject to the approval of the transportation board, a variance from the standards established by this section may be established by written agreement of the agency of Transportation, all involved railroad companies and any effected municipality.

13.1.6.3 Waterways

Vertical clearances over waterways will be based on hydraulics, geometric and navigational considerations as minimum considerations.

13.1.7 Horizontal Clearances

13.1.7.1 Clear Zones

Safety requirements dictate that the designer maintain a clear zone between the edge of traveled way and any obstructions. The designer shall use the Vermont State Standards, the AASHTO "Green Book" and AASHTO "Roadside Design Guide" where applicable when establishing the clear zone. The Designer may modify clear zone distances shown in Table 3.1 of the "Roadside Design Guide", based on accident history, existing conditions, economics, etc. If clear zone distances are modified, then the reasons should be recorded in the design folder.

Clear zone distances shall be shown on the layout sheets and typical section at the preliminary plan submittal. The minimum clear zone distance will be delineated on the layout by a line consisting of a repeating pattern of two dots and a dash and labeled with a "CZ" [i.e., _..CZ.._.._.._.._..CZ..]. The delineation of the clear zone should begin at "Begin Project" station and end at the "End Project" station. No clear zone delineation is shown behind bridge rail or in other words, the clear zone stops at the beginning of the bridge rail.

Where clear zone distance changes, it must be done by moving at 90 degrees to the centerline. Some reasons for changing the clear zone distance include guard rail, change of design speed, climbing lanes, sight distance. The clear zone behind guard rail will be the dynamic deflection distance, however the full clear zone distance should extend approximately 50' *(15 m)* along the guard rail from the terminal end.

13.1.7.2 Railroads

Horizontal clearances at highway structures over or adjacent to railroads will be according to AREA Guide and are subject to railroad approval.

13.1.7.3 Waterways

Horizontal clearance for a waterway will be based on Hydraulics considerations as a minimum.

13.1.8 Bridge Width

The width of all bridges without sidewalks, including grade separation structures, shall be the dimension between the faces of railing, and shall be in conformance with the manuals referenced above. Where there is a sidewalk, the width shall be the dimension to the face of curb.

- The only roads classified as local roads are those that do not show on the functional classification map. Those roads that are Town Highways, and show on the Functional Classification Map, are classified as something other than Local Roads, and should be designed using applicable classification.

- Selection of bridge width on local roads will be from Table 6.3 of the Vermont State Standards. For the collector the width should be based on Table 5.3. Any new bridge not meeting the minimum for the appropriate table, requires an approval for a design exception.
- On a local road with ADT of 50 or less, a design exception allowing a one lane bridge should be considered.
- Use the projected [future] ADT and DHV traffic information for width selection.
- Use sidewalks only where such walks exist on the approaches.
- When requesting traffic data, try to give the best possible estimate of the construction year. The design year will be 10 years beyond the estimated date for rehabilitation projects and 20 years beyond for new construction.

13.1.9 Approaches

It is important when dealing with bridge projects that approaches are kept to a minimum. The designer should not attempt to correct the existing roadway deficiencies that would exceed the limits of a normal bridge approach. Detail a transition from the bridge width to the existing roadway width. The maximum rate of width transition is 1:25.

13.2 DESIGN CRITERIA

The designer will gather a variety of information as described in 13.1 and summarize this information into a Design Criteria Sheet. The designer will use these criteria to determine the need for any exceptions.

13.2.1 Design Criteria Sheet

Use reasonable engineering judgement in the application of the Vermont State Standards and the AASHTO "Green Book" guidelines. Produce a design criteria sheet for each project, to be placed in the front of the design folder. On this design criteria sheet, list the following:

- Traffic data
- Design speed and the reason for its selection. Include the references to the appropriate tables in the Vermont State Standards and the "Green Book."
- Horizontal and vertical alignment criteria, using references to the Vermont State Standards and the "Green Book" as necessary.
- Determination of typical section values.
- Maximum banking with reference to the appropriate tables. Also include any notations as to conditions that have warranted elimination or modification of the banking.

13.2.2 Design Exception

Design exceptions will be necessary only in those situations where the design criteria do not fall within the range of possible values and combinations with the Vermont State Standards.

13.3 PAVEMENT DESIGN

13.3.1 Roadway Pavement Considerations

The following describes the different types of roadway pavement design conditions.

- On class 1 town highways, all pavement types shall be with the 75 blow mix for standard bituminous concrete pavement.
- Analyze Class 2 highway projects on a project by project basis. Generally, use the 50 blow mix where the 20 year ESAL's are less than 1 million and the 75 blow mix on projects with ESAL's of 1 million or more. Exceptions to this policy would include projects near an intersection or on a relatively steep grade, where the stiffer mix might be necessary.
- Class 3 town highway projects will normally use the 50 blow mix, except those few cases where the ESAL's exceed 1 million. Use the 75 blow mix in this case.

The above criteria assumes the designer uses the 50 blow mix only on projects requiring Type II, III, or IV mix. Do not specify in any case the Type I mix with the 50 blow Marshall.

Use the most recent flexible pavement design procedure or the low volume pavement design procedure from the VAOT Pavement Design Committee for the pavement and subbase design as appropriate. Refer to the 1993 AASHTO Guide for Design of Pavement Structures as an additional resource.

The use of the standard pavement design software [DARWIN] can help in pavement design.

13.3.2 Pavement Thickness on Bridge Decks

Pavement thicknesses shall be two lifts on all new bridge projects. The bottom lift is 1 $^1/_4$ " *(30 mm)* of Type IV mix and the top lift is 1 $^1/_2$ " *(40 mm)* of Type III mix. This is the standard treatment on all new bridges.

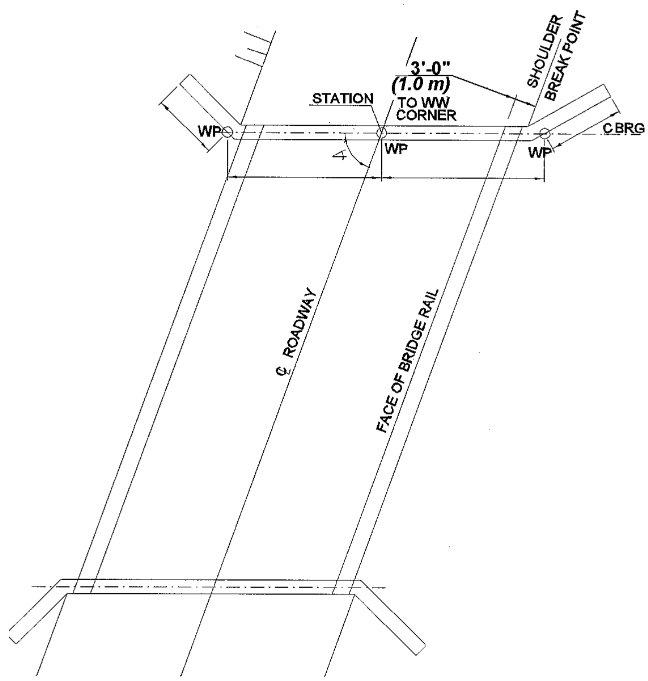
13.4 SUBSTRUCTURE LAYOUT PROCEDURES

13.4.1 Beam and Girder Structures

On beam and girder structures, lay out the abutments from the centerline of bearings. A working point shall be located at the centerline of the roadway and the centerline of bearings. An additional working point shall be located at the point where the centerline of bearing intersects the exposed face of each wing wall. Dimension the wing wall lengths from these right and left working points, to the end of the wingwalls. See Figure 13-1.

Figure 13-1

Beam or girder bridge



13.4.2 Concrete Structures

On cast-in-place concrete slab structures, precast concrete slab structures, large concrete boxes and concrete rigid frames, lay out the abutments or outside walls from the begin and end bridge points extended along the back face. A working point shall be located at the centerline of the roadway and begin and end bridge points. Working points shall be located left and right along the back of abutments and where this line meets the buried side of the wingwalls at the top of footing. Dimension the wing wall lengths from these right and left working points to the end of the wingwalls. See Figure 13-2 and 13-3.

13.4.3 Pipes, Small Boxes and Small Frames

On small concrete boxes and small concrete frames, lay out the corrugated plate arches, corrugated plate pipes and corrugated plate pipe arches from the centerline of structure at the centerline of the stream. A working point shall be located at the centerline of the roadway and the centerline of structure. Show the dimensions left and right from this working point to the ends of the structure. Dimension the ends of the wingwalls from the edge of the structure. See Figure 13-4.

Figure 13-2

Slab bridge, large box, or large rigid frame

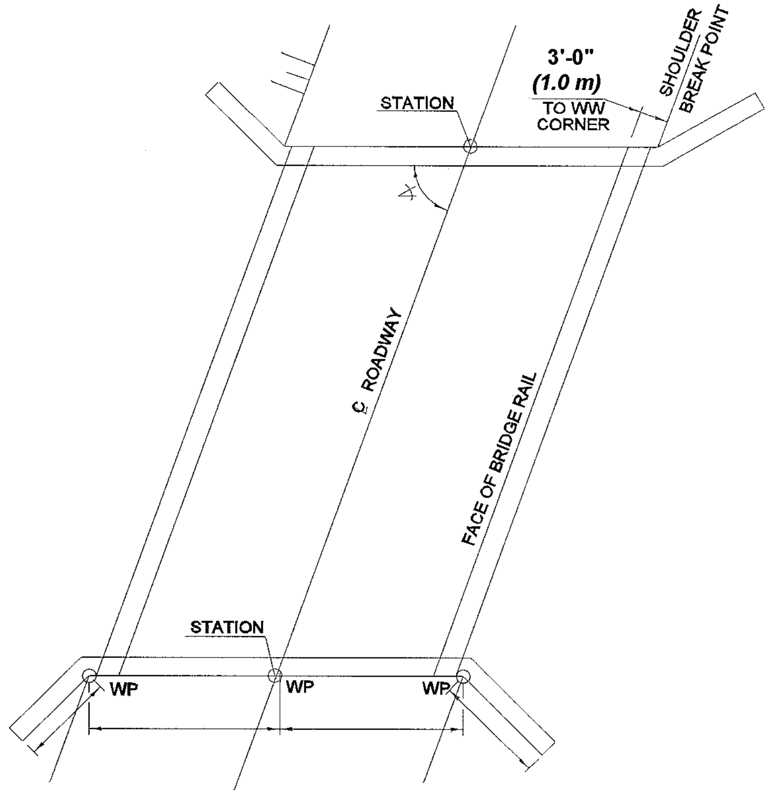


Figure 13-3

Two cell box or two cell frame

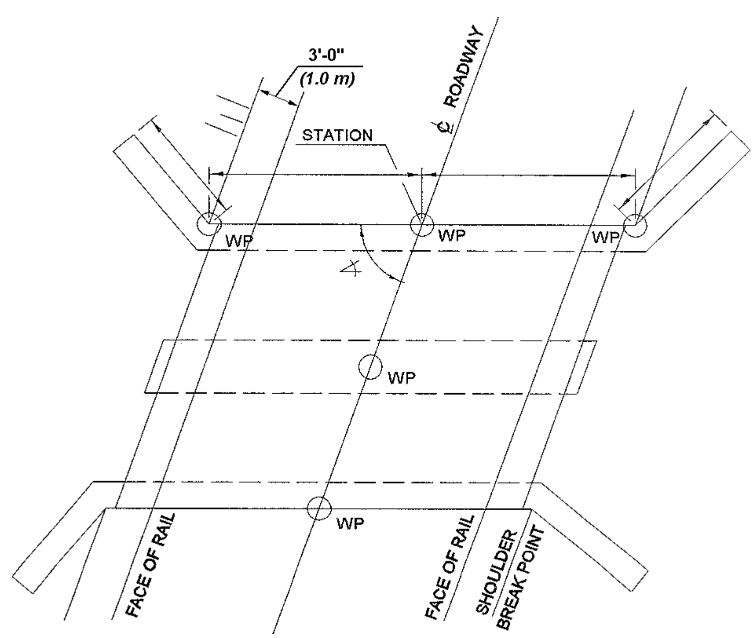
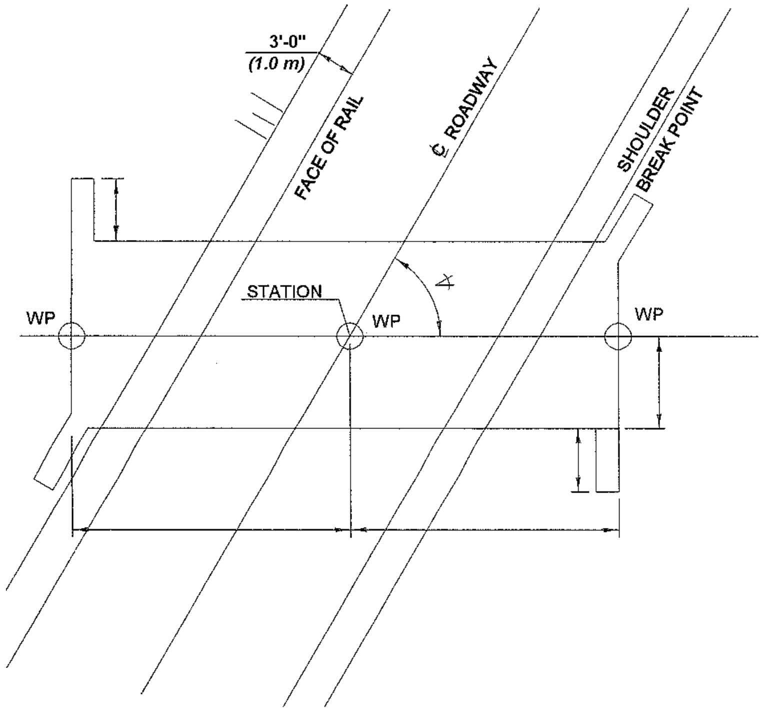


Figure 13-4

Pipe, small box or small frame



13.4.4 Skew and Askew Definition

13.4.4.1 Skew

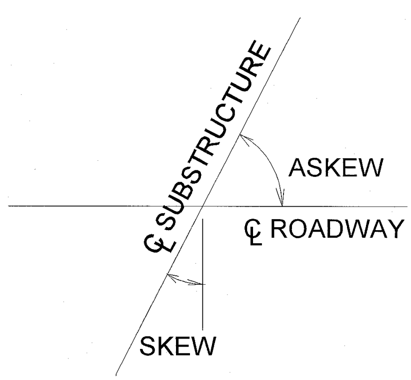
The angle between the center line of the substructure and a normal or radial line through the intersection point. See Figure 13-5.

13.4.4.2 Askew

The angle between the centerline of the substructure and the centerline of the roadway or tangent line through the intersection point. See Figure 13-5.

Figure 13-5

Skew and Askew definition



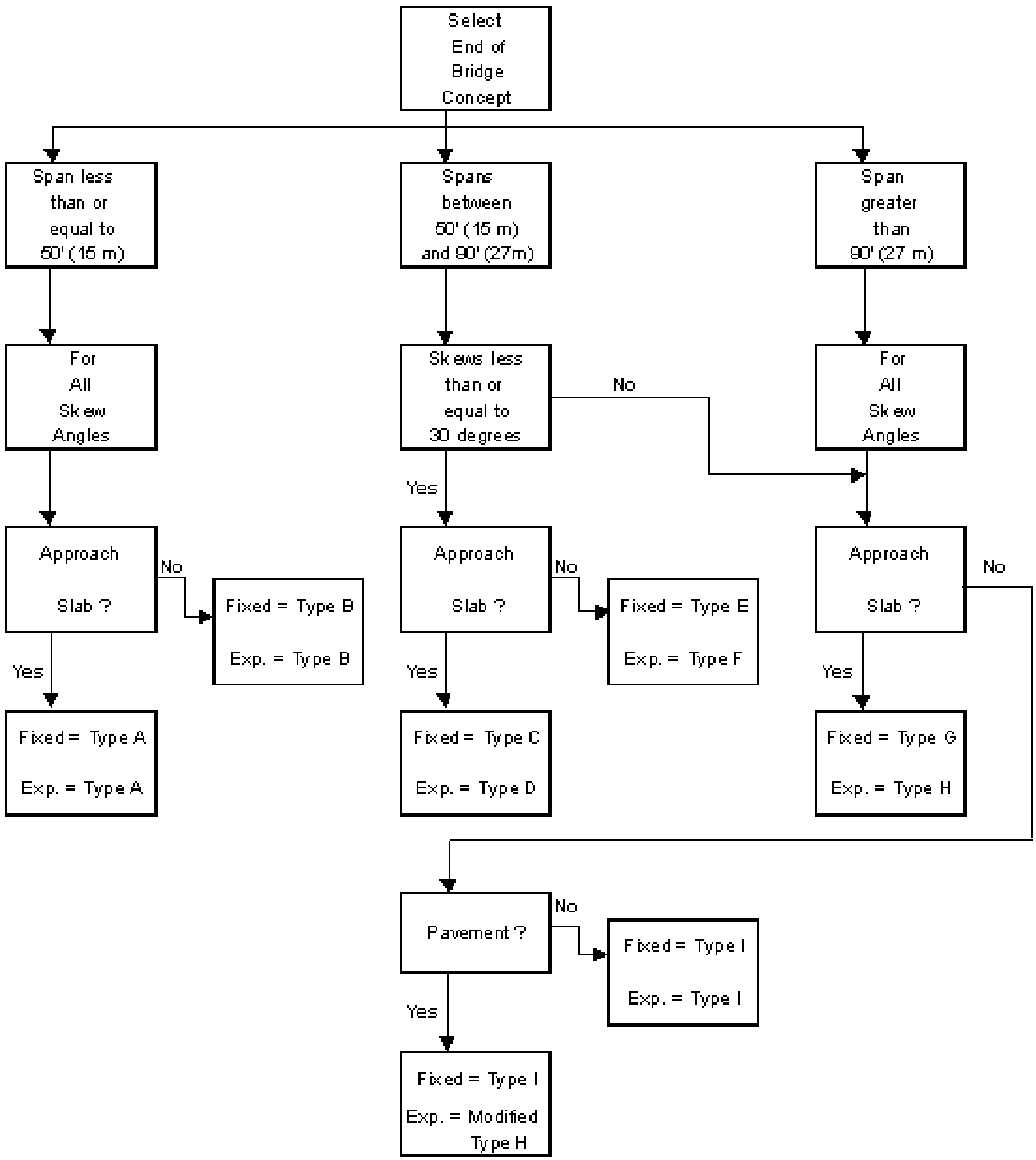
13.5 EXPANSION JOINTS

The use of expansion joints should be kept to an absolute minimum. The expansion joint type used shall be dependent on the length of span and total movement required. Do not use a joint in the pavement for spans of 50'-0" *(15.0 m)* or less. Refer to Figure 13-6 to assist in selecting the appropriate joint.

The use of Figure 13-6 will assist the designer in the proper selection of end of bridge details and expansion joints.

Figure 13-6

Flowchart used for selecting end of bridge details.



Refer to the next nine figures for use with this chart

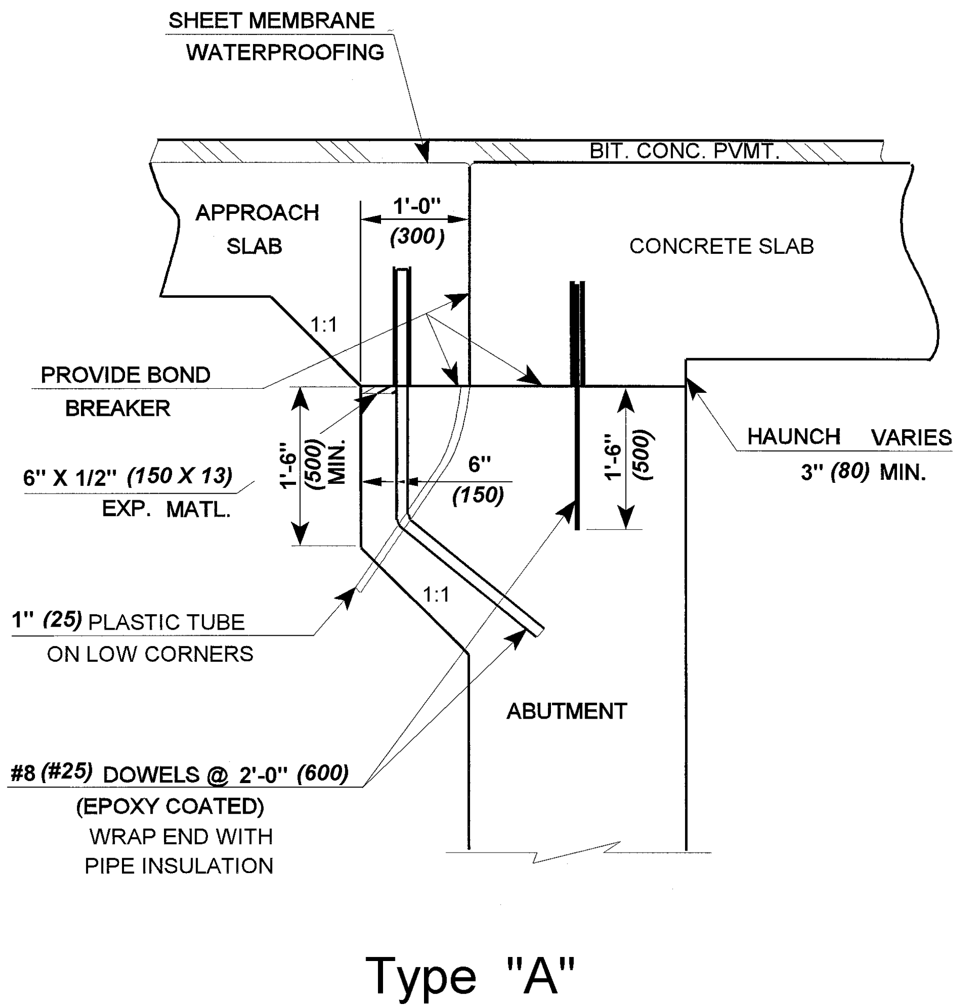


Figure 13-6 (a)

Type A fixed and expansion ends typical section normal to abutment.

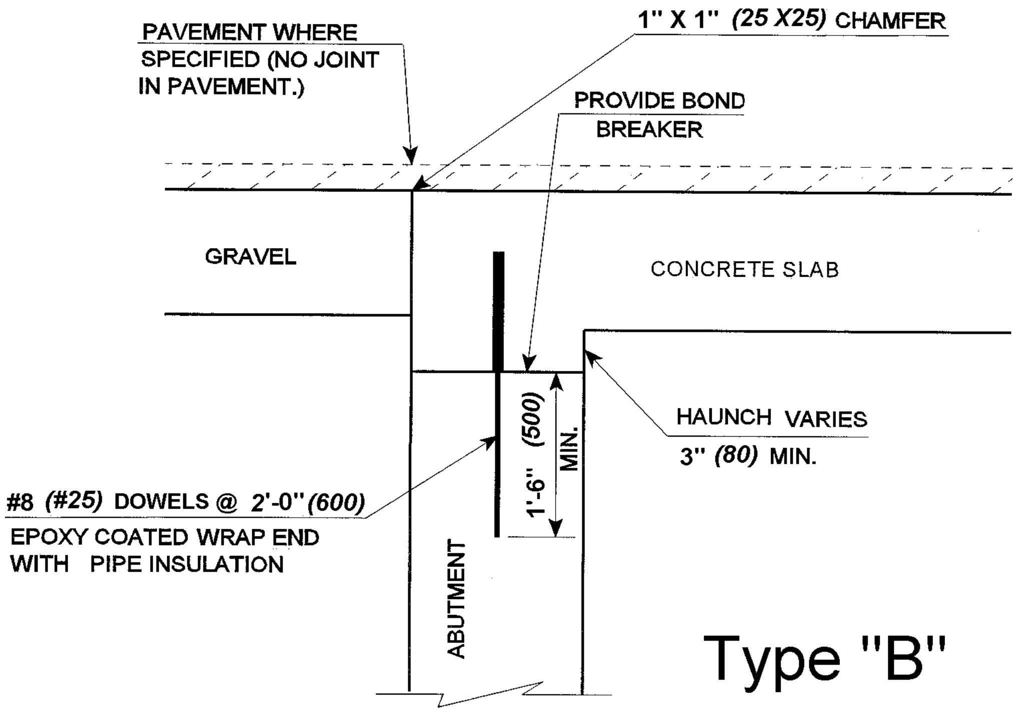


Figure 13-6 (b)

Type B fixed and expansion ends typical section normal to abutment.

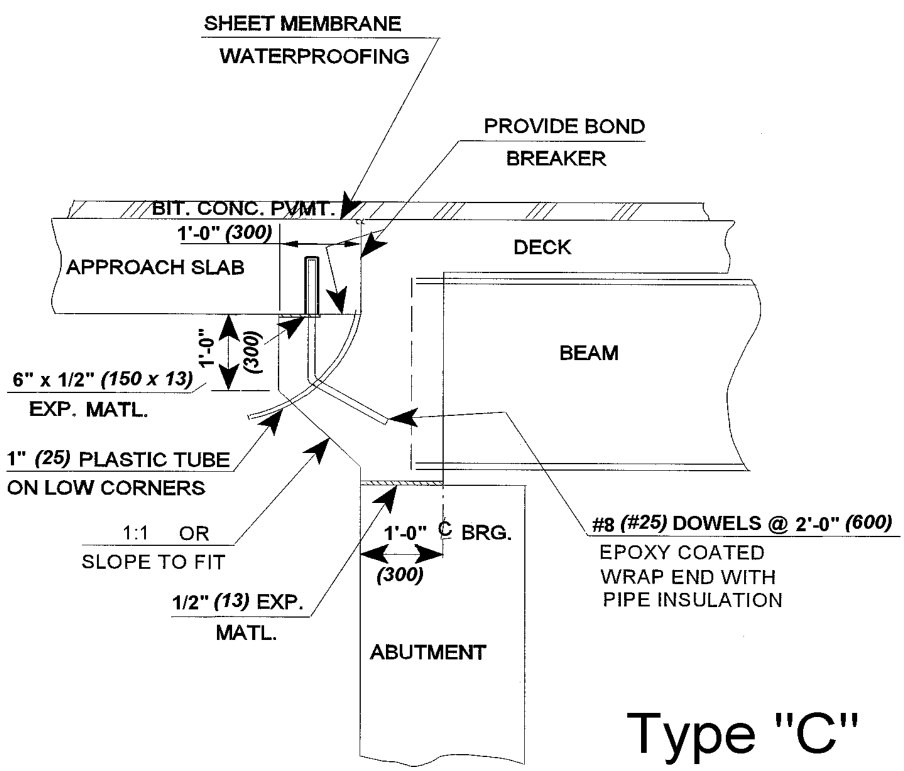
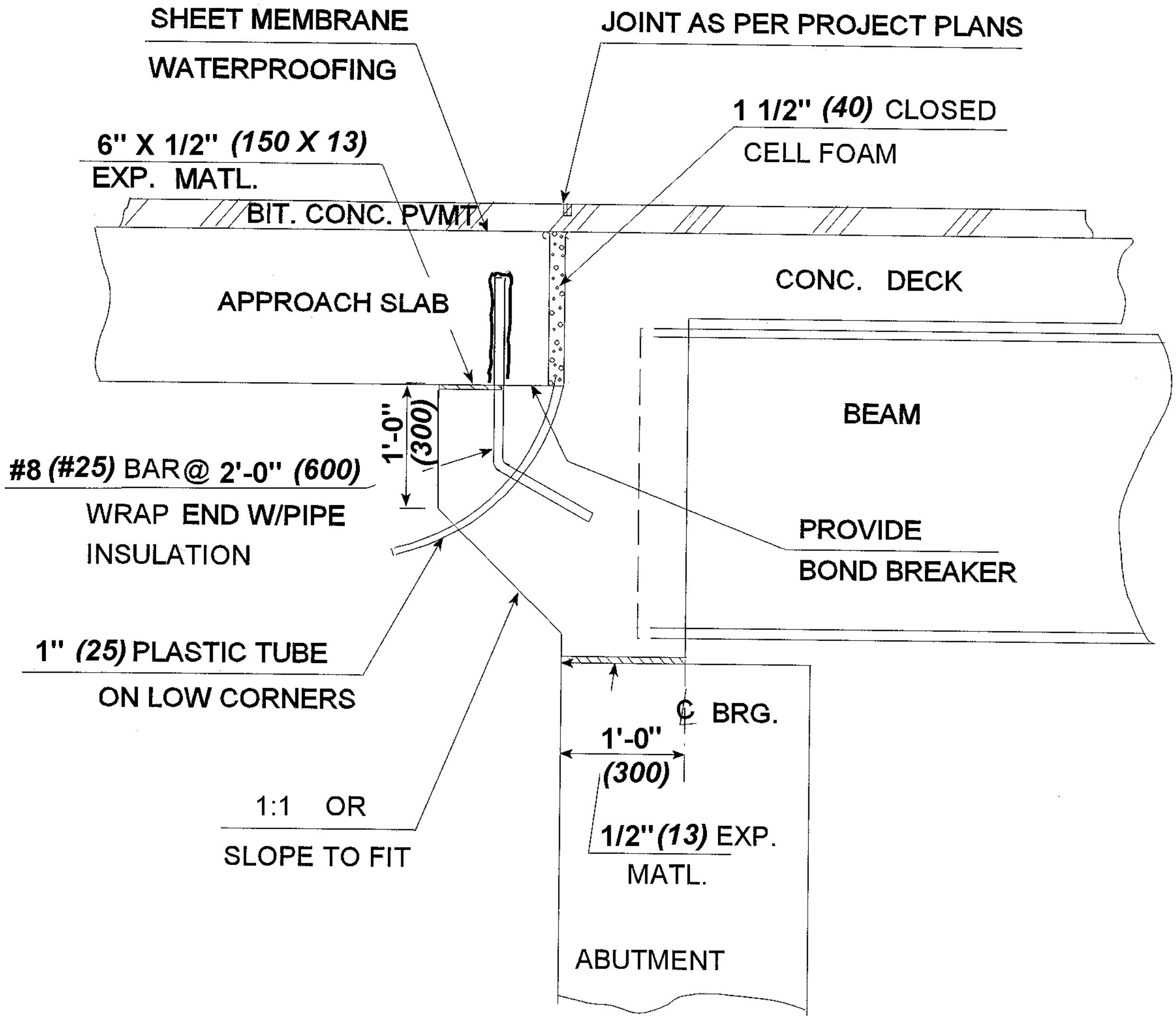


Figure 13-6 (c)

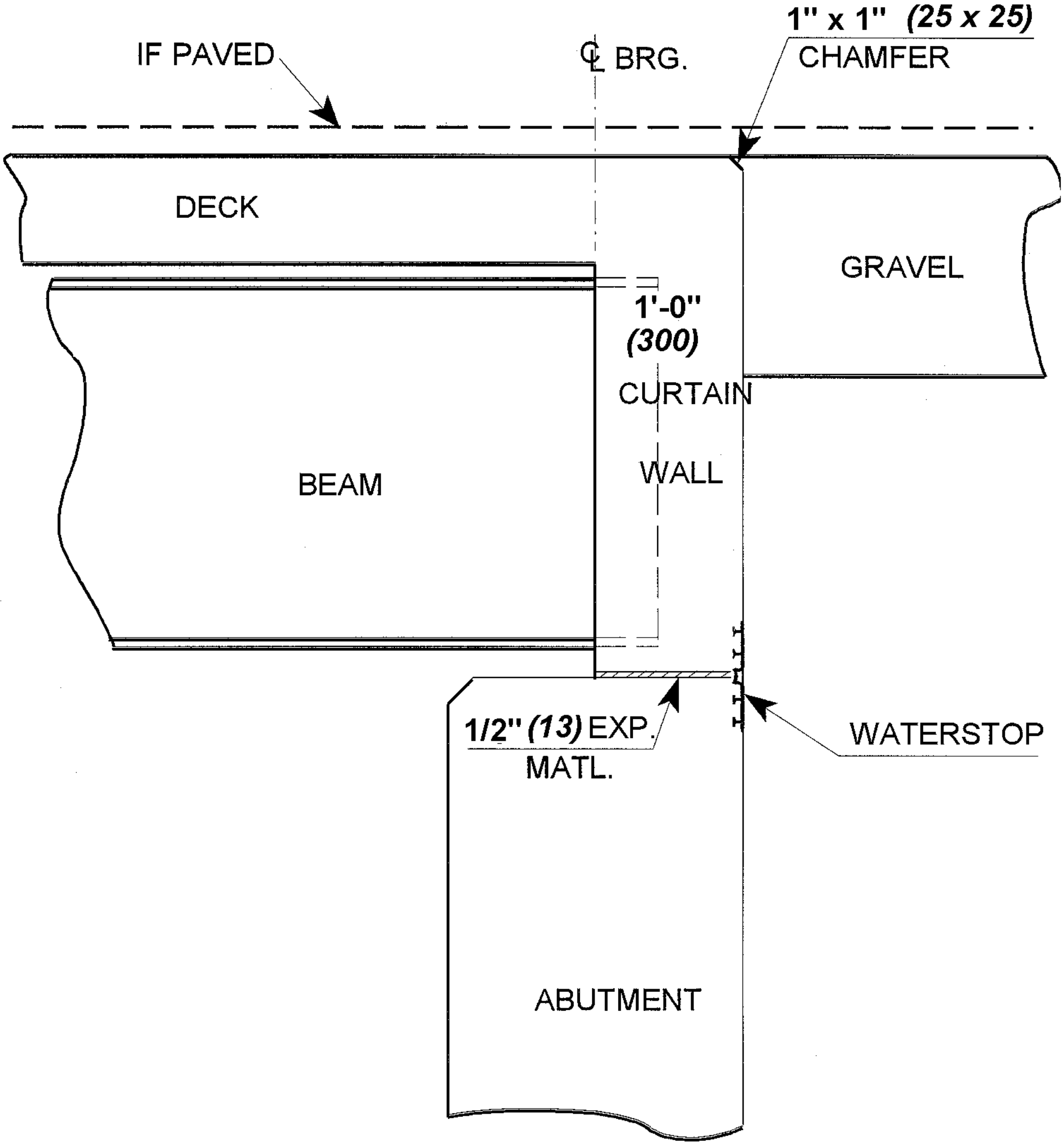
Type C fixed end typical section normal to abutment.



Type "D"

Figure 13-6 (d)

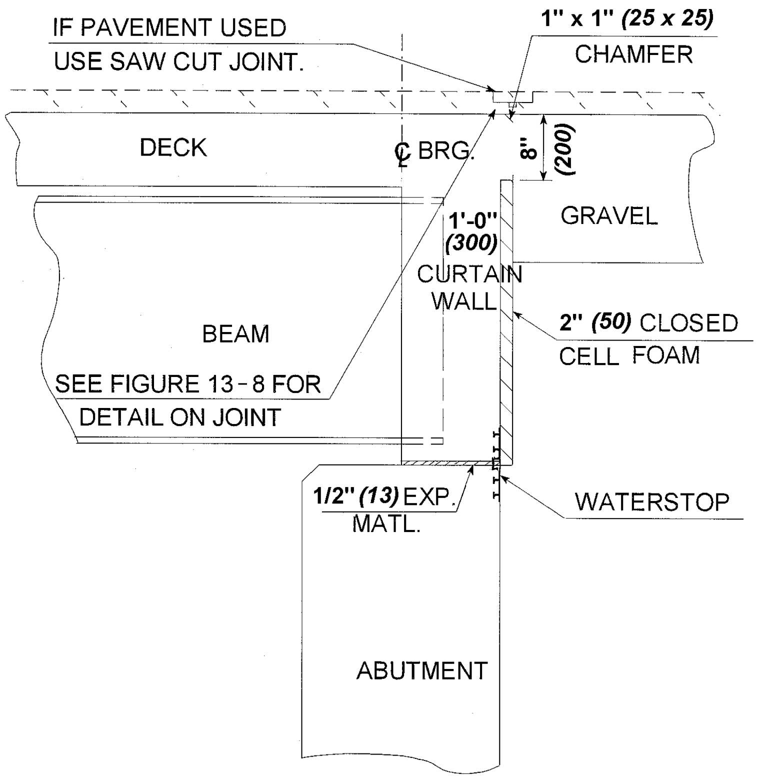
Type D expansion end typical section normal to abutment.



Type "E"

Figure 13-6 (e)

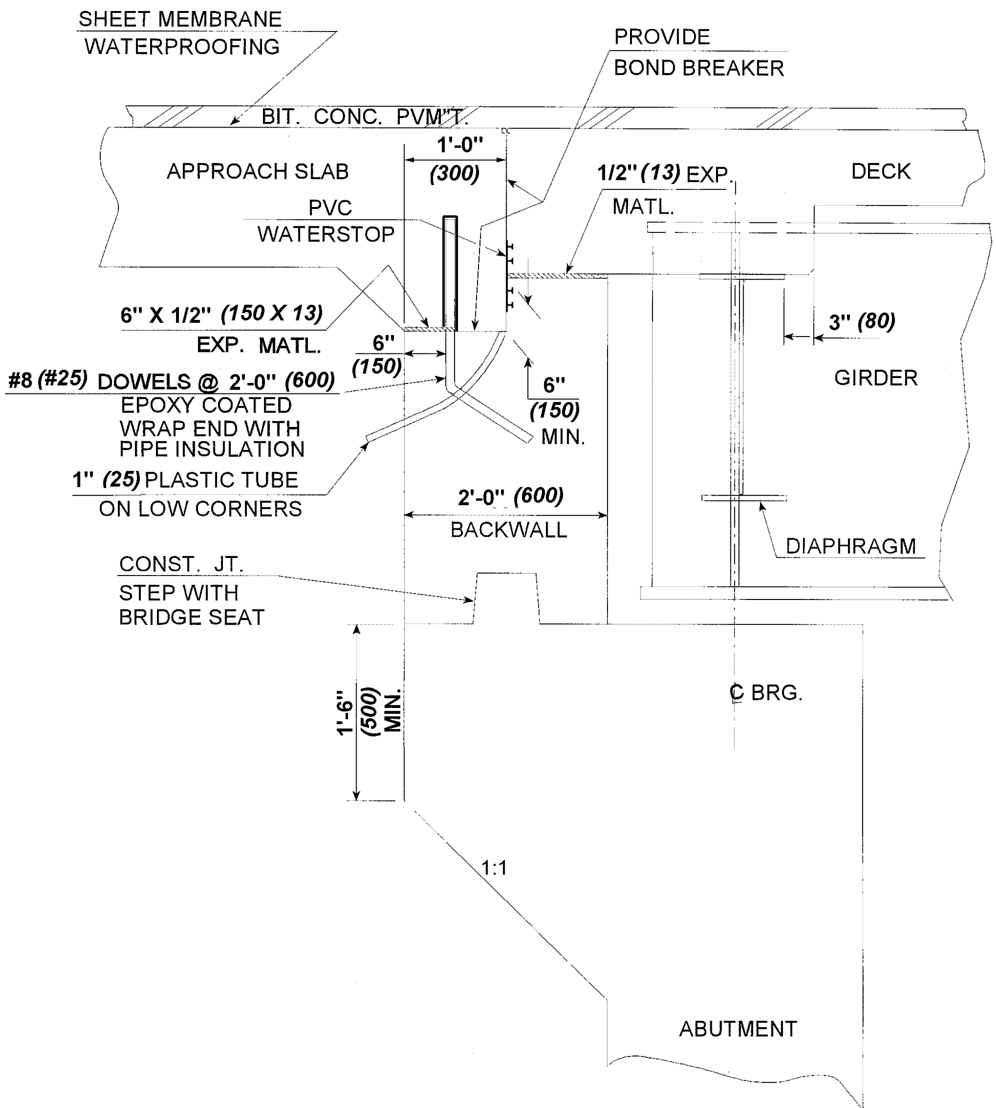
Type E fixed end, for gravel roads, typical section normal to abutment.



Type "F"

Figure 13-6 (f)

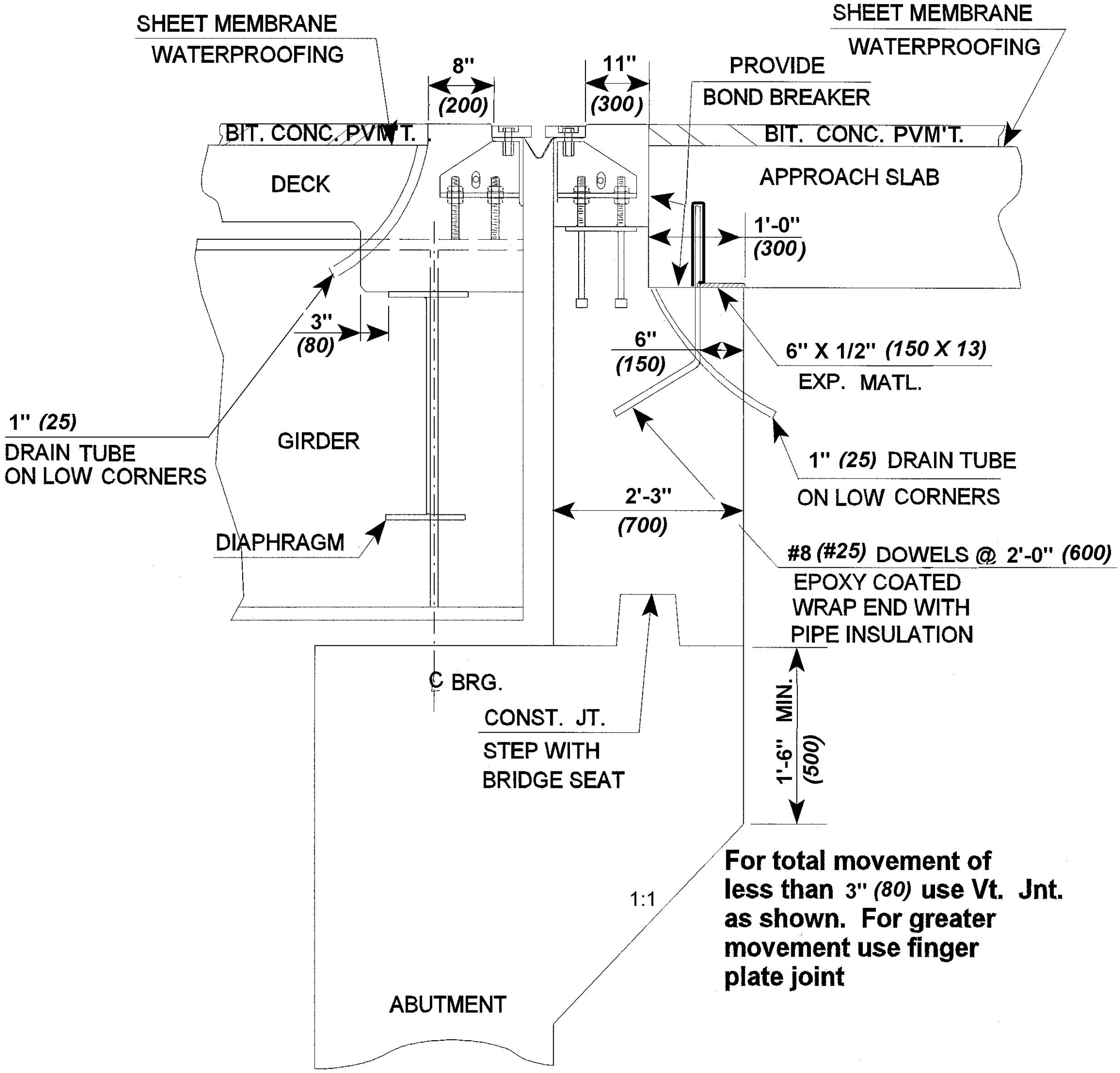
Type F expansion end, for gravel roads, typical section normal to abutment.



Type "G"

Figure 13-6 (g)

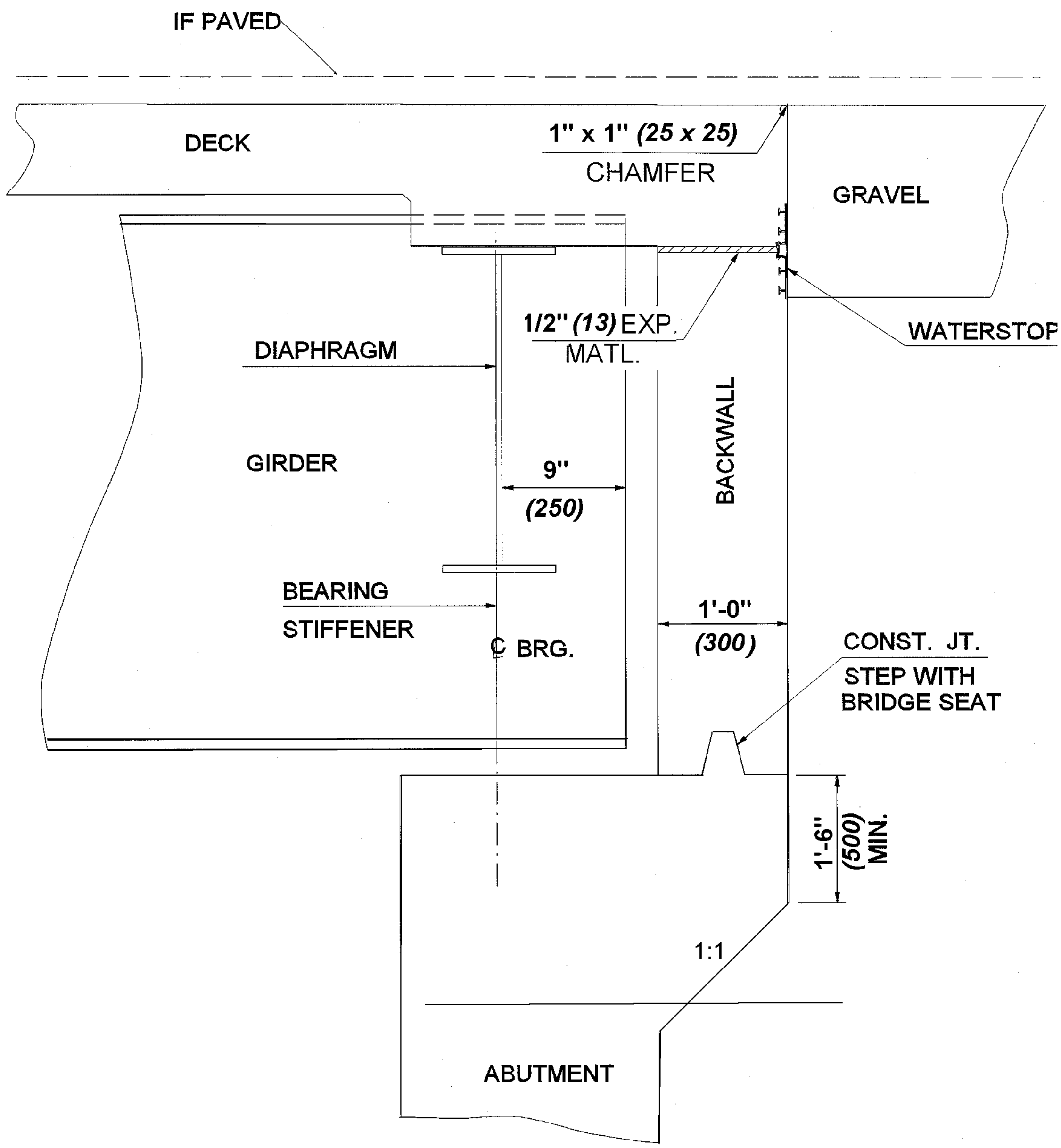
Type G fixed end typical section normal to abutment.



Type "H"

Figure 13-6 (h)

Type H expansion end typical section normal to abutment.



Type "I"

Figure 13-6 (i)

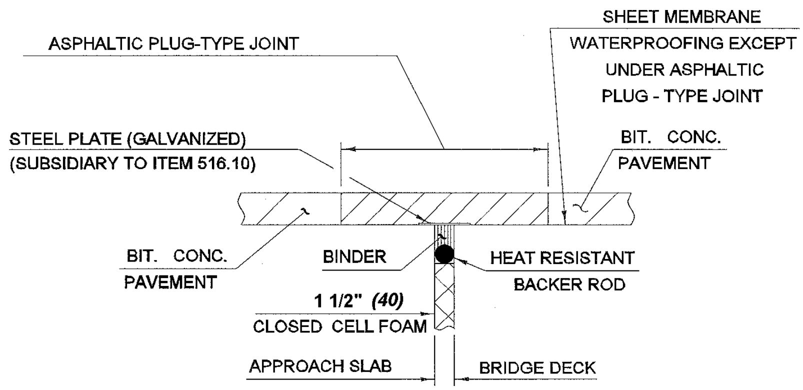
Type I fixed and expansion ends, for gravel roads, typical section normal to abutment.

13.5.1 Wide Band Joint

Wide band joints [see Figure 13-7] or plug joints are fairly new. The AOT has installed only a few to date. The joint is the thickness of the bituminous concrete pavement and is mainly joint sealer hot poured with binder aggregate in sealer to support vehicles.

Figure 13-7

Wide Band Pavement Joint Detail

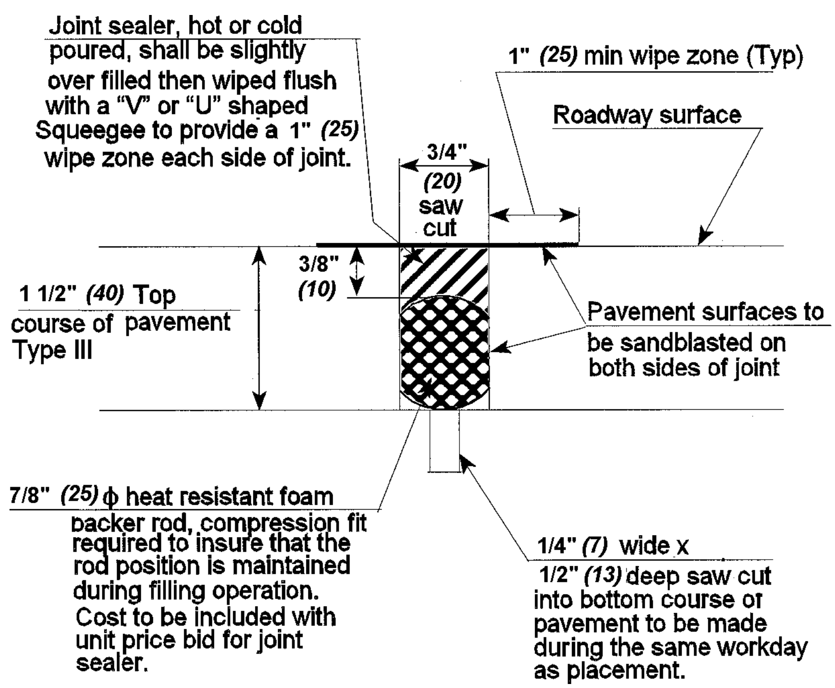


13.5.2 Saw Cut Joint

The Saw-Cut joint is commonly used in projects. Refer to Figure 13-8 for information regarding this type of joint.

Figure 13-8

Saw Cut Joint detail



13.6 BARE DECK

Use bare concrete decks for structures on gravel roads providing the structure will not be close to a paved road. The salting of the paved road would affect the bare deck structure.

13.7 GUARD RAIL

13.7.1 Bridge Rail

Bridge rail types and standards have and will continue to change, due to research and testing. The current bridge rail policy used by the Structures Section is as follows:

13.7.1.1 Federally Funded Projects

Bridge rail for new structures shall be as follows:

- The designer will use NETC box beam rail on all new structures except as noted in the following statements.
- The designer may use three tube aluminum rail in low speed areas, especially when anticipating pedestrian traffic.
- The designer may use heavy duty steel W-beam rail on local road bridges having a design ADT of less than 500, and a design speed less than 40 mph *(60 km/h)*.
- The designer may use heavy duty steel W-beam mounted with a longitudinal steel box beam unit on bridges requiring Performance Level I as defined in the AASHTO Guide Specifications for Bridge Railing.

Bridge rail for rehabilitation projects shall be as follows:

- On bridges requiring widening or with deteriorated edges that require removal and replacement of the railing, replace the railing in conformance with the requirements for new structures.
- When no widening is being done and the existing curb and rail are in good condition, any bridge rail replacement will conform to section 13.7.1.2.
- Railings for trusses and covered bridges shall be evaluated on a project by project basis and be subject to approval by the Structures Program Manager.

13.7.1.2 Bridge rail for 3-R Projects

- Retain existing railing meeting the following conditions:
  - Standard two tube galvanized box beam.
  - Aluminum two or three tube elliptical.
  - Steel W-beam where post spacing does not exceed 6’-3” *(1905 mm)* and the offset blocks are in place.
- Replace existing railing not meeting the conditions above. This replacement shall conform to one of the following:
  - Any rail system defined for new structures.
  - NETC box beam rail mounted on existing concrete posts where such posts are in good condition and where the post spacing does not exceed 8’-0” *(2400 mm)*.

13.7.2 Approach Railing

Approach Railing to Galvanized Box Beam bridge railing shall be according to Standard SB-R4B-82. Approach Railing to Steel Beam bridge railing shall be according to details on Standard SB-R6-82. Aluminum approach railing shall be according to what the Structures Section has developed in CADD.

Refer to Guide Specifications for Bridge Railings, 1989, and the "Roadside Design Guide", 1996.

When using two tube galvanized box beam bridge railing, steel approach posts, include drawings SB-R4C-93 or SB-R4D-93 and SB-R4E-93 as detail sheets with the project plans.

13.8 GENERAL DETAILS

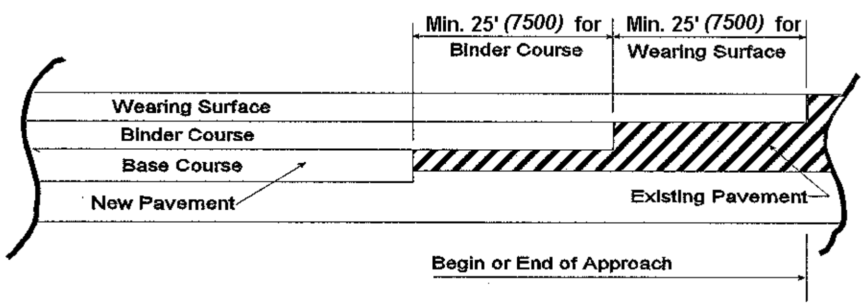
13.8.1 Cold Planing

The designer will include the item for Cold Planing Bituminous Concrete Pavement on all paved projects on Class I Town Highways. The use of cold planing for Class II and III Town Highways shall be evaluated on a project by project basis.

Normally, the procedure is to stagger the wear course and binder by extending both into the existing pavement area. See Figure 13-9.

Figure 13-9

Cold Planning Section



13.8.2 Cofferdam Section

Show details and notes, if needed, on the plans according to the following:

- When a cofferdam is specified on the plans, all excavation and removal of existing structure within the defined limits of the cofferdam will be paid for under the item “Cofferdam”.
- Any removal of existing structure outside the limits of the cofferdam and within the limits of the excavation items, shall be paid for under the appropriate excavation item and the limits for these items shall be clearly defined on the plans.
- If any portion of the existing structure, which needs to be removed, falls outside the limits of the excavation items; removal shall be paid for as “Removal of Structure” or “Partial Removal of Structure.”

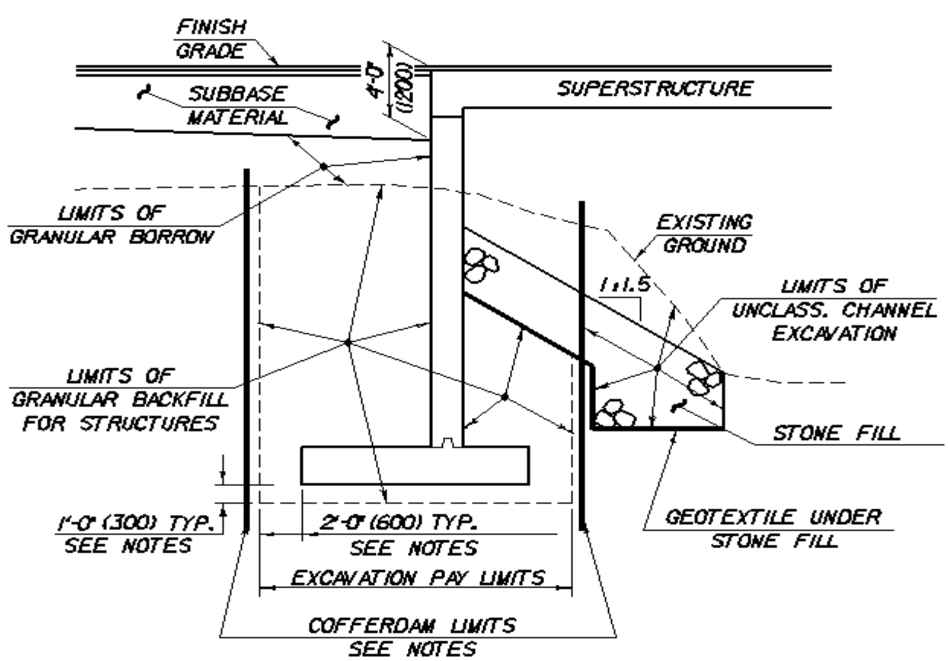
13.8.2.1 Cofferdam Notes.

The following cofferdam limits notes shall be placed on the plans as they apply to the project, along with Figure 13-10.

- Cofferdam size to be determined by the contractor.
- The pay limits of "Cofferdam Excavation, Earth" and "Cofferdam Excavation, Rock" shall be 2'-0" *(600 mm)* outside the perimeter of the footing.
- 1'-0" *(300 mm)* undercut as determined necessary by the resident engineer.
- If a cofferdam is constructed which is larger than the cofferdam excavation pay limits, payment for all unclassified channel excavation, including that portion which is inside the cofferdam but outside the cofferdam excavation pay limits, will be made at the contract unit price for unclassified channel excavation.

Figure 13-10

Typical Abutment Section Showing Cofferdam



TYPICAL ABUTMENT SECTION
(NOT TO SCALE)

13.8.3 Backfill

The backfill material behind abutments and retaining walls shall be as shown in Figure 13-10 or in other project details.

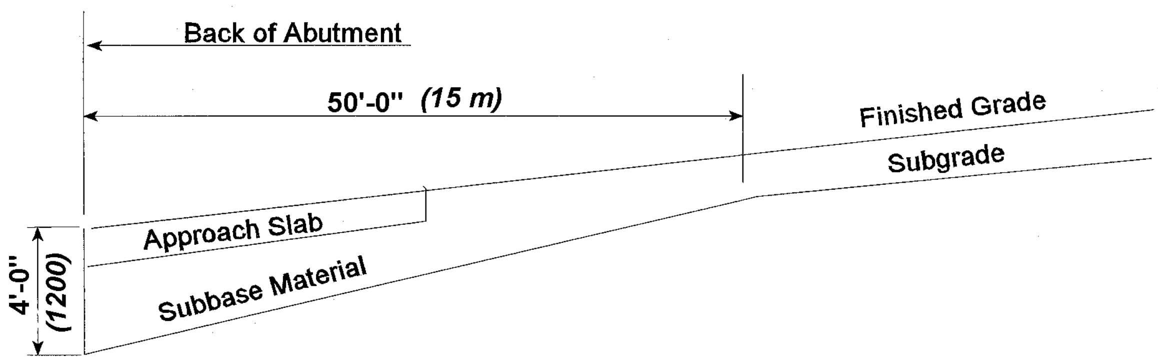
13.8.4 Subbase Details

13.8.4.1 Subbase Detail at Abutment

Figure 13-11 shows how the materials are detailed behind the abutment.

Figure 13-11

Subbase detail at abutment

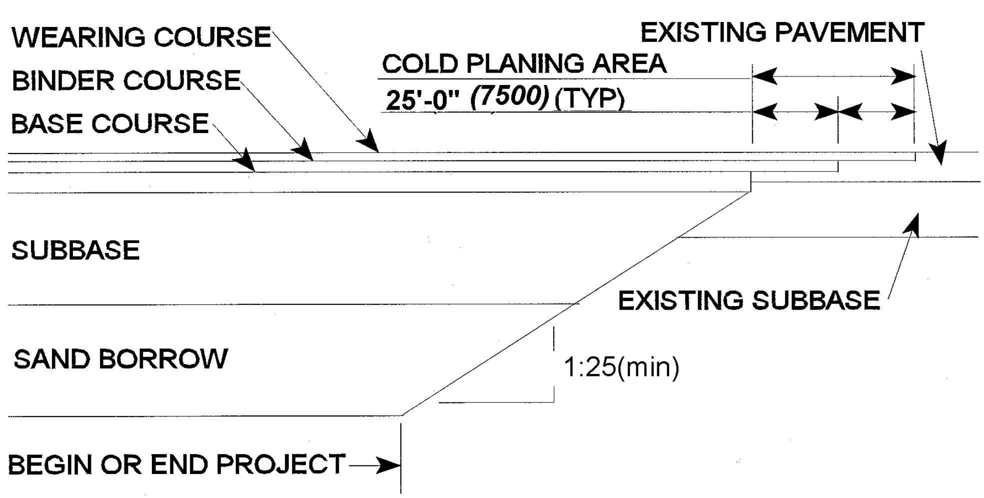


13.8.4.2 Subbase at Begin and End of Project

Figure 13-12 shows how the materials are detailed at the begin and end of project.

Figure 13-12

Subbase at begin and end project



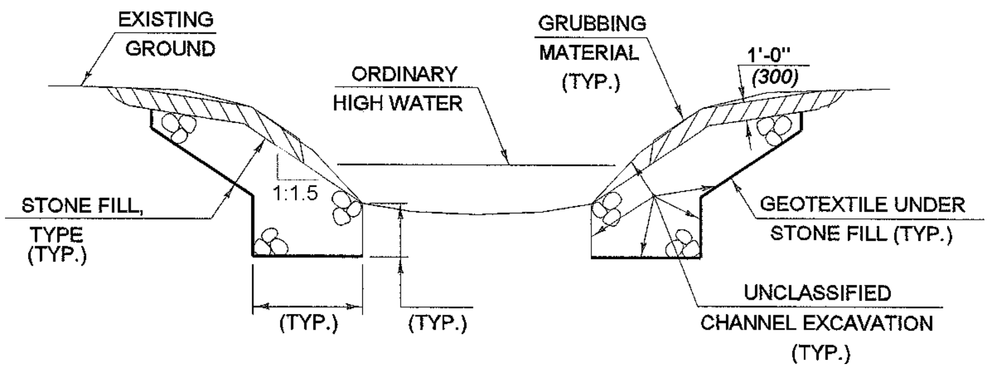
13.8.5 Typical Channel Section

Figure 13-13 show the typical quantities detail of the channel section.

- Continue stone fill to 1’-0” *(300 mm)* below existing ground or 1’-0” *(300 mm)* above design flow elevation. Whichever is lower.
- Grubbing material shall not be placed on the stone fill in the area under the bridge. Whenever channel slope intersects roadway subbase, grubbing material shall begin at the bottom of subbase.

Figure 13-13

Channel Typical Section



Stone Fill Type	I	II	III	IV
Thickness	1'-0" *(300)*	2'-0" *(600)*	3'-0" *(900)*	4'-0" *(1200)*
Width of keyway	2'-0" *(600)*	4'-0" *(1200)*	6'-0" *(1800)*	8'-0" *(2400)*
Depth of keyway	1'-0" *(300)*	2'-0" *(600)*	3'-0" *(900)*	4'-0" *(1200)*

Chapter Fourteen
Loads

For metric equivalents of the English expressions found in the AASHTO Standard Specifications for Highway Bridges, see Appendix E of those specifications.

14.1 DEAD LOADS

All loads are according to AASHTO Section 3, except as noted below:

- All Earth Loadings = 140 lb/ ft ^{3} *(22 kN/m^3)*

14.2 LIVE LOADS

The following conditions apply for live loads:

- For all Interstate, Primary, Secondary and Federal Secondary Routes and all Town Highway Routes on-system and off-system, design new structures for HS 25 *(MS 22.5)* live load.
- Design temporary bridges for HS 20 *(MS 18)* live load at a minimum of posted rating.
- On all rehabilitation work on structures, attempt to design for HS 25 *(MS 22.5)* live load. The load rating shall at least be a posted rating for HS 20 *(MS 18)* unless otherwise approved by the Structures Program Manager.
- By designing all structures for HS 25 *(MS 22.5)* live load, the designer avoids the need to design for future pavements.

14.3 LATERAL EARTH PRESSURE

The designer may evaluate lateral earth pressure and then apply according to Figure 14-1.

Figure 14-1

Lateral Earth Pressure

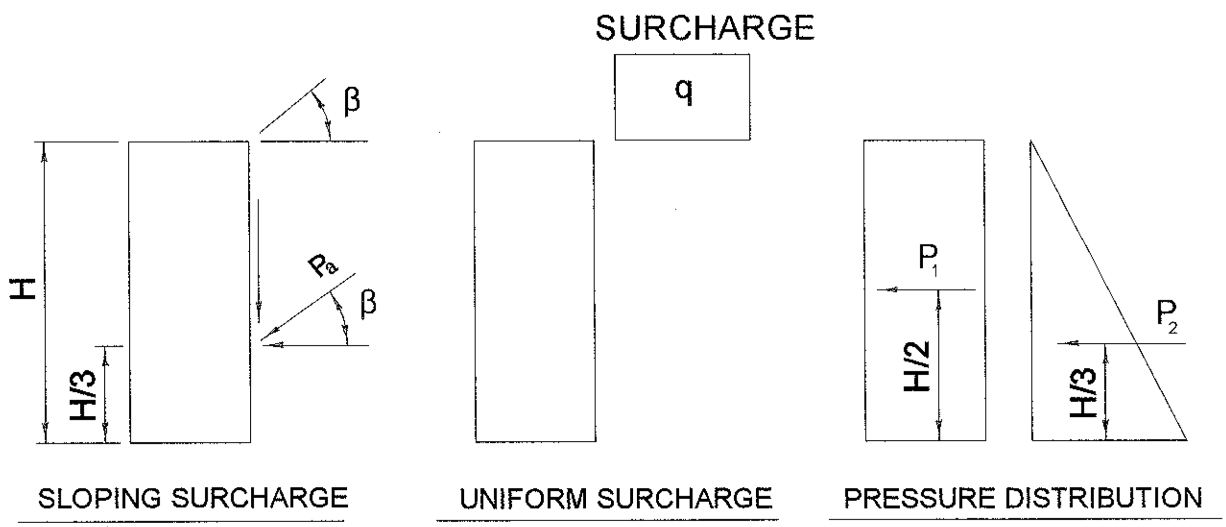
$P_a = ½γH^2K_a$ (CAN BE APPLIED PER METER OR SUMMARIZED FOR UNIT APPLICATION)

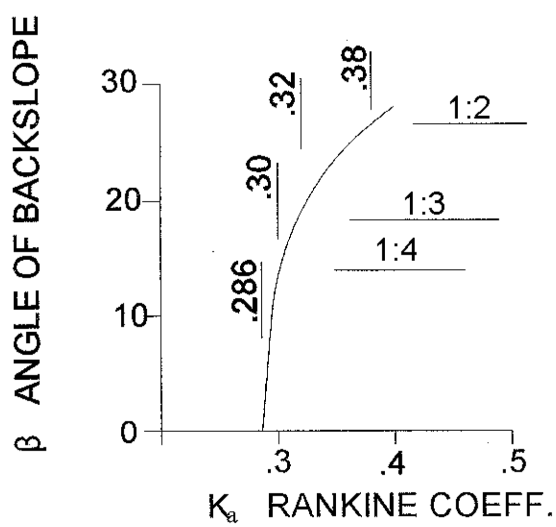
P_a = ACTIVE PRESSURE AGAINST WALL

$γ$ = UNIT WEIGHT OF SOIL 140 lb/ft^3 (22 kN/m^3)

H = HEIGHT OF WALL

K_a = COEFFICIENT (USE ∅ ANGLE OF 33°-40')





$P_1 = H\ q\ K_a$

$P_2 = ½γH^2K_a$

14.4 EARTHQUAKE DESIGN

Seismic design shall be considered in all new and rehabilitated structure designs.

14.4.1 Seismic Design Specifications

Accomplish a seismic design using the following specifications:

14.4.1.1 New Structures

AASHTO 1996 “Standard Specification for Highway Bridges” with interims.

14.4.1.2 Structure Rehabilitation

May 1987 FHWA Report “Seismic Design and Retrofit Manual for Highway Bridges.”

14.4.2 Design Criteria

- Single span structures—Design for Category A
- Multi-Span Structures—Design for Category A
- Acceleration coefficient = 7.5%
- Soil Profile Type, as determined by standard penetration borings, assumes Soil Profile Type II. The designer shall check the bridge seat width per Division IA, Section 5.3 in Standard Specifications for Highway Bridges, dated 1996, with interim specifications.
- Single span bridges shall be seismic analyzed according to Division 1A Section 5 of the AASHTO Standard Specification for Highway Bridges.

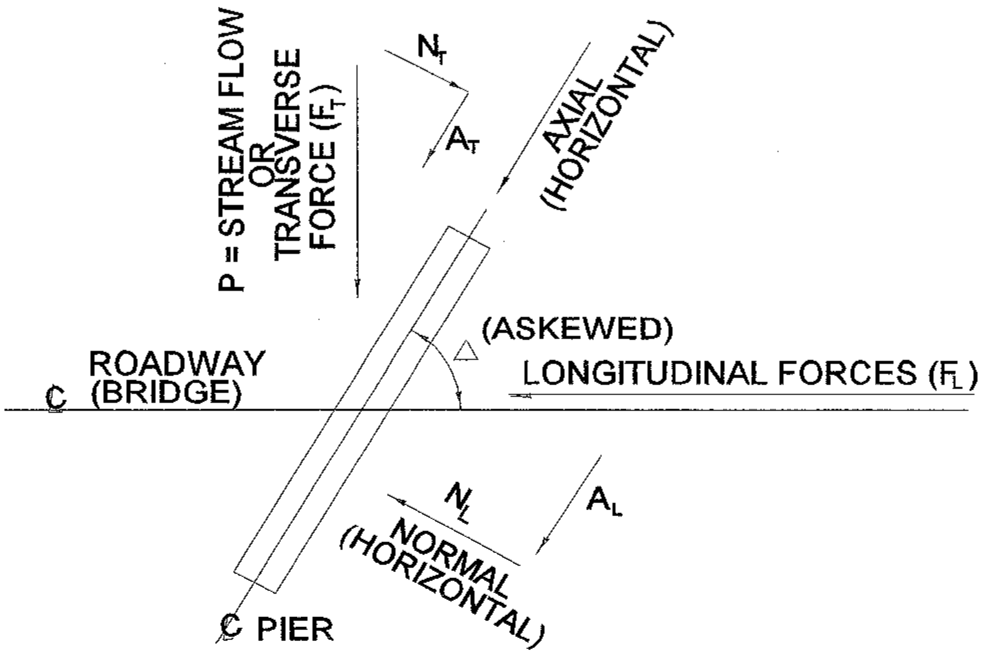
14.5 APPLICATION OF LOADS

Horizontal forces applied to the substructure directly or through the superstructure shall be broken into their respective components according to the force orientation example shown on Figure 14-2.

When a substructure is square, radial, or skewed, transmit the normal and axial force components to the substructure at their applied elevation.

Figure 14-2

Applying Forces by their Components



LONGITUDINAL FORCE COMPONENTS

AXIAL (LONG) = F_L (cos △) = A_L

NORMAL (LONG) = F_L (sin△) = N_L

TRANSVERSE FORCE COMPONENTS

AXIAL (TRANS.) = F_T (sin△) = A_T

NORMAL (TRANS.) = F_T (cos△) = N_T

SUMMATION OF FORCES

AXIAL FORCE = $A_L \pm A_T$

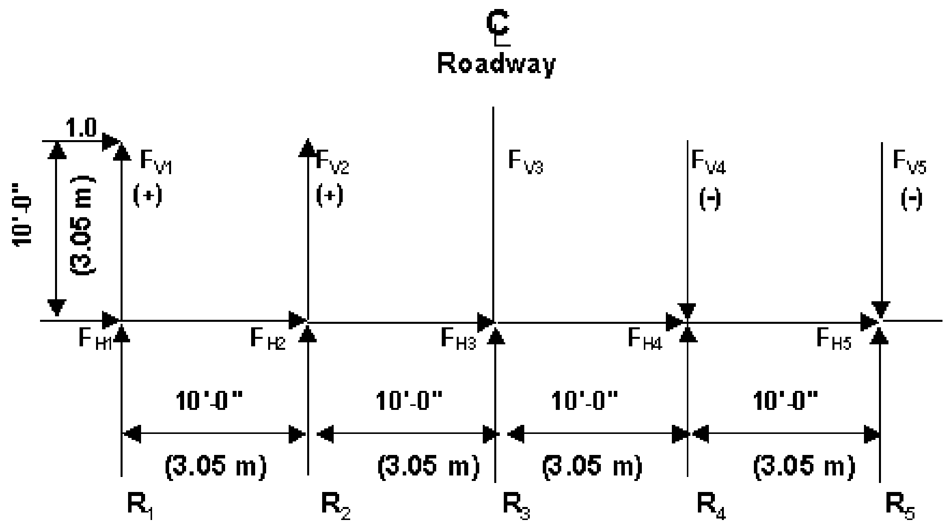
NORMAL FORCE = $N_L \pm N_T$

14.5.1 Equating Transverse Forces to Horizontal and Vertical Components

When designers transmit superstructure forces to a substructure for substructure analysis, they must convert the forces to equivalent horizontal and vertical components reacting at each bearing location. See Figure 14-3.

Figure 14-3

Equating Transverse Forces to Horizontal and Vertical Components



MOMENT OF INERTIA OF GROUP REACTIONS

$2x(10' \times 12\ ^{IN}/_{FT})^2$	=	28,800	$(2x(3.05m \times 1000mm/m)^2$	=	18 605 000)
$2x(2 \times 10' \times 12\ ^{IN}/_{FT})^2$	=	115,200	$(2x(2 \times 3.05m \times 1000mm/m)^2$	=	74 420 000)
		144,000 in^4			(93 025 000 mm^4)

$$\frac{Mc}{I} \text{ @ } R_1 \text{ and } R_5 = \frac{1.0 \times 12^{in}/_{ft} \times 10' \times (10' + 10') \times 12^{in}/_{ft}}{144000 \text{ in}^4} = 0.2$$

$$= \left(\frac{1.0 \times 3050mm \times (3050mm + 3050mm)}{93\,025\,000 \text{ mm}^4} \right) = 0.2$$

$$\frac{Mc}{I} \text{ @ } R_2 \text{ and } R_4 = \frac{1.0 \times 12^{in}/_{ft} \times 10' \times (10') \times 12^{in}/_{ft}}{144000 \text{ in}^4} = 0.1$$

$$= \left(\frac{1.0 \times 3050mm \times (3050mm)}{93\,025\,000 \text{ mm}^4} \right) = 0.1$$

F_{V1} and F_{V5} = 0.2 x TRANSVERSE FORCE

F_{V2} and F_{V4} = 0.1 x TRANSVERSE FORCE

F_{V3} = 0.0

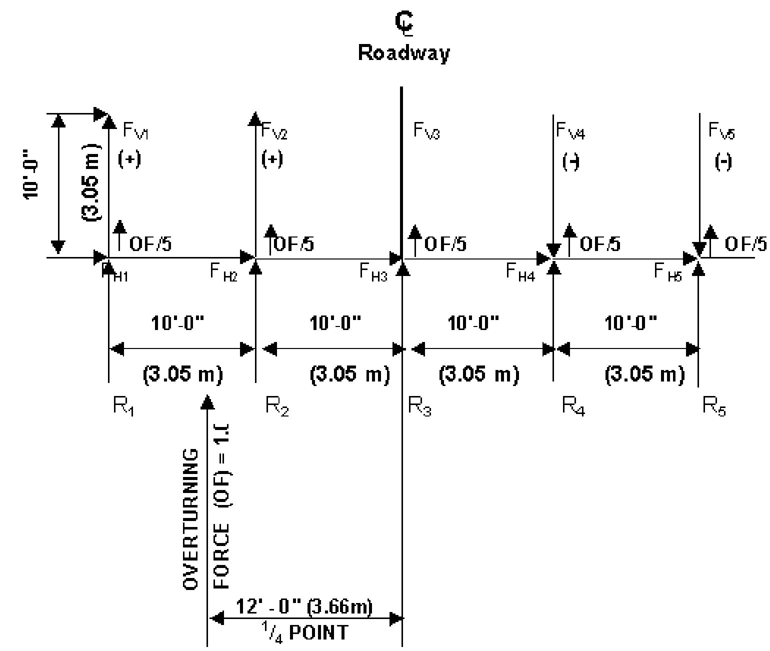
F_{H1} thru F_{H5} = 1/5 x TRANSVERSE FORCE

14.5.2 Equating Overturning Force to Horizontal and Vertical Components

Figure 14-4 shows a method of equating a vertical overturning force on the superstructure to equivalent vertical components acting on the substructure.

Figure 14-4

Equating overturning force to horizontal and vertical forces.



MOMENT OF INERTIA OF GROUP REACTIONS

(SAME AS FIGURE 14-3) = 144,000 in^4 (93 025 000 mm^4)

$$\frac{Mc}{I} \quad @ R_1 \text{ and } R_5 = \frac{1.0 \times 12^{in}/_{ft} \times 12' \times (10' + 10') \times 12^{in}/_{ft}}{144000 \text{ in}^4} = 0.24$$

$$= \left(\frac{1.0 \times 3660\text{mm} \times (3050\text{mm} + 3050\text{mm})}{93\,025\,000 \text{ mm}^4} \right) = 0.24$$

$$\frac{Mc}{I} \quad @ R_2 \text{ and } R_4 = \frac{1.0 \times 12^{in}/_{ft} \times 12' \times (10') \times 12^{in}/_{ft}}{144000 \text{ in}^4} = 0.12$$

$$= \left(\frac{1.0 \times 3660\text{mm} \times (3050\text{mm})}{93\,025\,000 \text{ mm}^4} \right) = 0.12$$

GROUP II

F_{V1} = (+) OFx(0.24)+OF/5	= (+)	________________	KIP (kN)
F_{V2} = (+) OFx(0.12)+OF/5	= (+)	________________	KIP (kN)
F_{V3} = +OF/5	= (+)	________________	KIP (kN)
F_{V4} = (-) OFx(0.12)+OF/5	= (-)	________________	KIP (kN)
F_{V5} = (-) OFx(0.24)+OF/5	= (-)	________________	KIP (kN)

14.5.3 Thermal Forces

Evaluate thermal forces for the cold climate temperature range. Refer to AASHTO 3.16

14.5.4 Stream Flow Pressure

Evaluate stream flow pressure according to AASHTO 3.18.1. Design piers subjected to stream flow for both axial and normal components of the stream flow pressure as follows:

- Normal Component = P Sin Ø
- Axial Component = P Cos Ø

Where: Ø = the angle between the centerline of the pier and the assumed direction of flow. Design all piers for a minimum of Ø = 20 degrees. The effective velocity shall be that calculated for the applicable Q for the condition under consideration.

Apply the component forces at the 0.6 times depth of flow for the Q condition being considered.

14.5.5 Ice Pressure

Follow the provisions of AASHTO Section 3.18.2, using the following guides:

- A semicircular pier nose with no inclination is the preferred shape. However, in any case this should be as recommended by the Hydraulics Unit.
- For pier shafts less than 4'-0" *(1200 mm)* wide, use p = 400 lb/in^2 *(2.8 MPa),* t = 36" *(900 mm)*.
- For pier shafts greater than 4'-0" *(1200 mm)* wide, the designer may use Figure 14-5 as a guide for selecting values of p: [t = thickness, p = pressure].
- Consult the Hydraulics Unit concerning ice thickness and stream conditions.

Figure 14-5. Pressure On Pier Shaft

t (Solid Ice)	Stream Condition	Pressure
12" to 24" (300 mm to 600 mm) Large Pieces	Light to moderate flows Light to moderate gradient Light to moderate breakups	150 psi (1.0 Mpa) to 250 psi (1.7 Mpa)
24" to 36" (600 mm to 900 mm) Large Pieces	Light to moderate flows Light to moderate gradient Light to moderate breakups	250 psi (1.7 Mpa) to 300 psi (2.1 Mpa)
36" (900 mm) or more Major movement	Large volume of flow Moderate to steep gradient Severe ice breakup	300 psi (2.1 Mpa) to 400 psi (2.8 Mpa)

- Apply ice forces at the elevation of a Q-10 discharge, unless otherwise recommended by the Hydraulics Unit.
- Ice pressures on pier shafts along the long dimension shall be at least 15% of the ice force at the nose.

14.6 DISTRIBUTION OF LOADS

14.6.1 Dead Loads

Uniformly distribute the superimposed dead load to each stringer except for structures wider than 30'-0" *(9200 mm).* For these structures, the designer may distribute the curb or sidewalk and railing load to the fascia girder and the first interior girder.

14.6.2 Live Load Distribution

Live Load Distribution shall be according to provisions of AASHTO Section 3, Part C, unless the designer selects an alternative method.

Transverse and longitudinal live load distribution for horizontal curved girders shall be according to the AASHTO Guide for Horizontally Curved Highway Bridges 1993, or other method approved by the Structures Program Manager.

14.6.3 Distribution of Wheel Loads Through Earth Fills

The designer may use Figures 14-6a and 14-6b for design loading due to one HS 25 *(MS 22.5)* truck on buried structures. The designer shall consider the effect due to multiple truck loading on a case by case basis. Load factors are not part of the following loading. With fills of less than 2'-0" *(600 mm),* see AASHTO, Section 6, Subsection 6.4.2.

Table 14.6a Distribution of wheel load through earth fills (English Units)

Cover (ft)	Earth Load (lbs/ft^2)	Live Load† (lbs/ft^2)	Total Load (lbs/ft^2)
1	140	8490	8630
2	280	2122	2402
3	420	943	1363
4	560	439	999
5	700	310	1010
6	840	231	1071
7	980	179	1159
8	1120	143	1263
9	1260	124	1384
*	*	*	*

† Impact used to 3' cover, Live loads HS-25 wheel loads

*Total Load = 140 x depth of cover if span length is exceeded

Table 14.6b Distribution of wheel load through earth fills (MetricUnits)

Cover (mm)	Earth Load (kPa)	Live Load† (kPa)	Total Load (kPa)
600	13	105	118
900	20	47	67
1200	26	22	48
1500	33	15	48
1800	40	11	51
2100	46	9	55
2400	53	7	60
2700	59	6	65
*	*	*	*

† Impact included up to 900 mm cover; live loads are MS22.5 wheel loads.

* Total Load = 22 x depth of cover, if span length is exceeded.

Chapter Fifteen
Foundations

15.1 SPREAD FOOTINGS

Refer to AASHTO Section 4 for more information.

15.1.1 Bearing Capacity

The Geotechnical Engineer usually recommends the bearing capacities for designs. In those cases where such recommendations are not available, use the following as maximums:

- Spread footings on soil- 4 k/ft^2 *(190 kPa)*
- Spread footings on rock- 10 k/ft^2 *(500 kPa)*

15.1.2 Spread Footings on Soil

Design spread footings that are not founded on solid rock on either compacted granular material, a natural subsoil of A-2 material or better, or a compacted layer of Granular Backfill for Structures.

- The minimum thickness of any compacted layer underneath a footing shall be 1'-0" *(300 mm)*.
- Remove unsuitable subsoil to a depth recommended by the Geotechnical Engineer.
- Backfill boulder holes with Granular Backfill for Structures.
- Use frost depths from the Flexible Pavement Design Procedure to set dry footings.

15.1.3 Spread Footing on Ledge

- Extend footings to sound, clean ledge.
- #8 *(#25)* Rebar dowels at 4'-0" *(1200 mm)* centers may be necessary on a smooth or sloping ledge.
- Step footings where the ledge elevation varies significantly along the footing. Steps should be kept to a minimum, have a vertical face, and extend for the full width of the footing. The lower footing shall support the upper footing at the step. The over breakage limits indicated in Chapter 25 shall apply.

15.2 PILE FOUNDATIONS

The Structures Section predominantly uses steel H-piles driven to point bearing on ledge, or refusal, for pile supported foundations. If sufficient subsurface exploration has been accomplished, other pile types will be considered upon recommendation by the Geotechnical Engineer. Refer to FHWA Publication "Manual on Design and Construction of Driven Pile Foundations," Rev. April 1, 1986, or "Highway Structures Design Handbook," AISC Marketing, Volume 1 Chapter 10 for additional pile foundation design information.

15.2.1 Allowable Pile Bearing Values

15.2.1.1 Vertical Design Loading

Vertical design loading for individual piles shall be limited to the following:

- Steel H-pile
  - Point bearing—9000 lb/in^2 *(62 MPa)* - use reinforced tip or shoe
  - Friction—individually analyzed
- Other type piles—See above referenced FHWA Manual for design guides.

15.2.1.2 Horizontal Design Loading

Pile groups shall resist horizontal loads applied against footings supported by the piles in the following order of preference:

- Pile Batter [horizontal component of the axial load]. Pile batter should not exceed 1:4.
- Limit the permissible passive resistance accepted by a pile to the values listed in Figure 15-1.

Figure 15-1. Types of Piles and Maximum Loading

Type of Pile	Maximum Allowable Horizontal Load with all Piles in Footing Available.
Steel	10 Kips (45 kN)

- Passive resistance applied to a vertical key projecting below the footing.

15.2.1.3 Friction Piles

Design friction piles according to methods outlined in the previously referenced FHWA Foundations Manual. When the design requires friction piles, specify a Pile Load Test to verify the assumed pile capacity. Materials & Research Unit may recommend a dynamic pile load test.

15.2.2 Pile Spacings and Clearances

- Maximum pile spacing shall be 10'-0" *(3000 mm).*
- Minimum pile spacing shall be 3'-0" *(900 mm).*
- Piles shall extend a minimum of 1'-0" *(300 mm)* vertically into the footing.

- Piles shall have a minimum side encasement of 9” *(230 mm)* from face of footing to face of pile.
- The minimum driven pile length in any substructure shall be 10’-0” *(3000 mm)*.

15.3 COFFERDAMS

Whenever the project requires excavation that is below the normal water level of a stream and is in or adjacent to the stream, use the cofferdam item. If placing the bottom of a spread footing below estimated scour depth is not practical, cut the cofferdam sheet piling at the top of footing elevation. Leave the remainder of the piling in place.

15.3.1 General Requirements

See Section 208 of the Standard Specifications and the General Special Provisions for general cofferdam requirements. Unusual site specific requirements should be covered by the Project Special Provisions.

If in the opinion of the designer, the project conditions would not warrant a professional engineer to design a cofferdam, this requirement shall be waived in the Project Special Provisions.

15.3.2 Cofferdams with Concrete Seals

The Structures Section may specify a seal be used at a substructure. The elevation of the top of seal shall be given, the cofferdam size shall be addressed. The weight of the seal shall resist the hydraulic pressure at the bottom when the cofferdam is dewatered to the top of the seal. The Contractor will verify seal dimensions with no Structures review.

Chapter Sixteen

Substructures and Retaining Walls

16.1 GENERAL DESIGN

Refer to AASHTO Section 5 and Section 7 for more information.

16.1.1 Design Methodology

- Design all substructures: wingwalls, retaining walls, abutments, pier columns and shafts, by the Service Load Design method.
- Design substructures on spread footings by either a 1 foot *(1 meter)* strip or a total unit design procedure.
- Design substructure on pile foundations as a unit.

16.1.2 Design Economy

The use of a design that is already prepared, such as a substructure unit slightly conservative in height, can be justified due to the savings in the design time.

16.2 SUBSTRUCTURES AND RETAINING WALLS

16.2.1 Factor of Safety

Use the following factors of safety:

- The Factor of Safety against overturning—equal to or greater than 2.0.
- The Factor of Safety against sliding—equal to or greater than 1.5, ignoring passive pressure at the toe.

16.2.2 Earth Pressure

Refer to Figure 14-1 for lateral earth pressure.

16.2.3 Weepholes

Detail 4" *(100 mm)* diameter weep holes, spaced at a maximum of 10'-0" *(3000 mm)* center to center in abutments and walls. The elevation of these shall be at the highest of either the approximate ordinary low water elevation or 1'-0" *(300 mm)* above top of footing.

16.3 FOOTING DESIGN

16.3.1 General Design

Abutment and pier footings should be founded at a minimum depth of 6'-0" *(1800 mm)* below stream bed, unless scour considerations, as determined by hydraulics, require a greater embedment. The designer need not bury footings on ledge. Consult Figure 16-1 for locating substructures on ledge and Figure 16-2 for substructures on piles. In addition, ask the Geotechnical Engineer to review ledge competency.

The minimum footing thickness shall be:

- Spread footing - 2'-0" *(600 mm)*
- Footing on Piles - 3'-0" *(900 mm)*

Footing reaction shall fall preferably within the middle one-third of the footing.

16.3.2 Toe Design

- Toe width shall be as required for stability.
- Design the toe reinforcement to resist the moment caused by the upward soil pressure minus the dead load moment of the footing toe. Shear shall be checked at a "d" distance from the face of the wall.
- Generally, the stem rebar extended into the toe is more than adequate for the toe design requirement.

16.3.2.1 Toe Steel

It is necessary to give special consideration to the area where the abutment steel intersects the wingwall steel. Insure that an adequate amount of reinforcing has been clearly shown and included in the reinforcing schedule. There are a variety of factors to be considered and the geometry in each case makes it necessary to give special consideration on a case by case basis to this part of the substructure design. It is especially important that this area is detailed on the project plans in such a way that the resident engineer will know what is intended and will not have to make judgements in the field relative to the reinforcing for this part of the abutment.

Main stem steel shall preferably turn toward the toe.

16.3.3 Heel Design

The critical section for shear shall be at the face of the wall. The shear requirements often control footing thickness.

Figure 16-1

Substructure on Ledge Foundation Treatment

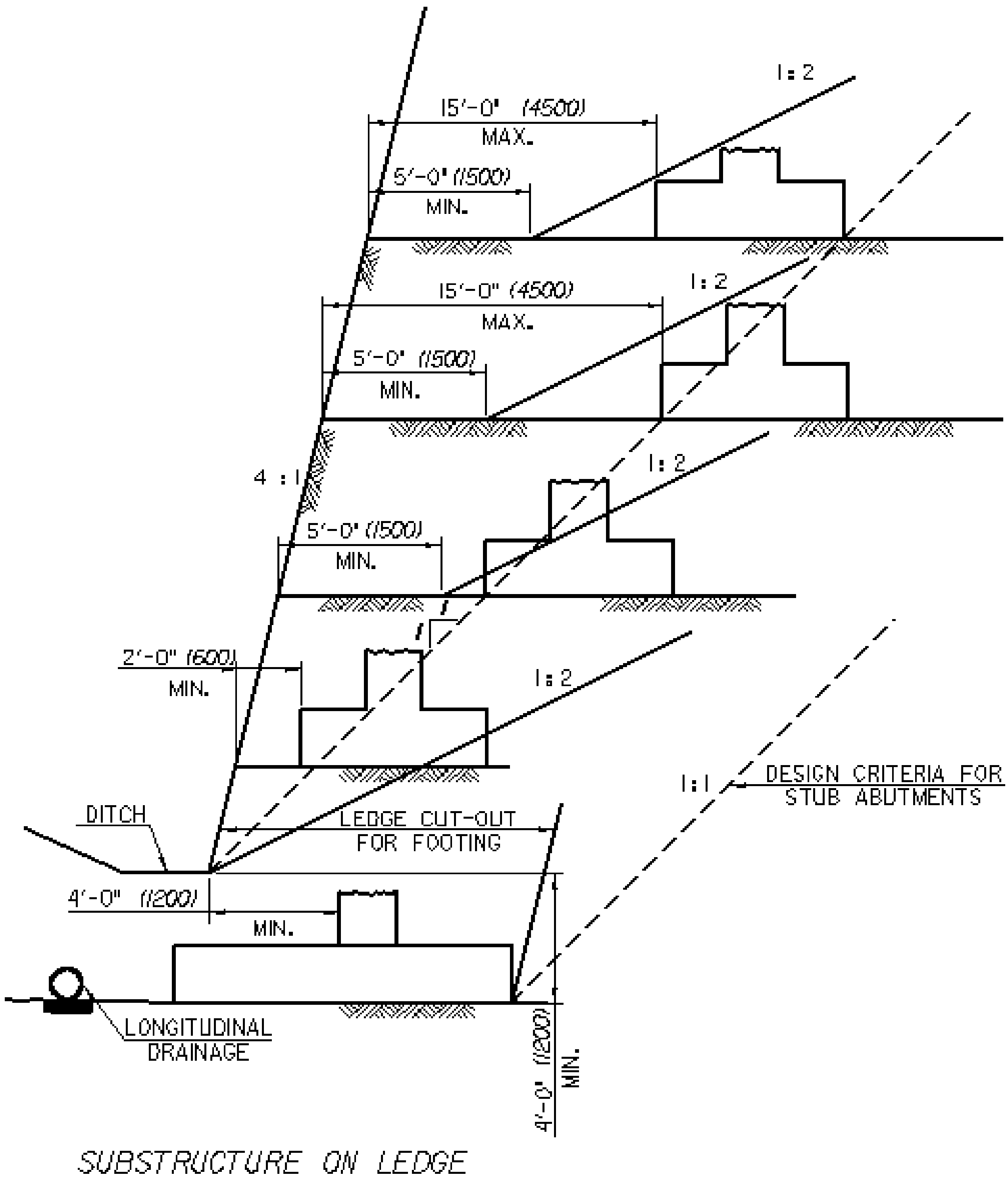
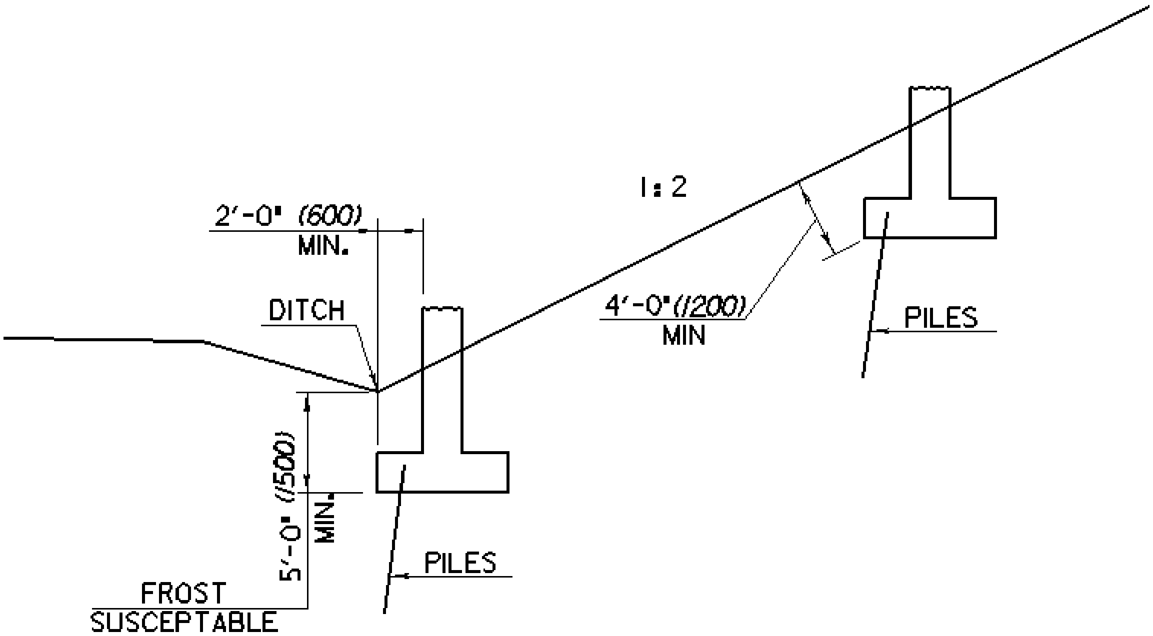
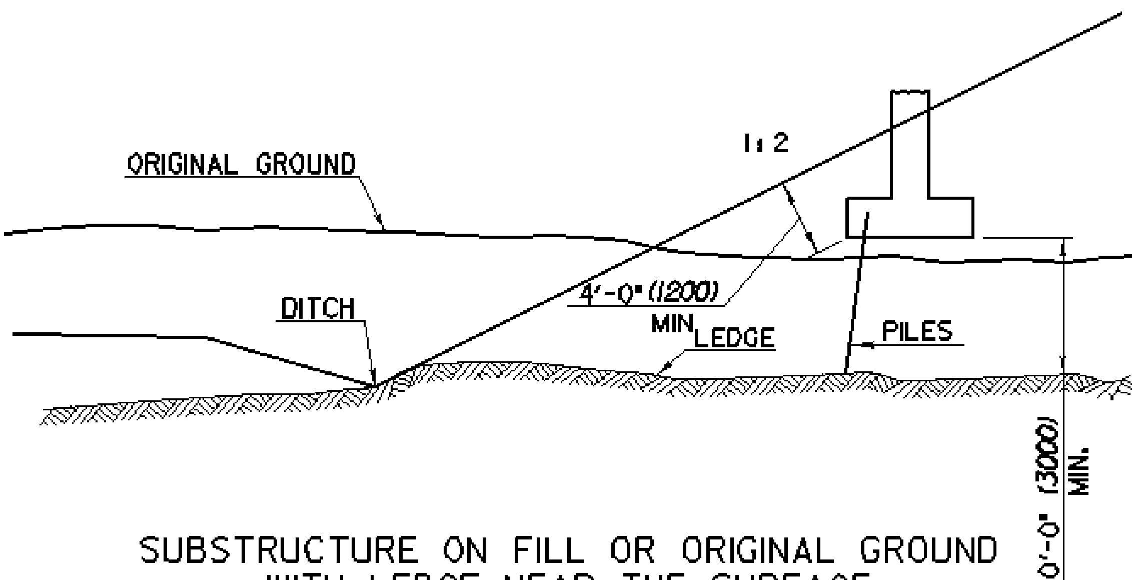


Figure 16-2

Substructures - Foundation Treatment



SUBSTRUCTURE ON FILL OR ORIGINAL GROUND



SUBSTRUCTURE ON FILL OR ORIGINAL GROUND
WITH LEDGE NEAR THE SURFACE

16.3.3.1 Full Down method

For short to intermediate height abutments or walls, the designer may conservatively design the heel reinforcement. Use the moment caused by the full earth height over the heel plus the heel weight, neglecting any upward soil pressure under the heel.

16.3.3.3 Detailed Analysis

For higher abutments or walls, the designer may elect to perform a more detailed analysis, taking into account all the forces acting on the heel. If this is done, use the maximum shear and moment calculated from the net loads or 67% of the total "full down" loads, whichever is greater, as the design shear and moment in the heel.

16.4 COMPRESSION MEMBERS WITH OR WITHOUT FLEXURE

Comply with the following procedure for pier columns and shafts designed as columns:

A. Use any appropriate method of analysis to obtain maximum transverse and longitudinal moments plus axial loads at each section being investigated.

B. Reinforcement for piers shall be 1% of gross area of design section required, minimum.

C. For axial loads, generate moment interaction diagrams about the X and Y axes of the trial section according to Sections 8.15.4 and 8.16.l - 8.16.5 of the AASHTO Specifications.

D. Apply moments and axial loads determined in Step A to interaction diagrams generated in Step C.

E. Repeat Steps B and C as required until moment and axial load values plot within the valid design region at Step D.

Solid shaft piers not designed as columns are subjected to biaxial bending and axial loads. Moments rather than axial loads usually control the design, therefore the piers are not compression members, as such. Considering this, flexure in the section becomes the basis of the design.

Chapter Seventeen
Culverts

17.1 GENERAL DESIGN

- Refer to AASHTO Section 6, 12, 16, 17 and the Roadway Design Manual for more information.
- Refer to Chapter 21 of this manual for Plate Pipe Structures.

17.2 CULVERT DESIGN

The Structures Section shall design and detail pipes 6'-0" *(1800 mm)* in diameter or larger, and all Structural Plate Pipes and Arches.

17.2.1 Minimum Cover

Minor drainage culverts should be below subgrade elevation for mainline culverts. Drive culverts should have a 1'-0" *(300 mm)* minimum cover.

17.2.2 Coatings

The designer shall request either a galvanized, aluminized or polymeric coating on all steel culverts.

17.3 UNDERCUTS

Design all culverts with a minimum of a 1'-0" *(300 mm)* undercut, with the removal of additional unsuitable foundation material as ordered by the Engineer.

17.4 BACKFILL MATERIALS

Backfill all undercut areas with Granular Backfill for Structures. Backfill for culverts shall meet the specification for Granular Borrow.

Granular Borrow should extend to bottom of subbase. The backfill shall not extend into subbase.

17.5 WEEP HOLES

- Concrete box culverts shall not use weep holes.
- For rigid frames or arches, consider using weep holes or underdrain.
- Wingwalls for box culverts, rigid frames or arches shall use weep holes.

17.6 HORIZONTAL EXCAVATION AND BACKFILL LIMITS

For all drainage structures with 6'-0" *(1800 mm)* or greater spans, pay limit for Structure Excavation and backfill shall be 3'-0" *(900 mm)* from the face of the structure.

Chapter Eighteen

Reinforced Concrete

18.1 GENERAL DESIGN

Refer to AASHTO Section 8 for more information.

18.1.1 Design Methodology

Use the Load Factor Design method for all reinforced concrete design, except substructure and retaining wall designs. See Chapter 16.

18.2 CONCRETE DESIGN

18.2.1 Reinforcing Steel Criteria

Use grade 60 *(420)*, AASHTO M31 *(AASHTO M31M)* billet-steel bars for reinforcement in all reinforced concrete designs.

18.2.2 Concrete Criteria

The unit stresses and design properties of concrete shall be as tabulated for the four classes of concrete shown in Figure 18-1.

18.2.3 Uses for Concrete Classes

- Use class A concrete in bridge decks placed on steel or prestressed supporting members.
- Unless otherwise designated, all concrete shall be Class B. Class C and Class D concrete are normally only used for massive pours where a lower design strength is acceptable.
- Use Silica Fume Concrete for curbs and sidewalks. [f'_c = 5000lb/in^2 *(35 MPa)*]
- Occasionally, the design may require a congested reinforcing bar configuration. This may happen where bar splices occur in a column's base. In this situation, limit the coarse aggregate to 3/4" *(19 mm)* stone by a note or Special Provision.

Figure 18-1. Concrete class properties

Concrete Class	A		B		C		D	
f'_c	4000 psi	*(30 MPa)*	3500 psi	*(25 MPa)*	3000 psi	*(20 MPa)*	2500 psi	*(20 MPa)*
f_c	1600 psi	*(12 MPa)*	1400 psi	*(10 MPa)*	1200 psi	*(8 MPa)*	1000 psi	*(8 MPa)*
f_s	24000 psi	*(165 MPa)*	24000 psi	*(165 MPa)*	24000 psi	*(165 MPa)*	24000 psi	*(165 MPa)*
E_c *	3605000 psi	*(25 900 MPa)*	3372000 psi	*(23 600 MPa)*	3122000 psi	*(21 200 MPa)*	2850000 psi	*(21 200 MPa)*
$n = \left(\frac{E_s}{E_c}\right)$	8	(8)	9	*(9)*	9	*(10)*	10	*(10)*
$k = \left(\frac{f_c}{\frac{f_s}{n} + f_c}\right)$	0.348	*(0.368)*	0.344	*(0.353)*	0.31	*(0.326)*	0.294	*(0.326)*
$j = \left(1 - \frac{k}{3}\right)$	0.884	*(0.877)*	0.885	*(0.882)*	0.896	*(0.891)*	0.902	*(0.891)*
$R = \left(\frac{f_c\, j\, k}{2}\right)$	246 psi	*(1.9 MPa)*	213 psi	*(1.6 MPa)*	167 psi	*(1.2 MPa)*	133 psi	*(1.2 MPa)*

f'_c - 28 day concrete compressive strength

f_s - tensile strength of reinforcement

E_c - concrete modulus of elasticity

n - modular ratio, steel to concrete

R - coefficient of resistance

f_c - The concrete allowable stress

j - The ratio of the ideal moment arm jd to the effective depth d.

k - The ratio of the ideal distance to the effective depth d.

* $E_c = 57{,}000 \sqrt{f'c}$ psi (= $4730\sqrt{f'c}$ MPa)

18.2.4 Minimum Concrete Thickness and Reinforcement Cover Requirements

18.2.4.1 Concrete Bridge Decks

- Paved deck
  - 2 $^1/_2$" *(60 mm)* clear to top rebar
  - 1 $^1/_2$" *(40 mm)* clear to bottom rebar
  - 8 $^1/_2$" *(220 mm)* minimum deck thickness
- Bare deck
  - 3" *(80 mm)* clear to top rebar
  - 1 $^1/_2$" *(40 mm)* clear to bottom rebar
  - 9" *(230 mm)* minimum deck thickness

18.2.4.2 Concrete Slabs

- 3” *(80 mm)* Clear top
- 1 $^{1}/_{2}$” *(40 mm)* Clear bottom

18.2.4.3 Curbs and Sidewalks

- 3” *(80 mm)* Clear

18.2.4.4 Walls

- Design walls with a reinforcing cover of 3” *(80 mm)* on exposed faces. Use a 2” *(50 mm)* clearance in buried concrete.

- Minimum wall thickness shall be as follows:

  - Height < 5’-0” *(1500 mm)*, use 12” *(300 mm)*
  - Height 5’-0” *(1500 mm)* to 10’-0” *(3000 mm)*, use 15” *(400 mm)*
  - Height > 10’-0” *(3000 mm)*, use 18” *(450 mm)*
  - Minimum wall thickness must satisfy equation 18.1 and the equation for the coefficient of resistance, R, as listed in Figure 18-1

$$dreq = \sqrt{12\frac{M}{Rb}} \qquad \left(dreq = 1000\sqrt{\frac{M}{Rb}}\right) \qquad (\text{Equ. } 18.1)$$

d_{req} = The required effective depth of the member in inches *(mm)*

b = The width of the section in inches *(mm)*

M = The design moment ft-pounds *(kN-m)*

- Design changes in non-battered wall thickness at horizontal construction joints.

18.2.4.5 Piers

- Design all pier components with a minimum 4” *(100 mm)* clear concrete cover, except footings.
- Pier caps shall have a minimum width of 3’-0” *(900 mm)*.

18.2.4.6 Footings

The clear concrete cover on all footings shall be 3” *(80 mm)* all around.

18.3 REINFORCEMENT

18.3.1 Minimum Reinforcement Requirements

- No. 5 *(16)* bars at 1’-0” *(300 mm)*.

- Minimum A_s = 0.25 % of the area of the design section.
- Waive the previous requirement if A_s provided is at least 1.33 times A_s required by design.
- Use the following formula to determine the area of flexural reinforcement for a Service Load Design:

$$\text{As req} = \frac{M}{fs\ j\ d} \times 12 \qquad = \left(\frac{M}{fs\ j\ d} \times 10^6 \right) \qquad \text{(Equ. 18.2)}$$

where:

- A_s = Required area of steel in^2 *(mm^2)*
- M = Moment in ft-kips *(kN-m)*
- f_s = Allowable stress in the steel in psi *(MPa)*
- j = The ratio of the ideal moment arm, jd, to the effective depth, d [see Figure 18-1]
- d = The effective depth of the member in inches *(mm)*

With grade 60 *(420)* reinforcement, and f'_c = 3500 lb/in^2 *(25 MPa)* with the above values, equation 18.2 simplifies to:

$$\text{As req} = \frac{M}{1.77\ d} \qquad = \left(\frac{6871\ M}{d} \right) \qquad \text{(Equ. 18.3)}$$

- For a Load Factor Design consult AASHTO Section 8.

18.3.2 Distribution Steel

18.3.2.1 Distribution Steel in Deck

- Design the bottom distribution steel.
- Use #5 *(16)* bars at 1'-0" *(300 mm)* for the top distribution steel.

18.3.2.2 Distribution Steel in Overhang

- Use #5 *(16)* bars at 6" *(150 mm)* for the distribution steel in the overhang.
- To reduce the deck cracking that begins at the overhangs, close up the bar spacing used.

18.3.3 Epoxy Coated Reinforcement

Reinforcing bars shall be epoxy coated in the following locations:

- Bridge decks on steel or prestressed beams [both top and bottom mats] and also curtain walls.

- Substructures in a tunnel environment that are likely to be subjected to salt spray from plowing operations.
- Bridge slabs and approach slabs
- Backwalls and Curtain walls

18.3.4 Splices and Development Length

- Avoid splicing of epoxy coated and conventional black reinforcing steel if possible. If mixing is necessary, it shall be done outside the area where the design requires epoxy coated rebar.

Figures 18-2a and 18-3 for tension splices of deformed bars were developed for the following criteria:

- f'_c = 3500 lb/in^2 *(25 MPa)*

  f_y = 60,000 lb/in^2 *(420 MPa)*

  s = bar spacing

- Basic development length—See AASHTO sections 8.25 and 8.26.
- AASHTO 1996 Edition and Interims
- Min splice—length = 2'-0" *(610 mm)*
- Normal weight concrete

Figure 18-2b for tension splices of deformed bars was developed under the same criteria except that f'_c = 4000 lb/in^2 *(30 MPa)*.

18.3.4.1 Lightweight Concrete

Increase the development lengths by a factor of 1.33 for all lightweight concrete. Also apply factors for splices as stated in AASHTO 8.25.2

Figure 18-2a. Bottom Steel includes bottom steel in concrete slabs, approach slabs and footings, and all steel in walls and concrete decks. f'c = 3500 lbs/in^2 (*25 Mpa*)

Bar Size	Development Length, l_d, in. (*mm*)	Class B Splice (1.3 l_d)	Class B Splice (1.3 l_d)
4 (*13*)	12 (*310*)	2'-0" (*610*)	2'-0" (*610*)
5 (*16*)	15 (*390*)	2'-0" (*610*)	2'-2" (*660*)
6 (*19*)	18 (*470*)	2'-0" (*610*)	2'-7" (*800*)
7 (*22*)	25 (*620*)	2'-8" (*810*)	3'-6" (*1050*)
8 (*25*)	33 (*810*)	3'-6" (*1050*)	4'-7" (*1380*)
9 (*29*)	41 (*1030*)	4'-5" (*1340*)	5'-9" (*1750*)
10 (*32*)	52 (*1310*)	5'-7" (*1700*)	7'-4" (*2230*)
11 (*36*)	64 (*1600*)	6'-11" (*2080*)	9'-0" (*2720*)

Figure 18-2b. Bottom Steel includes bottom steel in concrete slabs, approach slabs, and footings, and all steel in walls and concrete decks. f'c = 4000 lbs/in2 (*30 MPa*)

Bar Size	Development Length, l_d, in. (*mm*)	Class B Splice 1.3 l_d	Class B Splice 1.3 l_d
4 (*13*)	12 (*310*)	2'-0" (*610*)	2'-0" (*610*)
5 (*16*)	15 (*390*)	2'-0" (*610*)	2'-2" (*660*)
6 (*19*)	18 (*470*)	2'-0" (*610*)	2'-7" (*800*)
7 (*22*)	23 (*560*)	2'-6" (*730*)	3'-3" (*950*)
8 (*25*)	30 (*740*)	3'-3" (*960*)	4'-3" (*1260*)
9 (*29*)	38 (*940*)	4'-2" (*1220*)	5'-5" (*1600*)

Figure 18-3. Top Steel Concrete Slabs and Footings with a minimum thickness of (12" (300 *mm*) + db + cover), f'c = 3500 lbs/in^2 (25 *MPa*)

		Class B (1.3 x 1.4 x ld)		Class C (1.7 x 1.4 x ld)	
Bar Size	1.4 l_d	S> 6" (*150 mm*), factor by 0.8	S< 6" (*150 mm*)	S> 6" (*150 mm*), factor by 0.8	S< 6" (*150 mm*)
4 (*13*)	17 (*430*)	2'-0" (*610*)	2'-0" (*610*)	2'-0" (*610*)	2'-5" (*730*)
5 (*16*)	21 (*550*)	2'-0" (*610*)	2'-3" (*720*)	2'-5" (*750*)	3'-0" (*940*)
6 (*19*)	26 (*660*)	2'-3" (*690*)	2'-9" (*860*)	2'-11" (*900*)	3'-7" (*1120*)
7 (*22*)	34 (*870*)	3'-0" (*900*)	3'-8" (*1130*)	3'-11" (*1180*)	4'-10" (*1480*)
8 (*25*)	45 (*1130*)	3'-11" (*1180*)	4'-11" (*1470*)	5'-2" (*1540*)	6'-5" (*1920*)
9 (*29*)	57 (*1440*)	5'-0" (*1500*)	6'-2" (*1870*)	6'-6" (*1960*)	8'-1" (*2450*)
10 (*32*)	72 (*1830*)	6'-3" (*1900*)	7'-10" (*2390*)	8'-3" (*2490*)	10'-3" (*3110*)
11 (36)	89 (2240)	7'-9" (2330)	9'-8" (2910)	10'-1" (3050)	12'-7" (3810)

Figure 18-4. Splice Class Criteria Tension Lap Splices

$\frac{A_s \text{ Provided}}{A_s \text{ Required}}$	Maximum percent of area of steel spliced within lap length 50	75	100
2 or greater	Class A	Class A	Class B
Less then 2	Class B	Class C	Class C

For Development Length and Splices in Compression Steel, see AASHTO 8.26 & 8.32.

18.3.5 Development of Flexural Reinforcement

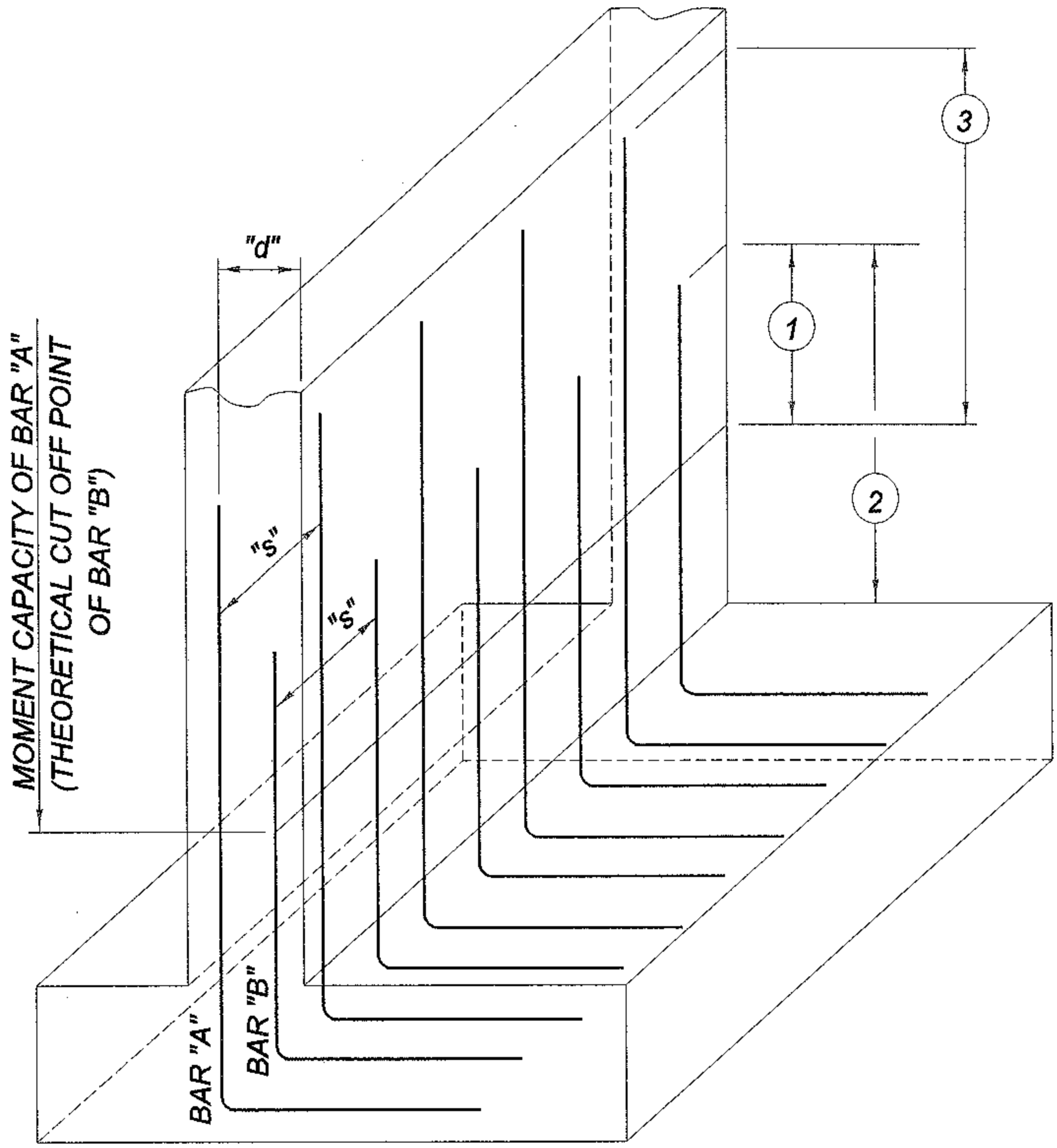
Critical sections for development of reinforcement are at points of maximum stress and points where adjacent reinforcement terminates or is bent.

To assist the designer in selecting the proper development or splice length, the following figures for the three cases are presented:

Case I: Alternate Bars are terminated, see figure 18-5.

Figure 18-5

Case I: Alternate Bars are terminated



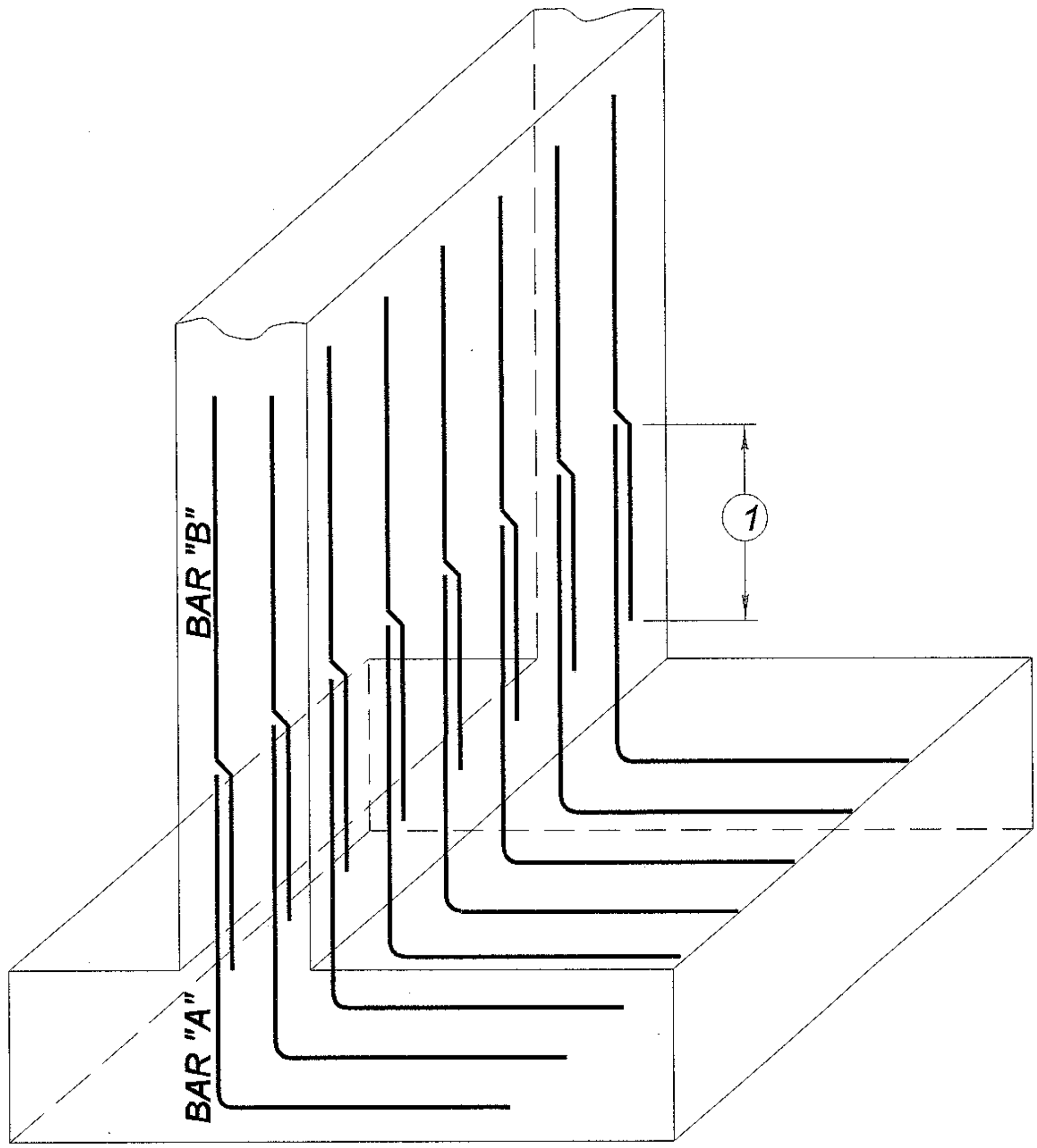
(1) ≥ "d" OR 15 "D " OR 0.05 TIMES STEM HEIGHT (OF BAR "B")

(2) ≥ l_d (BAR "B")

(3) ≥ l_d (BAR "A")

Figure 18-6

Case II: Bars spliced at footing

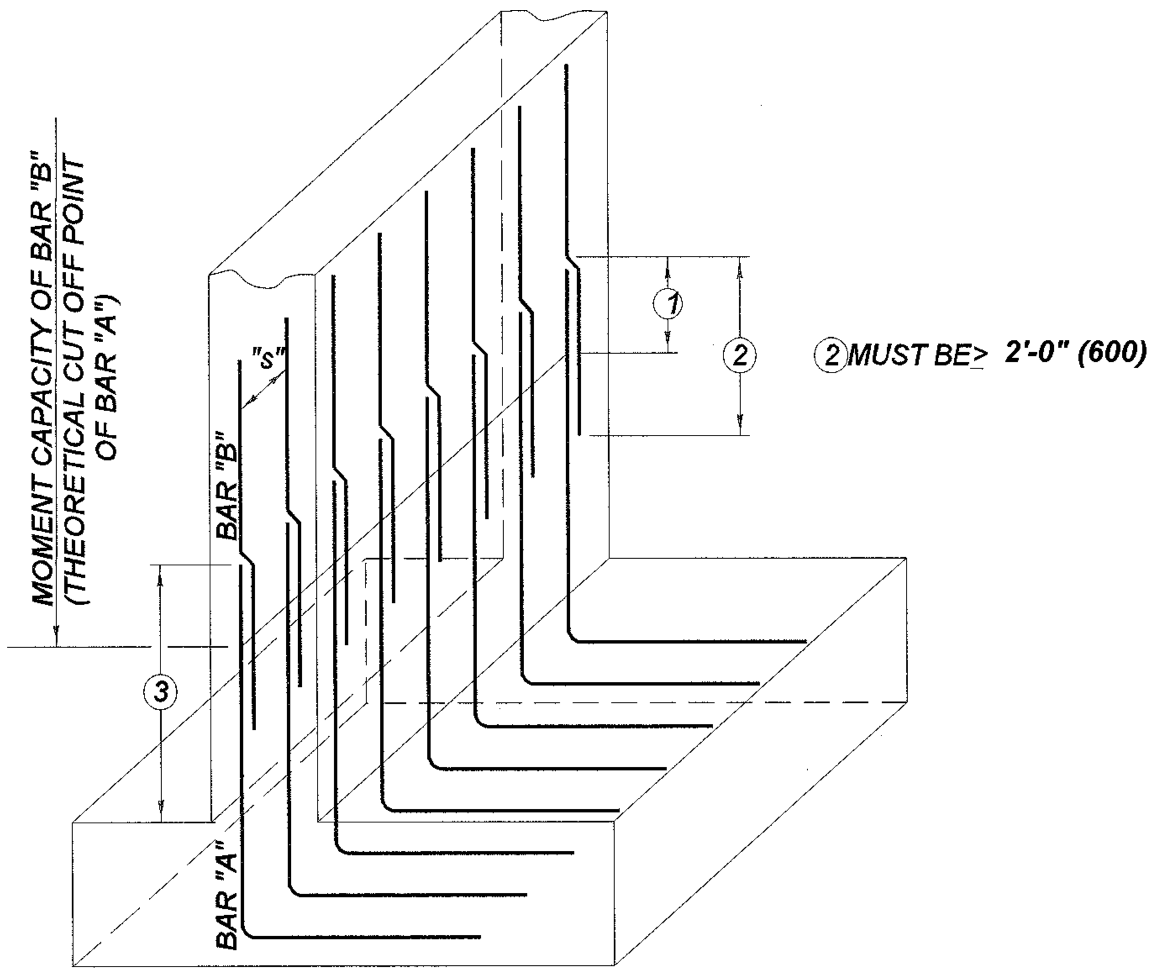


BAR "A" = BAR "B": (1) $\geq l_d$ (1.7) (CLASS C SPLICE) =

BAR "A" > BAR "B": USE CASE III CRITERIA

Figure 18-7

Case III: Bars spliced above the footing



BAR "A" ≥ BAR "B"

(1) "d" OR 15 "d_b" OR 0.05 TIMES STEM HEIGHT (BAR "A")

(2) 1.7 l_d OF BAR "B" (CLASS C SPLICE) =

1.3 l_d IF ONLY HALF OF THE BARS ARE SPLICED (CLASS B SPLICE) =

(3) $l_d \geq l_d$ OF BAR "A"

Case II: Bars spliced at the top of the footing, see figure 18-6.

Case III: Bars spliced and bar size changed at the moment capacity of the smaller bar, see figure 18-7.

18.3.5.1 Conventions Used by the Structures Section

The figures 18-5, 18-6 and 18-7 follow the following convention and criteria:

- d = Effective depth
- d_b = Nominal bar diameter
- l_d = basic development length
- s = spacing between bars being developed
- If the spacing(s) is 6" *(150)* or more, the designer may choose to apply a factor of 0.8 to the development length.
- Do not use bar sizes larger then #11 *(#36)* in splices.
- Refer to the Building Code Requirements for Reinforced Concrete ACI 318R-89 *(ACI 318RM-89)* [Revised 1992] Commentary for more information.

18.3.6 Varying Reinforcement Bar Lengths

Avoid detailing reinforcing bars with varying lengths, such as the vertical bars required in sloping wingwalls. Detail the bars with the longest length required with the remaining bars cut to fit in the field.

18.3.7 Reinforcing for Wingwall Corners

Refer to Figure 18-8 and 18-9 for the layout of the reinforcing steel in the corner where the abutment meets the wingwall.

Figure 18-8

Wingwall corner detail for 45 ° or under

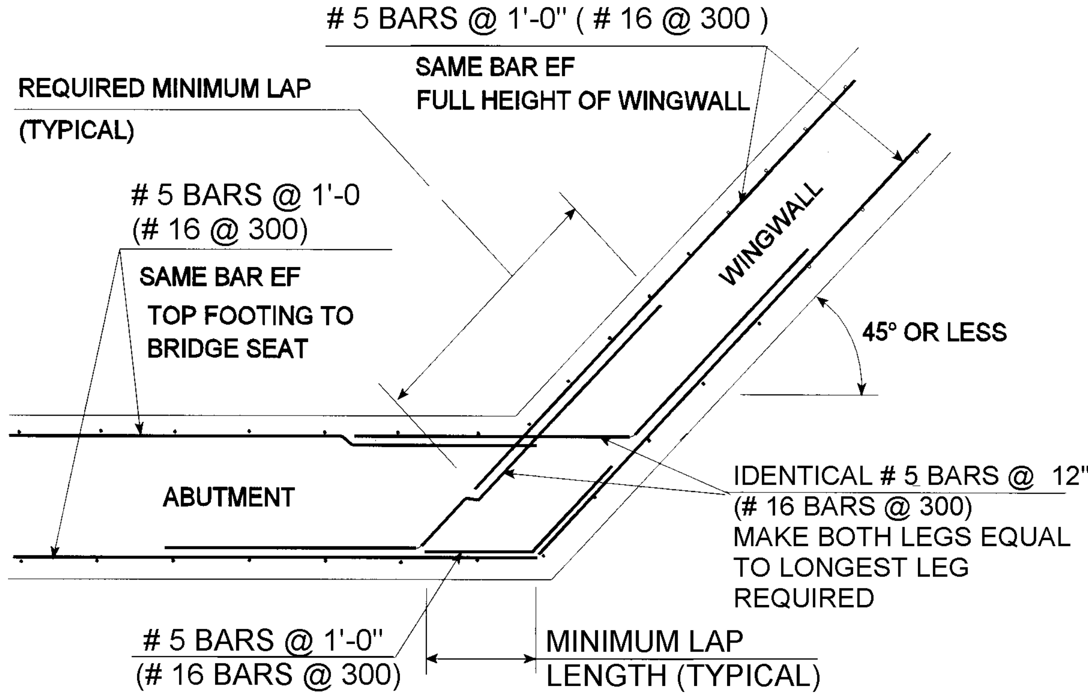
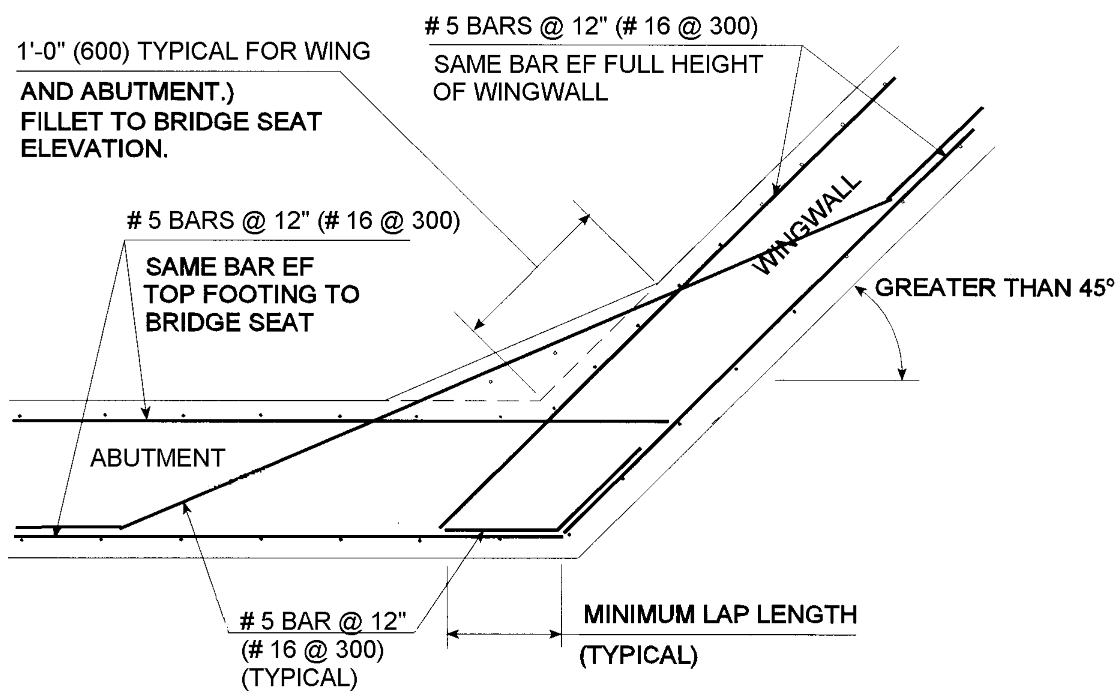


Figure 18-9

Wingwall corner detail for more than 45 ° angle



18.4 JOINTS IN CONCRETE

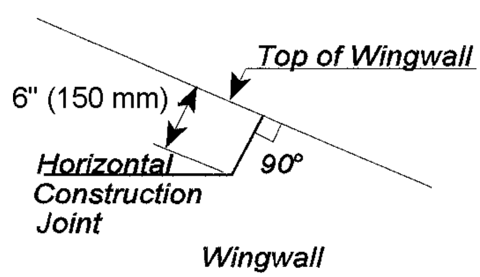
Detail all desired horizontal and vertical joints, both construction and expansion, adequately on the plans. Clearly show all optional joints as such.

18.4.1 Construction Joints

- Vertical construction joints in substructures and walls should be provided at a maximum of 30'-0" *(9000 mm)* intervals. The 30'-0" *(9000 mm)* interval shall be measured along the face of the abutment and wingwalls.
- Place horizontal construction joints as directed by the reinforcement requirements and concrete placement limitations, generally a 20'-0" *(6000 mm)* to 25'-0" *(7500 mm)* maximum height increment.
- In designing superstructures using any type of girder or beam system, steel or prestressed, detailing a horizontal construction joint at the elevation of the adjacent beam seat elevation is mandatory. The wingwalls and abutments shall include this joint. Refer to Figure 18-10 for the detail on the wingwall. Note that no concrete may be placed above this joint until the contractor has taken beam profiles and has established the final finished grade.

Figure 18-10

Horizontal construction joint in wingwall.



18.4.2 Expansion Joints

Provide vertical expansion joints at a maximum of 90'-0" *(27.0 m)*. The 90'-0" *(27.0 m)* intervals shall be measured along the face of the abutment and wingwalls.

18.5 CONCRETE PLACEMENT SEQUENCE

18.5.1 Simple Spans

Whenever possible, single span deck concrete placements should be made in one pour, beginning at the low end and proceeding to the high end.

18.5.2 Continuous Spans

Establish a deck concrete placement sequence for a continuous span structure using the following criteria:

- Provide joints at the approximate location of the dead load inflections.
- Positive moment regions shall be placed prior to the negative moment regions.

18.5.3 Three Span Continuous Cantilevers

Three span continuous cantilevers designed with a specific cantilever end dead load due to end wall items and wingwalls, shall have these end loadings placed 48 hours prior to any deck pours.

18.5.4 Deck Construction Joint Details

Show transverse deck construction joint details on the plans.

18.5.5 Curbs and Sidewalks

The contractor shall place curbs and sidewalks in 15'-0" *(4500 mm)* length sections. The pour sequence will be in alternating sections.

18.6 APPROACH SLABS

18.6.1 Criteria

To eliminate variation and duplication in the design of approach slabs, the Structures Section has established the following criteria:

- As a rule, use at grade approach slabs on all projects where the design requires a paved surface and the projected ADT is more than 400.

Figure 18-11. Criteria for approach slab lengths

Skew	Traffic Volume	Span Along Centerline
0° to 19°	ADT < 1,000	15'-0" (*4500 mm*)
	ADT ≥ 1,000	20'-0" (*6000 mm*)
20° to 34°	All Traffic volumes	20'-0" (*6000 mm*)
35° and over	All Traffic volumes	25'-0" (*7500 mm*)

- Slab lengths are measured parallel with the center line of the roadway and are to be selected from Figure 18-11.

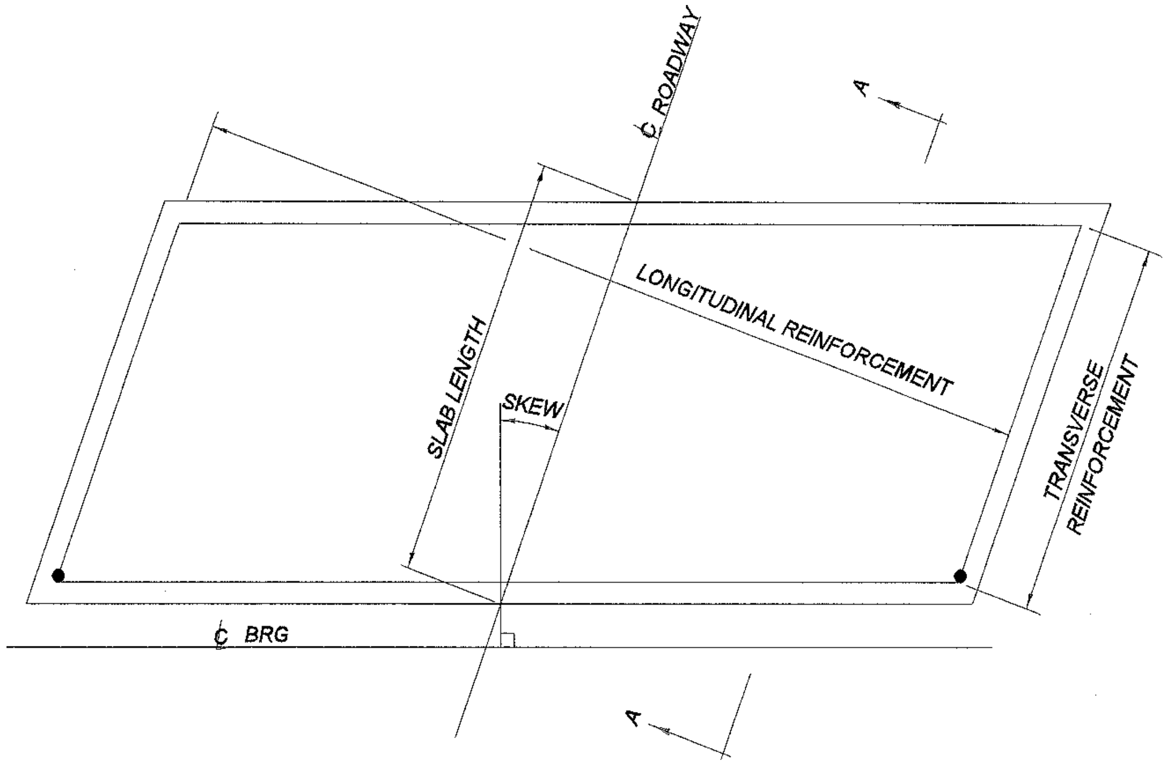
Figure 18-12. Criteria for approach slab properties

Slab Length	15'-0" (*4500 mm*)	20'-0" (*6000 mm*)	25'-0" (*7500 mm*)
Concrete depth	14" (*360 mm*)	15" (*380 mm*)	16" (*410 mm*)
Reinforcement (long)	#6 @ 6" (*#19 @ 150 mm*)	#9 @ 10" (*#29 @ 250 mm*)	#9 @ 9" (*#29 @ 230 mm*)
Reinforcement (trans)	#5 @ 12" (*#16 @ 300 mm*)	#5 @ 12" (*#16 @ 300 mm*)	#5 @ 12" (*#16 @ 300 mm*)

- At grade approach slabs shall follow the criteria in Figure 18-12.
- Longitudinal reinforcement to run parallel with the centerline of the roadway. Transverse reinforcement to run parallel with the centerline of bearing.
- Approach slabs require epoxy bars.
- Detail the approach slabs with sheet membrane waterproofing and 2 $^3/_4$" *(70 mm)* of bituminous concrete pavement.
- Approach slab designs are based on the following criteria:
  - Load factor design.
  - HS 25 *(MS 22.5)* wheel loading.
  - 2 $^3/_4$" *(70 mm)* of pavement. No future pavement with HS 25 *(MS22.5)* loading.
  - Design stresses were f_y = 60,000 lb/in^2 *(420 MPa)* and f'_c = 3,500 lb/in^2 *(25 MPa)*.
  - Bottom reinforcing steel cover 3" *(80 mm)*.
  - Effective span = L - [.25L + 1'-0"] x ½ *(L - [.25L + 300] x ½)*.
    - – Bearing area is 25% of slab length.
    - – L = overall length in ft *(mm)*
    - – 1'-0" *(300 mm)* abutment bracket.
  - Distribution of axle loads, AASHTO 3.24.3.2: 2E where E=[4+0.06 x span] $\leq$ 7'-0" *(E=[1200+0.06 x span] $\leq$ 2100 mm)*
  - Impact = 30%.

Figure 18-13

Approach Slab Detail



PLAN
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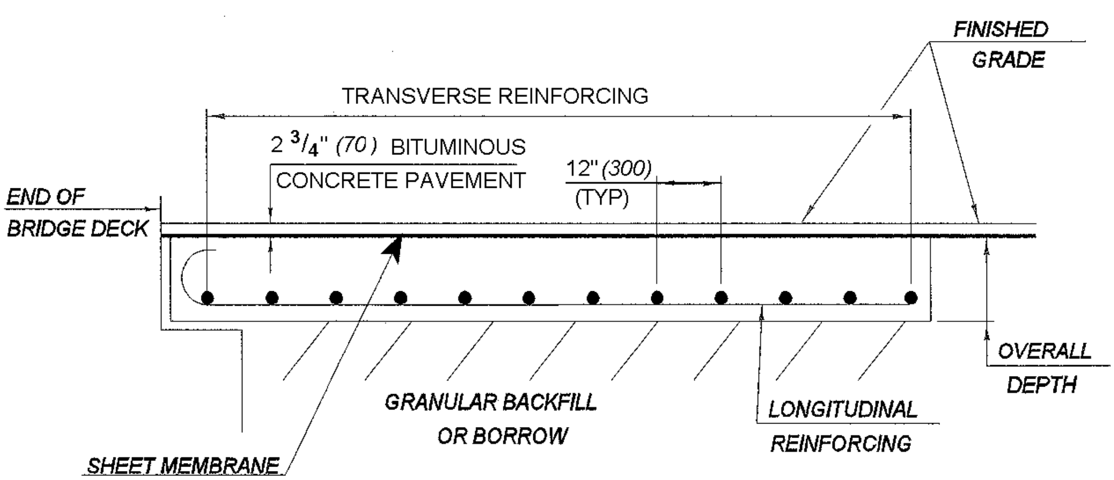


SECTION A-A
NTS

Chapter Nineteen
Prestressed Concrete

19.1 GENERAL DESIGN

Prestressed concrete design shall be according to Section 9—Prestressed Concrete, of the AASHTO Standard Specifications, or interim modifications.

19.1.1 Design Methodology

Use the Service Load Design concepts for the design of prestressed concrete. Check the members by the Load Factor Design method.

The design shall investigate the stress under each loading condition anticipated in the manufacture, handling, and service life of the prestressed member.

19.2 PRESTRESS CONCRETE DESIGN

19.2.1 Distribution Factors

AASHTO developed the distribution factors for live loads, published in the 1996 AASHTO and interims, to provide guidance for the design of multi-beam precast bridges. These bridges consist of single and multiple stemmed members placed adjacent to each other. The types of beams considered are single tee, bulb tee, double tee, triple tee, and quadruple tee. The channel beam also fits in this category. The research assumptions behind these distribution factors do not apply to voided or box beams. The designer shall use the 1983 AASHTO provisions for voided slabs and box beams.

19.2.2 Allowable Stresses

Use the following values in the design of prestressed concrete members:

19.2.2.1 Prestressing Steel

- f’s = 270 ksi *(1860 MPa)* ultimate strength of grade 270 *(1860)* low relaxation strands per AASHTO M203 *(M203 M/M203),* Supplement 1, 0.6 in *(15.24 mm)* dia. max. strand size)

- f's [.75] = 202.5 ksi *(1395 MPa)* allowable temporary tensile stress prior to loss due to creep and shrinkage

19.2.2.2 Concrete

- f'c = 6 ksi *(45 MPa)* recommended compressive strength of concrete at 28 days.

19.2.3 Design [Span and Conspan]

Be aware that the uniform dead load used in the computer design program is approximate. The calculated dead load does not take into account any dead load from the end blocks or any other solid section that the unit may have. This additional dead load may be considerable and the designer may want to allow for this when designing a bridge [especially with voided box beams].

19.3 AASHTO 1983 PROVISIONS [FOR VOIDED SLABS OR BOX BEAMS]

A multi-beam bridge consists of precast reinforced or prestressed concrete beams placed side by side on the supports. The interaction between the beams is developed by continuous longitudinal shear keys and lateral bolts that may, or may not, be prestressed.

In calculating bending moments in multi-beam precast concrete bridges, conventional or prestressed, assume no longitudinal distribution of wheel loads.

Determine the live load bending moment for each section by applying to the beam the fraction of a wheel load [both front and rear] determined by the following relations:

$$\text{Load Fraction} = \frac{S}{D} \qquad (19-1)$$

where

$$S = \frac{12 N_L + 9}{N_g} \qquad (19-2)$$

and

$$D = 5 + \frac{N_L}{10} + \left(3 - \frac{2N_L}{7}\right)\left(1 - \frac{C}{3}\right)^2 \quad \text{when } C \le 3 \qquad (19-3)$$

or

$$D = 5 + \frac{N_L}{10} \quad \text{when } C > 3 \qquad (19-4)$$

N_L Total number of traffic lanes from AASHTO Article 3.6

N_G Number of longitudinal beams

C $= K\left(\frac{W}{L}\right)$, a stiffness parameter

W Overall width of bridge in feet *(meters)*

L Span length in feet *(meters)*

Figure 19-1. Use these values of K for $C = K\left(\frac{W}{L}\right)$

Bridge Type	Beam Type and Deck Material	K
Multi-beam	Non-voided rectangular beams	0.7
	Rectangular beams with circular voids	0.8
	Box section beams	1.0
	Channel beams	2.2

19.4 PRESTRESS CONCRETE DESIGN DETAILS

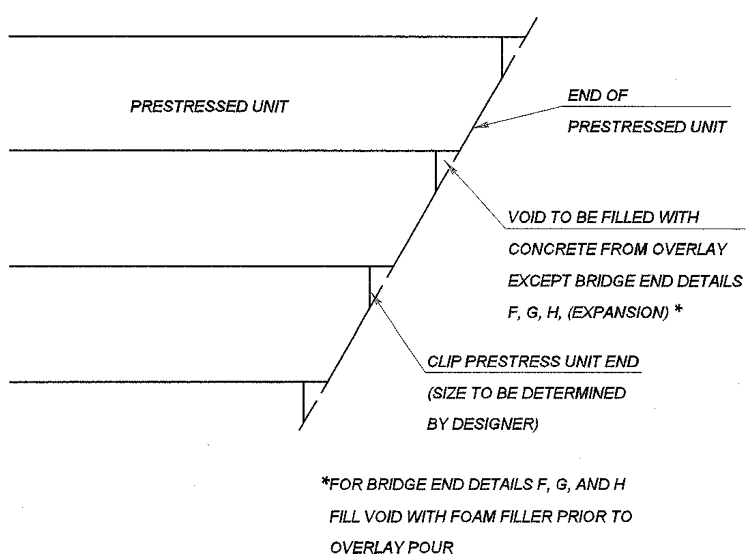
Most of the details, which the Structures Section developed, show nominal widths for the prestress units. The nominal width is the width at the bottom of the prestress voided slabs and/ or boxes. Most details are available in CADD for use on projects. Refer to CADD resources for locations.

19.4.1 Skews

- Form the ends of the voided slab or box beam units on skews up to 45°.
- Voided slabs or box beam units that are formed greater than 30° skew will have the acute corner clipped. The designer should determine the clip size. Accepting different clip sizes that the fabricator has shown on shop drawings is acceptable. The clip is to minimize breakage of the corner upon strand release.
- Make sure the shop plans show recessed and grouted strands at the ends of the prestress units. This insures the beams will have fully enclosed strands.
- Voids in box beams shall be skewed at the same angle as the beam ends. Step the voids in voided slabs in order to maintain the minimum clearance from the transverse strands.

Figure 19-2

Clip detail for skews greater then 30°



19.4.2 Overlays

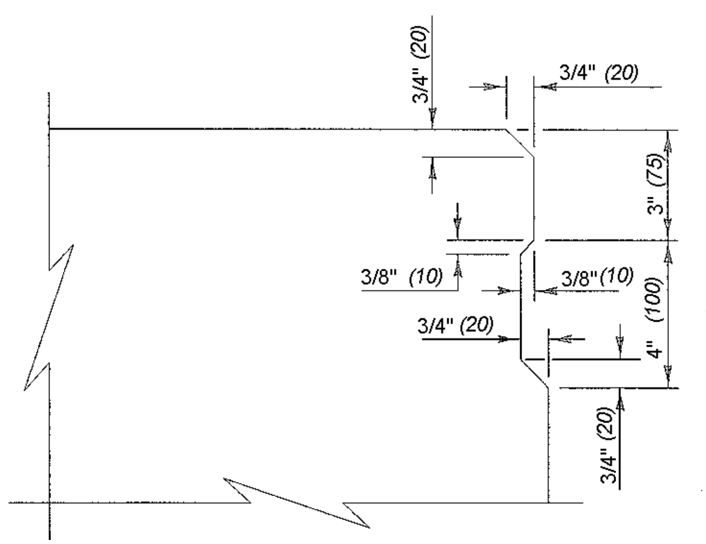
- All prestress multi-beam deck units will have concrete overlays except:
  - For Prestress, multi-beam, deck units on gravel surface town highway, the designer may choose between a concrete overlay with no pavement or a waterproofing membrane and pavement with no overlay.
  - For Prestress, multi-beam, deck units on low volume, paved, town highways, the designer may choose to eliminate the concrete overlay and use a waterproofing membrane and pavement.
- Overlays will be Concrete Class "AA" unless the designer has a special circumstance that requires a different class of concrete.
- The minimum overlay thickness will be 5" *(130 mm)*.
- If the designer chooses not to use an overlay, the decision must be documented in the project file, along with appropriate justification.

19.4.3 Shear Keys

Figures 19-3 and 19-4 show the shear key details. All prestress projects will require these details. The details shown can be found in CADD cells.

Figure 19-3 (a)

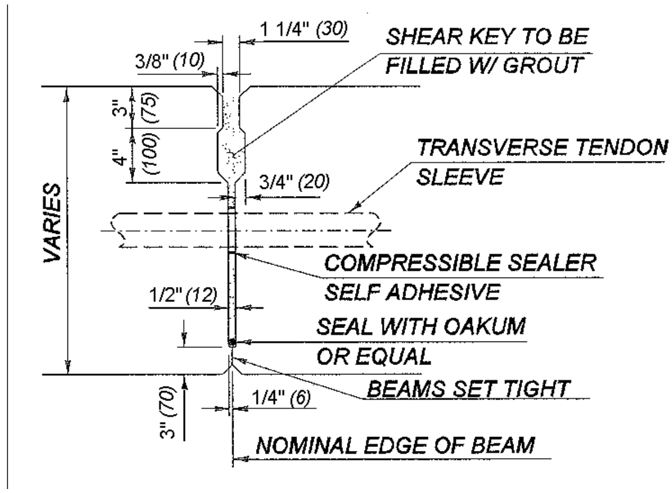
Shear key detail for voided slabs



All dimensions shown in parentheses are in millimeters

Figure 19-3 (b)

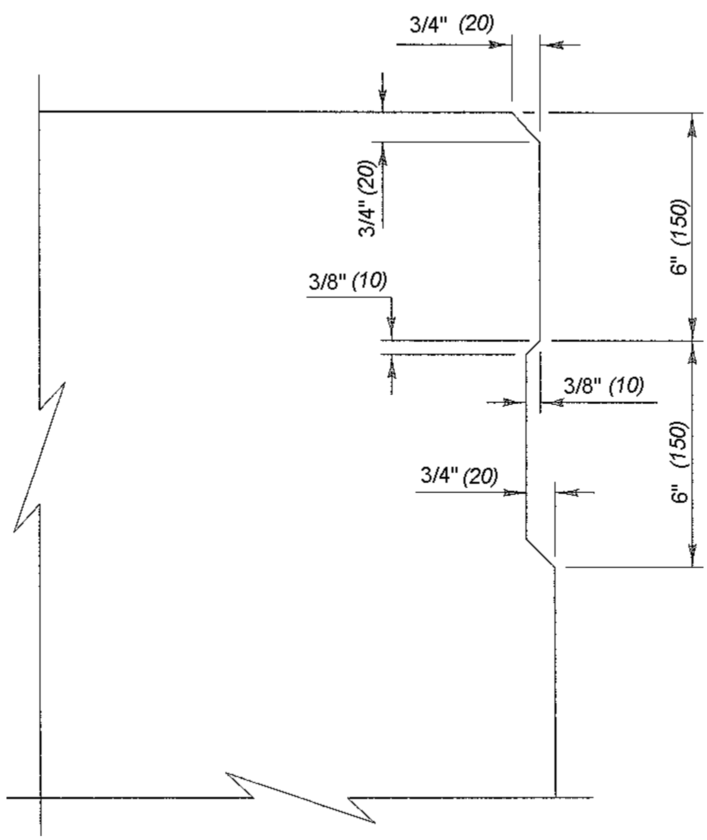
Shear key section for voided slabs



All dimensions shown in parentheses are in millimeters

Figure 19-4 (a)

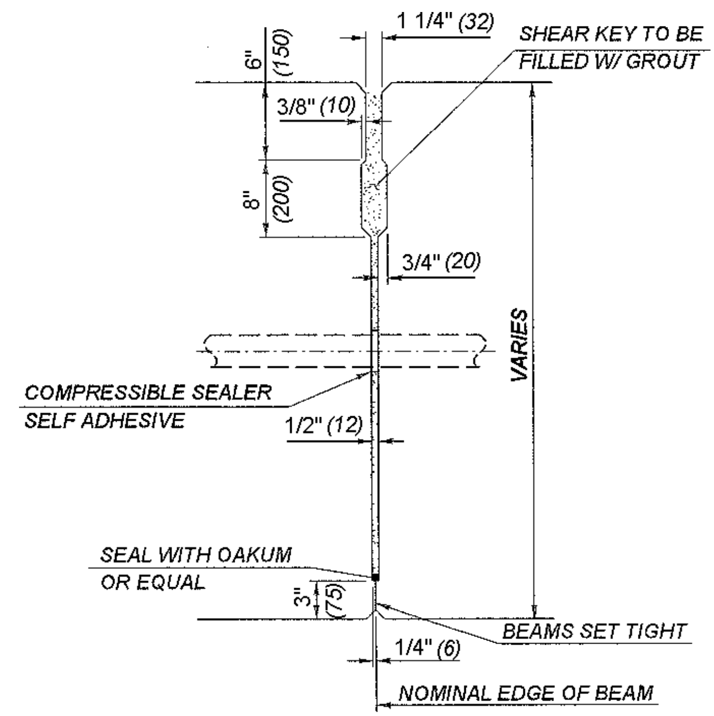
Shear key detail for box beams



All dimensions shown in parentheses are in millimeters

Figure 19-4 (b)

Shear key section for box beams



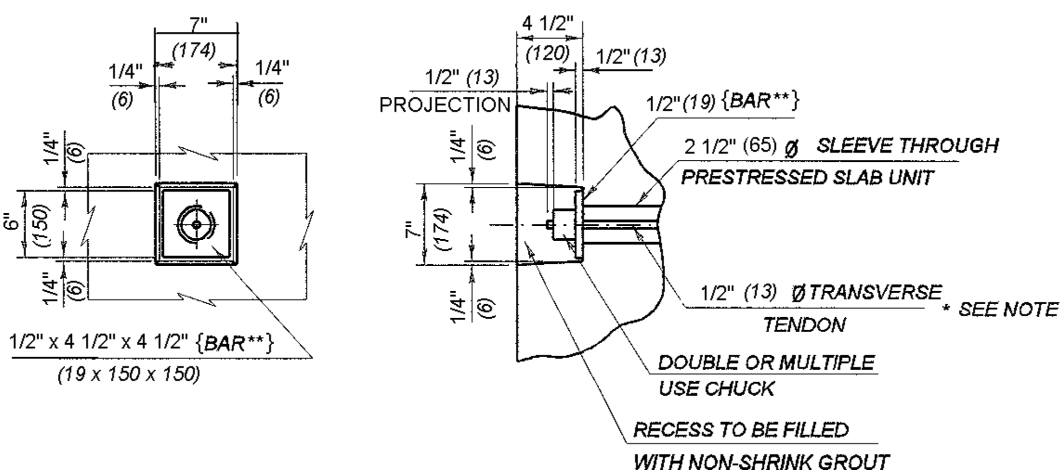
All dimensions shown in parentheses are in millimeters

19.4.4 Transverse Tendons

- The designer shall no longer use transverse tie rods. Using transverse tendons will be the preferred practice. Figure 19-5 is the detail needed for the plans and this is a cell.

Figure 19-5

Transverse Tendon detail



All dimensions shown in parentheses are in millimeters

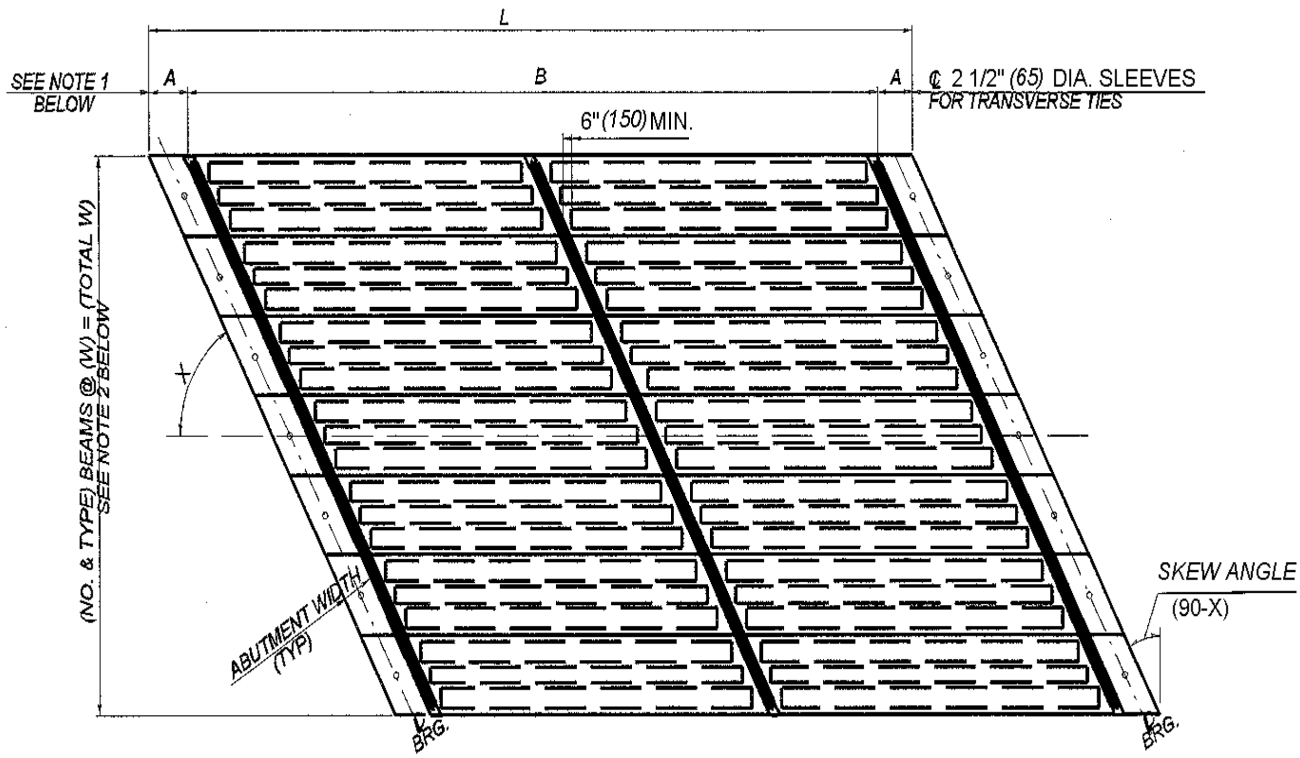
** AASHTO M270 Grade 50 steel *(M270/M270M, Grade 345 Steel)*

* Transverse Ties Shall Be Covered By Seamless Polypropylene Sheath [With Corrosion Inhibiter Grease Between Sheath And Strand] For The Length Of Strand, Except At Anchorage Locations, Ties Shall Be Tensioned to 30,000 lbs *(133.5 kN)*.

- Figure 19-6 shows the spacing guideline for transverse tendons for voided slabs. Figure 19-7 and Figure 19-8 show the guideline for box beams
- Post-tensioning of the transverse tendons will follow the construction guidelines detailed in section 19-5 in this manual.
- Tension transverse tendons to 30,000 lbs *(133.5 kN)*.

Figure 19-6

Framing plan for prestressed voided slab units

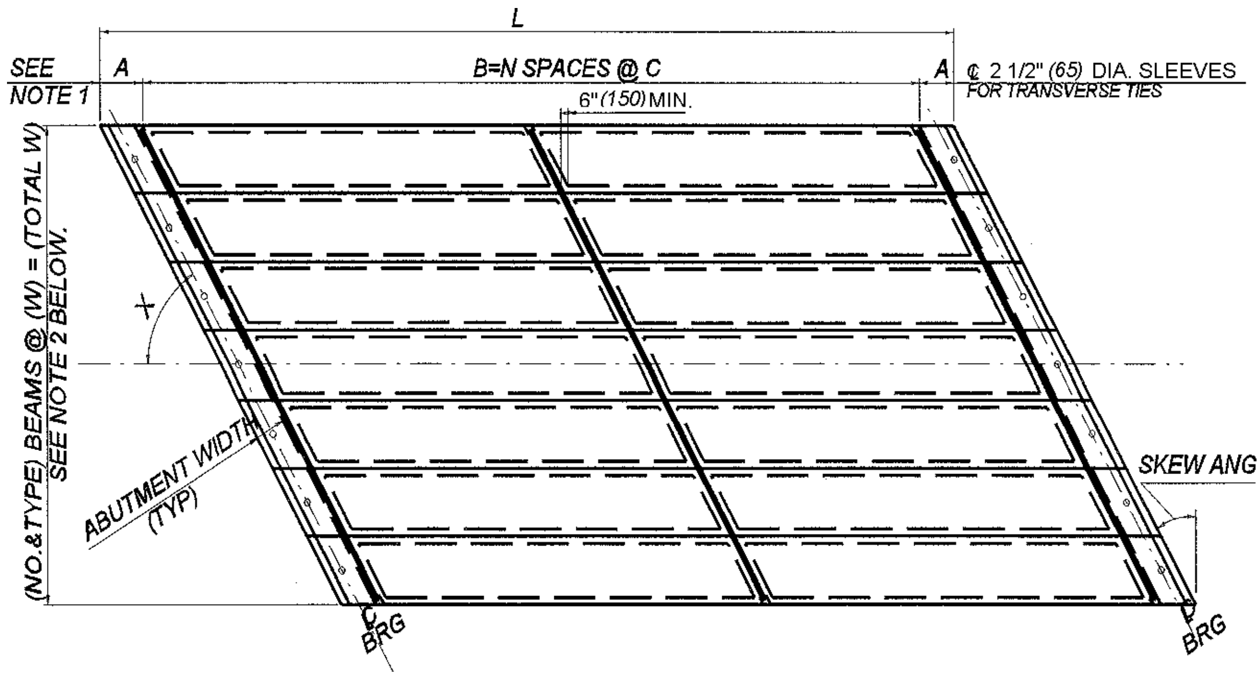


1. A =(ABUTMENT WIDTH / COS (SKEW ANGLE))+ 6" (150)
   L =(SPAN LENGTH + A)OR((℄ BRG TO ℄ BRG) + A)
   B =(L - (2 X A))
2. SPECIFY BEAM TYPE. USE ONLY NOMINAL BEAM WIDTHS WHEN SPECIFING BEAM WIDTH (W) AND CALCULATING TOTAL WIDTH (TOTAL W).
3. FRAMING PLAN SHALL BE DRAWN FULL LENGTH WITHOUT BREAKS AND TO SCALE ON THE CONSTRUCTION PLANS. SHOW ALL INTERNAL VOIDS AND TRANSVERSE TIES.
4. IF TORSIONAL LOAD IN FASCIA BEAMS (DUE TO SIDEWALK OVERHANG OR UTILITIES) IS EXCESSIVE, CONSIDERATION WILL BE GIVEN TO INCREASING THE NUMBER OF STANDS AND/OR POST-TENSIONING AND ADJUSTING TRANSVERSE TIE LOCATIONS AS NECESSARY.

All dimensions shown in parentheses are in millimeters

Figure 19-7

Framing plan prestressed box beam units



1. *A =(ABUTMENT WIDTH / COS (SKEW ANGLE))+ 6" (150)*
   L =(SPAN LENGTH + A)OR((℄ BRG TO ℄ BRG) + A)
   B =(L - (2 X A))
   C = B/N WHERE N = NUMBER OF INTERNAL VOIDS
2. *SPECIFY BEAM TYPE. USE ONLY NOMINAL BEAM WIDTHS WHEN SPECIFING BEAM WIDTH (W) AND CALCULATING TOTAL WIDTH (TOTAL W).*
3. *FRAMING PLAN SHALL BE DRAWN FULL LENGTH WITHOUT BREAKS AND TO SCALE ON THE CONSTRUCTION PLANS, SHOW ALL INTERNAL VOIDS AND TRANSVERSE TIES.*
4. *SEE TABLE 1 FOR TRANSVERSE TIE LOCATIONS.*
5. ***ENDS OF VOIDS SHALL BE PARALLEL TO FACE OF ABUTMENT.***

All dimensions shown in parentheses are in millimeters

Figure 19-8 Transverse tie locations for box beams

Beam Depth	Span Length	Toe Locations				Top Strand	Bottom Strand†
		Ends	1/4 Points	1/3 Points	Midspan		
27" Deep (690 mm)	< 50'-0" (15.0 m)	✓			✓	✓	
	> 50'-0" (15.0 m)	✓		✓		✓	
33" Deep (840 mm)	< 75'-0" (23.0 m)	✓		✓		✓	
	> 75'-0" (23.0 m)	✓	✓		✓	✓	
39" Deep (990 mm)	< 75'-0" (23.0 m)	✓		✓		✓	✓
	> 75'-0" (23.0 m)	✓	✓		✓	✓	✓
42" Deep (1070 mm)	All	✓			✓	✓	✓

If the torsional load in the fascia beams (due to sidewalk overhangs or utilities) is excessive, consider increasing the number of transverse ties and/or the post-tensioning force. Adjust the transverse tie locations as necessary.

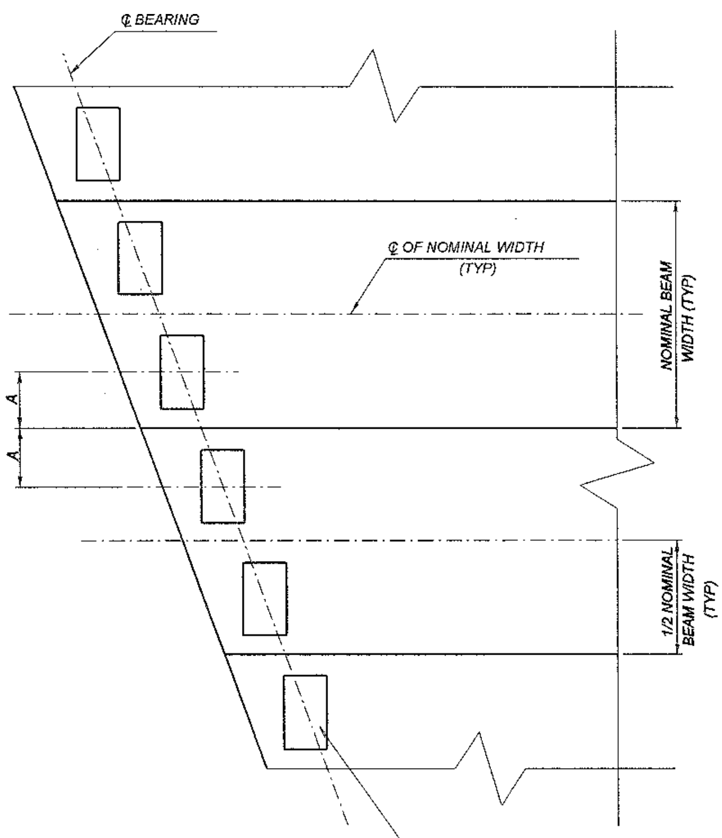
†The designer is to verify that no conflict exists with the prestressing strands and the transverse tendons.

19.4.5 Bearings

- All box beams and voided slabs will require the use of two elastomeric bearing pads per end. Figure 19-9 is the standard bearing placement detail.
- Place a table on the plans to indicate the bridge seat elevations for each bearing. Also, designers will continue to provide elevations at the fascias and centerline for each abutment.
- Pay for bearings as a separate item [i.e., not as part of the Prestress item]. The designer must be sure to modify the Prestress item to do this. 510.20 in the Specifications includes the cost of the bearings in the bid price for the prestress unit.

Figure 19-9

Layout of bearings for all spans.



19.4.6 Bridge End Details

- Figures 19-11 [a-h] contain the approved bridge end details for voided slabs and box beams. Use these on all prestress projects. Refer to the flow chart in Figure 19-10 to select the proper bridge end detail.

- Use backwalls for all boxes with approach slabs and for those without approach slabs when the skews are 30° or greater. For 27" *(690 mm)* deep box beams, the designer may use the voided slab end details when an approach slab is present.

Figure 19-10

Flowchart used for selecting end of bridge details.

Refer to the next eight figures for use with this chart.

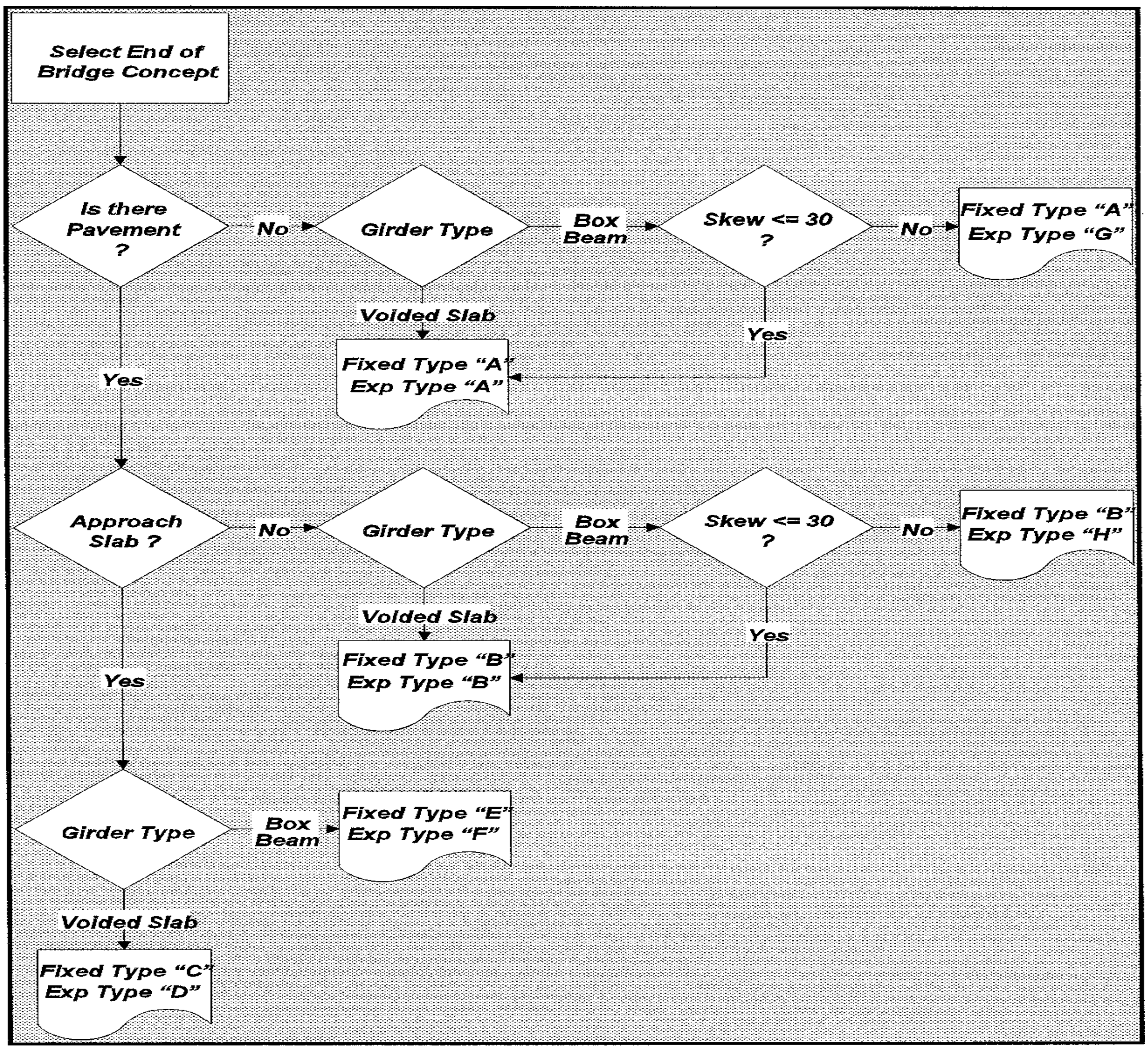
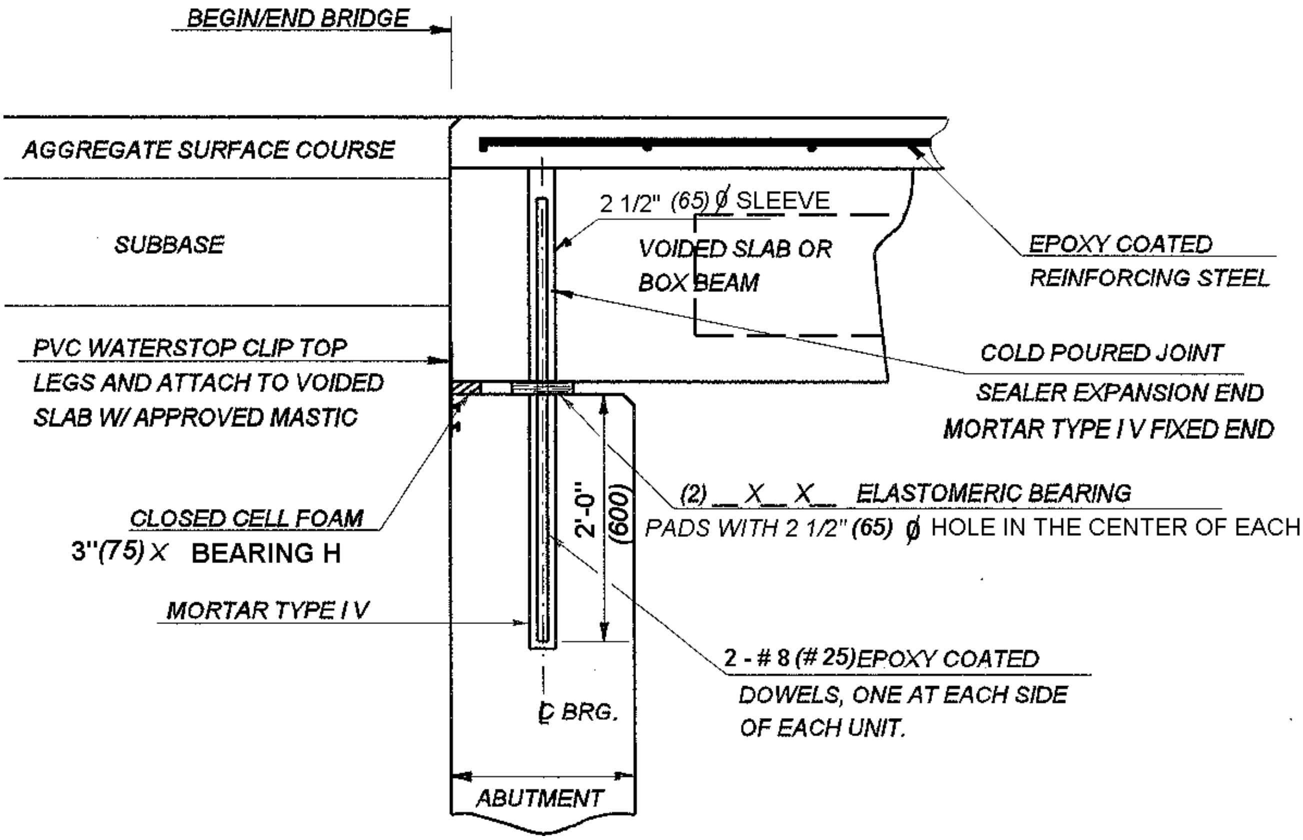


Figure 19-11 (a)

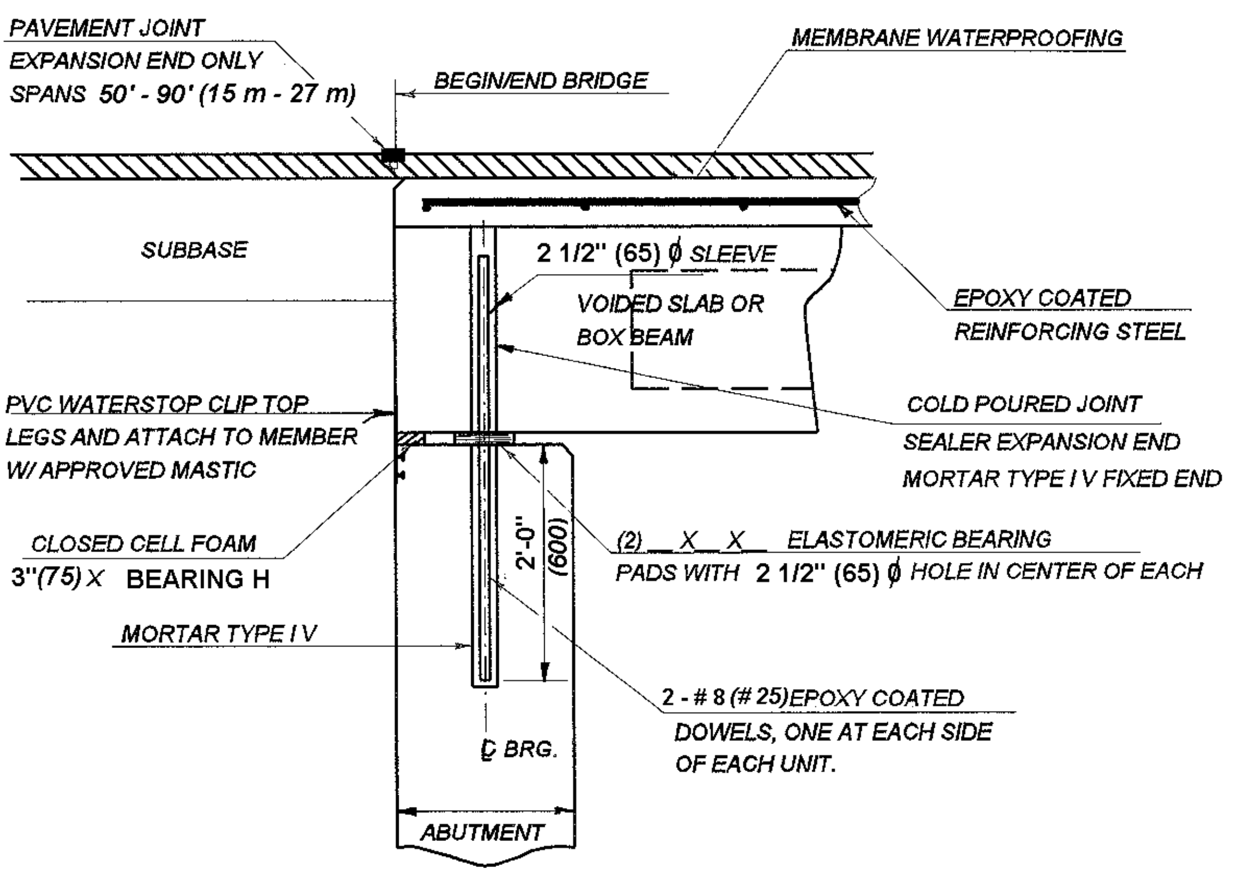
Type "A" voided slab or box beam with no pavement or approach slabs.



All dimensions shown in parentheses are in millimeters

Figure 19-11 (b)

Type "B" voided slab or box beam with pavement but no approach slabs.

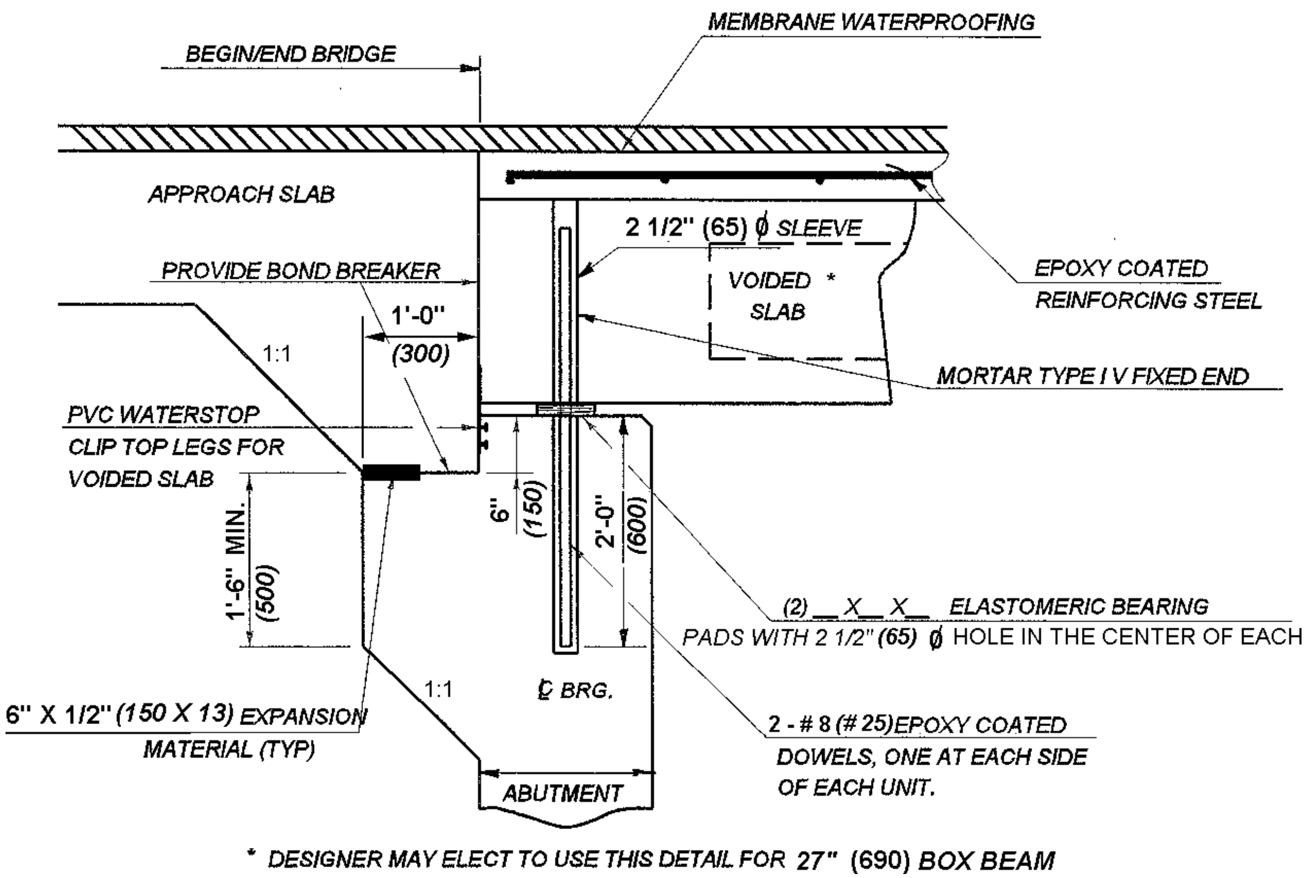


All dimensions shown in parentheses are in millimeters

Figure 19-11 (c)

Type "C" voided slab with pavement and approach slabs.

Use this detail for a fixed bearing set-up

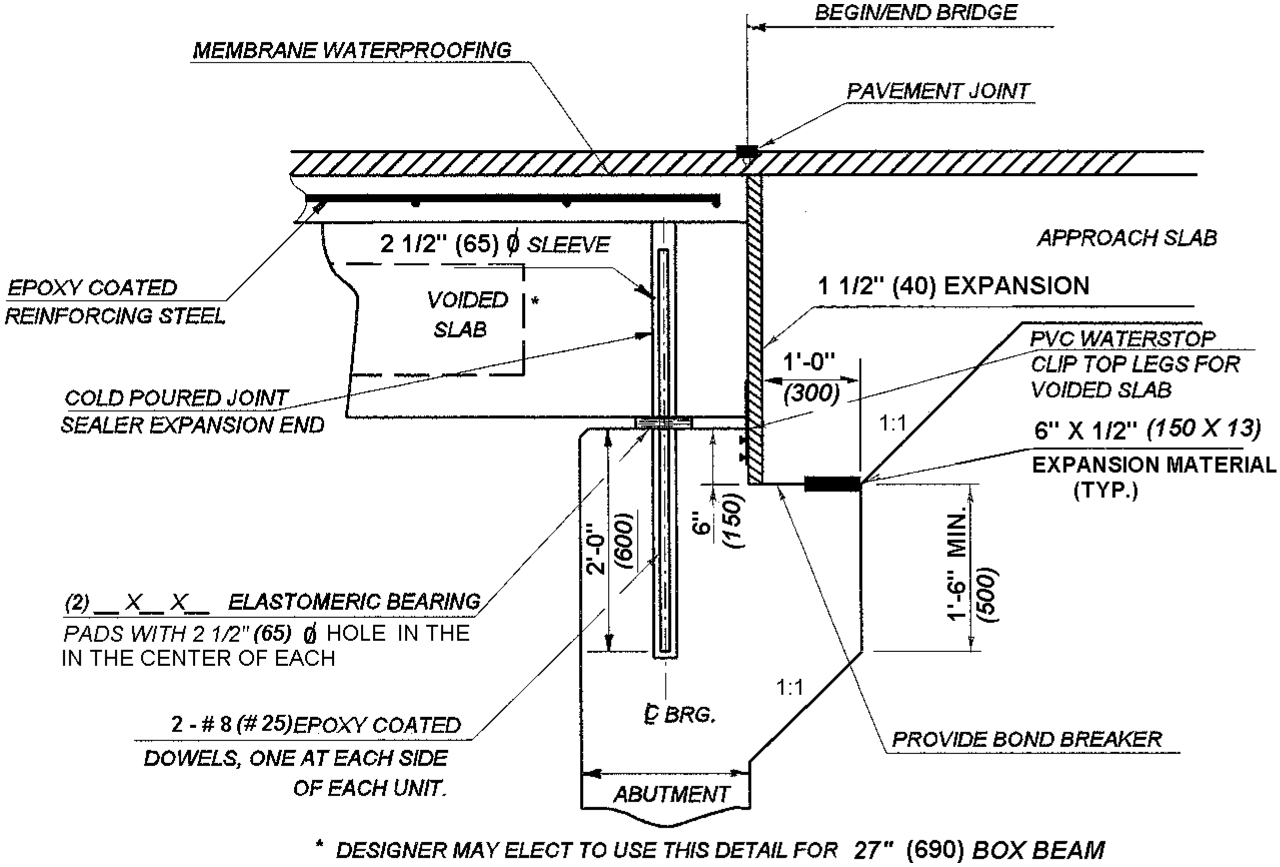


All dimensions shown in parentheses are in millimeters

Figure 19-11 (d)

Type "D" voided slab with pavement and approach slabs.

Use this detail for an expansion bearing set-up

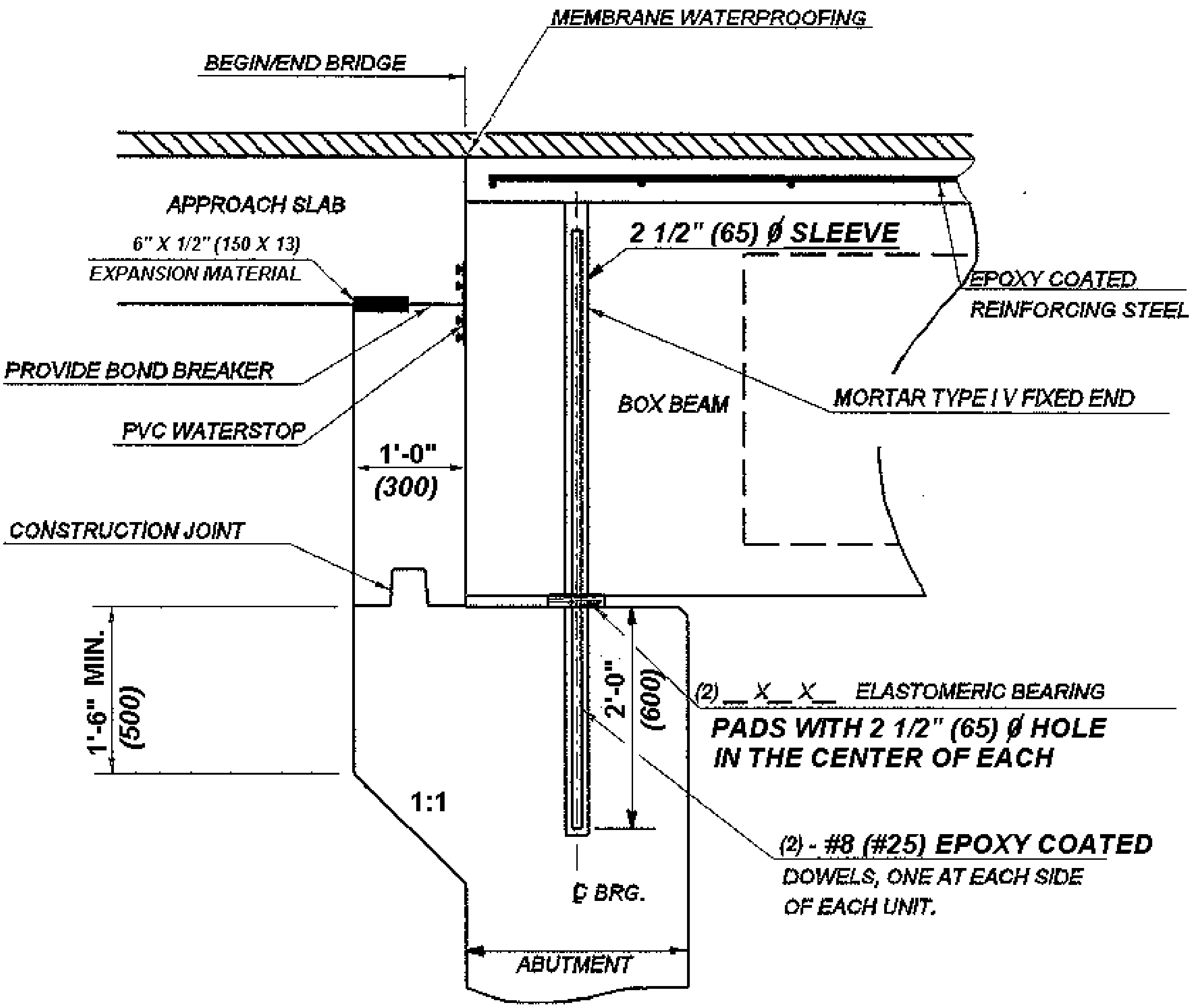


All dimensions shown in parentheses are in millimeters

Figure 19-11 (e)

Type "E" box beam with pavement and approach slabs.

Use this detail for a fixed bearing set-up

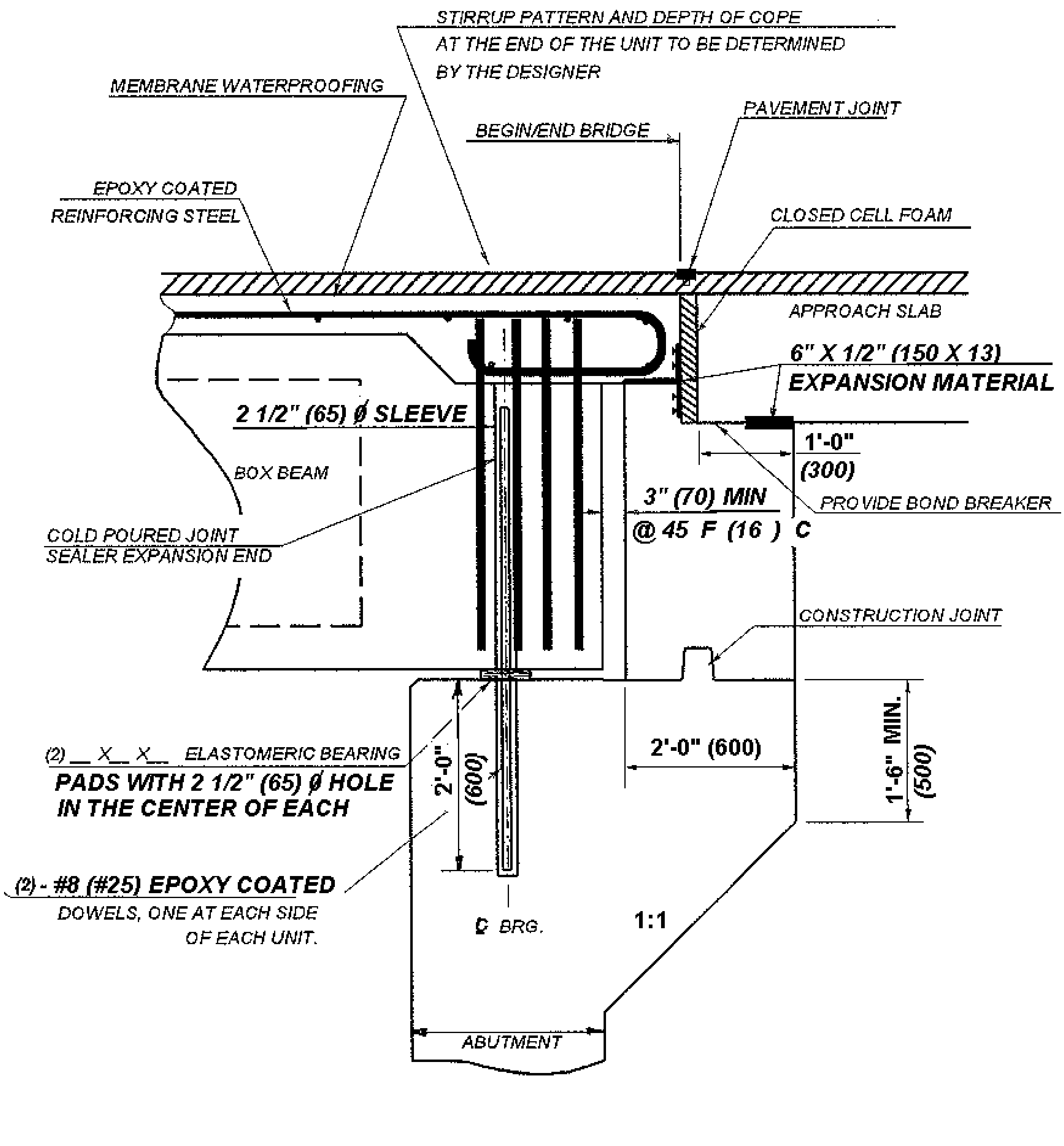


All dimensions shown in parentheses are in millimeters

Figure 19-11 (f)

Type "F" box beam with pavement and approach slabs.

Use this detail for an expansion bearing set-up

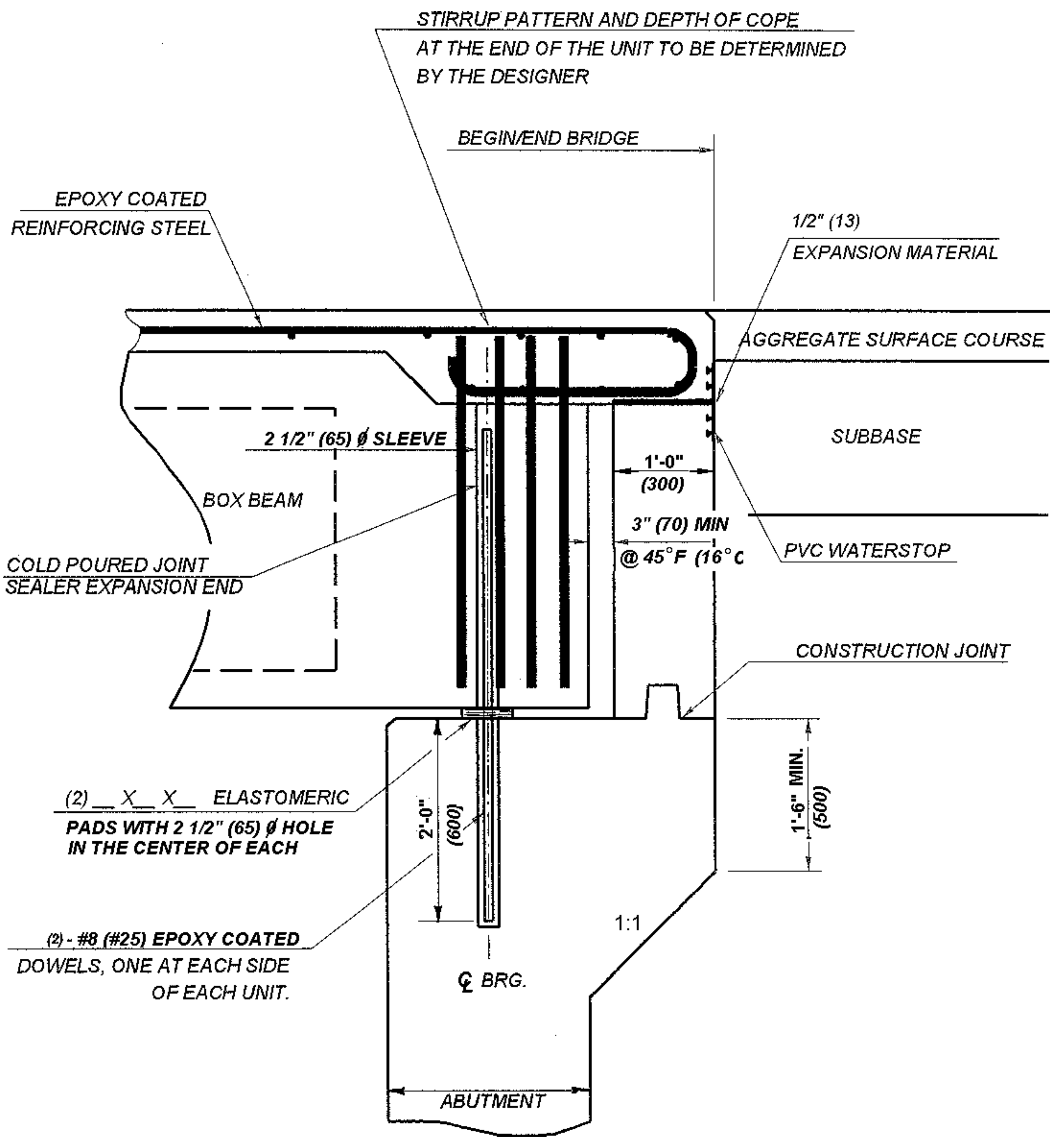


All dimensions shown in parentheses are in millimeters

Figure 19-11 (g)

Type "G" box beam with no pavement or approach slabs.

Use this detail for skews over 30 ° and expansion bearing set-ups

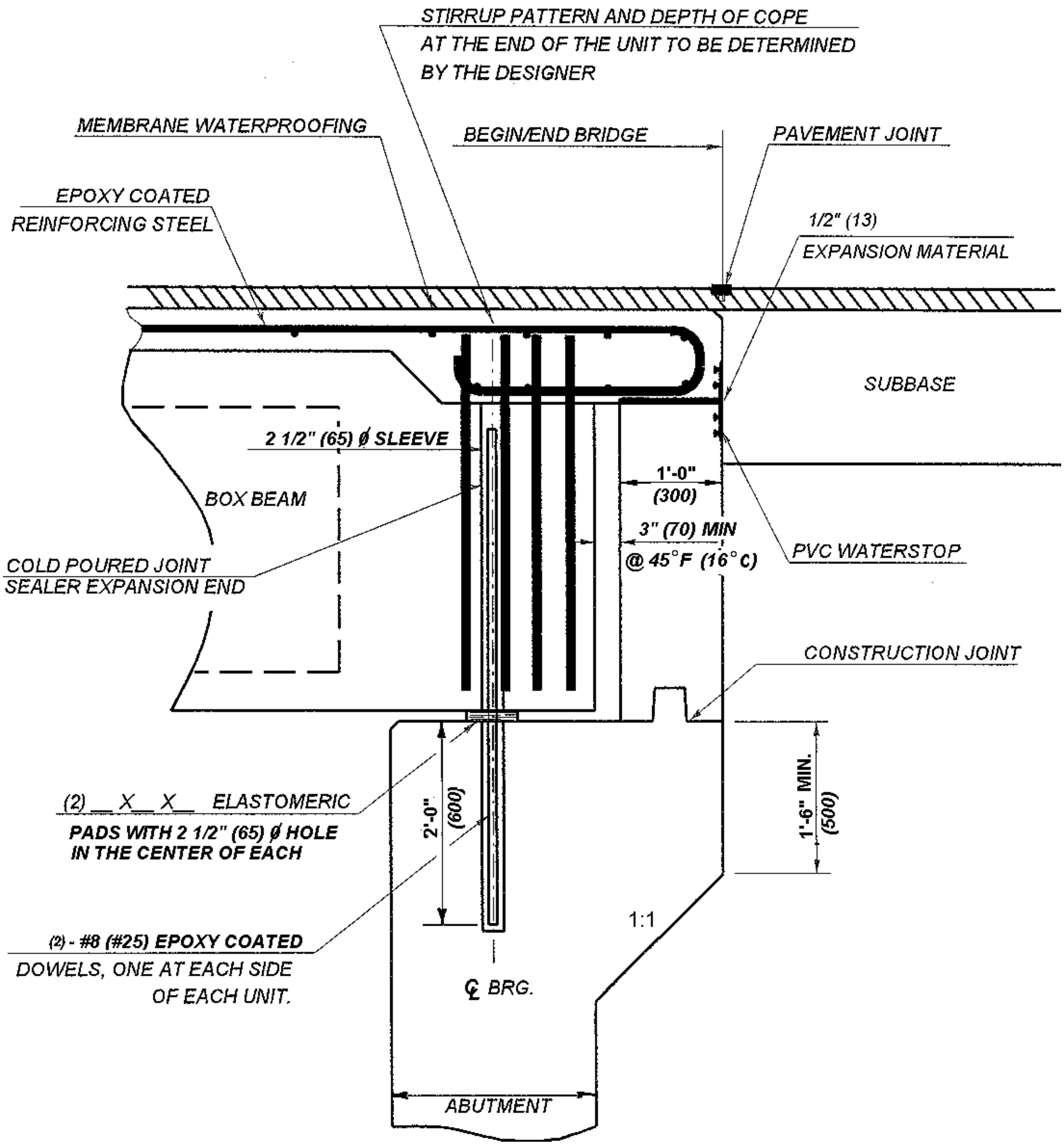


All dimensions shown in parentheses are in millimeters

Figure 19-11 (h)

Type "H" box beam with pavement and no approach slabs.

Use this detail for skews over 30 ° and expansion bearing set-ups



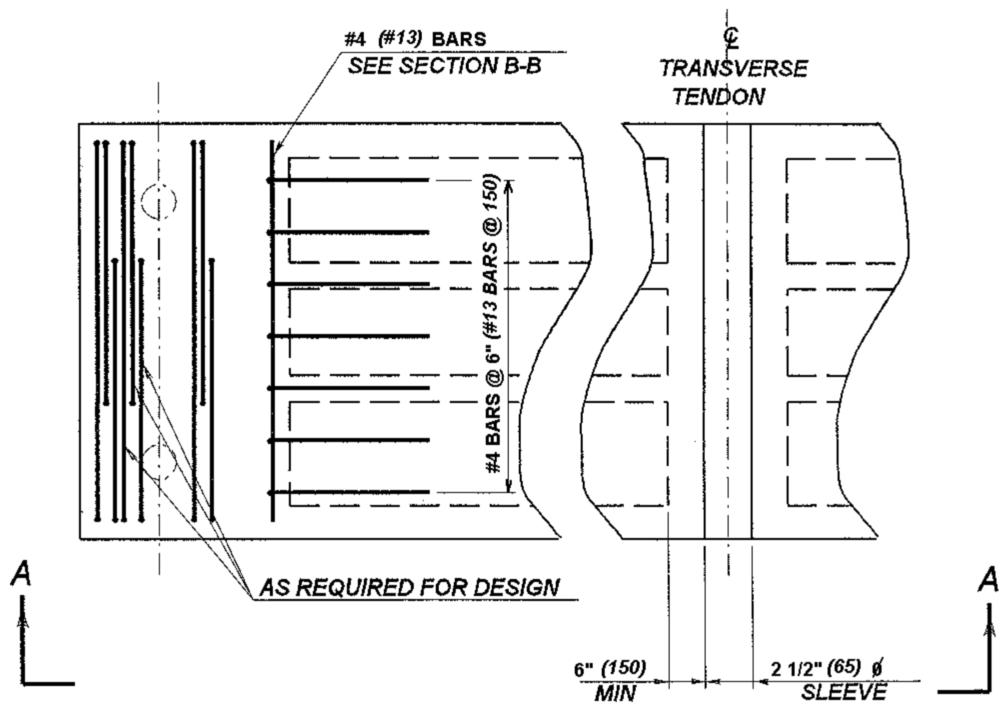
All dimensions shown in parentheses are in millimeters

19.4.7 End Blocks

Voided Slabs require end blocks. Use end blocks where the beam has a break in the void [i.e., location of a transverse tendon]. End blocks are on both sides of the voids to handle any bending stresses that cross the voids. An example of end blocks details are as shown on Figure 19-12.

Figure 19-12 (a)

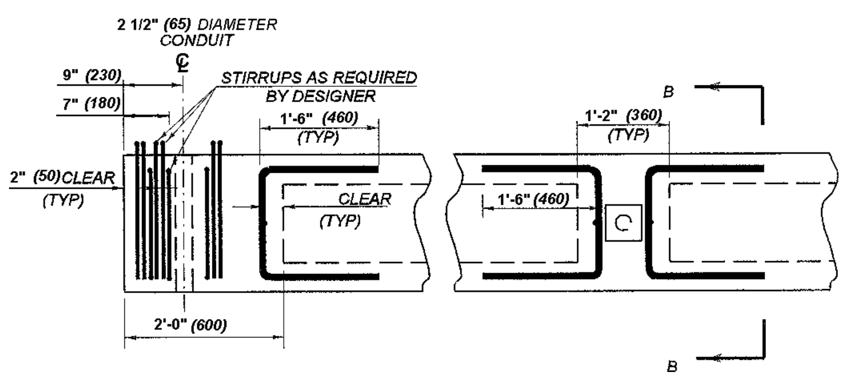
Plan of end block detail



All dimensions shown in parentheses are in millimeters

Figure 19-12 (b)

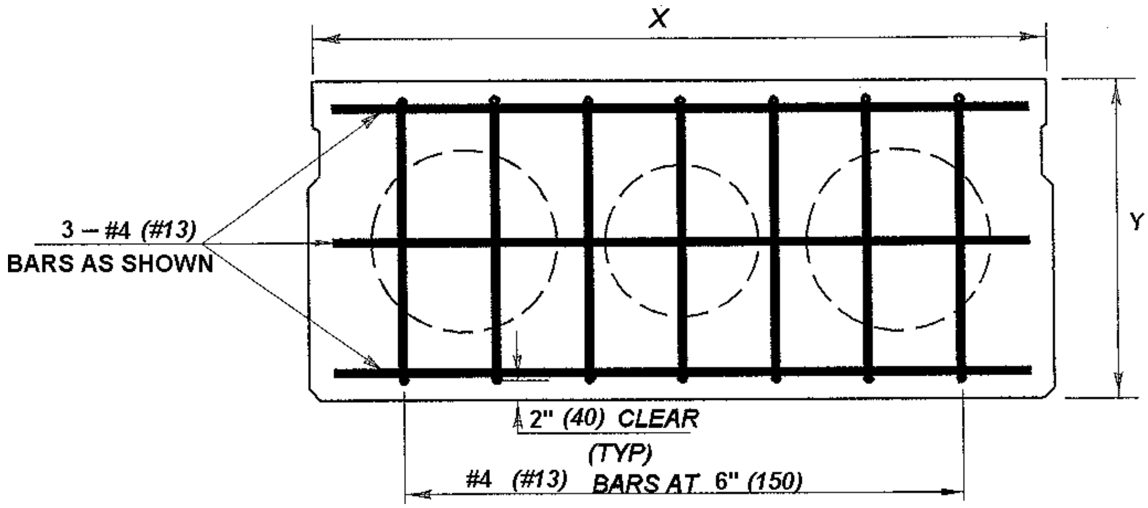
Section A-A of Figure 19-12a showing elevation of the block end detail.



All dimensions shown in parentheses are in millimeters

Figure 19-12 (c)

Section B-B from Figure 19-12b showing section of block end detail



All dimensions shown in parentheses are in millimeters

19.4.8 Void Drains

All voided slabs and box beams require void drains. This does not require a detail, but do add a note to the project plans. The note should state that "the drain hole is $^3/_4$" *(20 mm)* diameter, nonferrous and the drains will be cleaned after erection."

19.4.9 Strand Patterns

- The Structures Section has developed strand patterns for all sizes of voided slabs and box beams [see appendix G .] These are not cells, but design details that the designer can use on a project by project basis. The designer simply eliminates the strands the beam design does not require. The stirrup patterns will stay the same. However, the quantity and/or size of the stirrups may be different. The designer may design the number of strands for each row, but may not alter the clearances detailed in the figures. This is to provide consistency among designers in strand patterns and clearances.
- The first row of the strands has been set at 2 $^3/_4$" *(70 mm)* from the bottom of the unit. The designer should not deviate from this distance.
- Designers will continue to have the option of designing debonded strands or adding reinforcing steel in the top portion of the units.
- All ties and stirrups will be epoxy coated.

19.4.10 Curbs

The designer should not have curb steel extending from the prestress units. Instead, incorporate the curb steel into the overlay. This results in no problems or concerns regarding the curb steel in the flares at the ends.

19.5 CONSTRUCTION

The following is a suggested sequence of construction and is included to inform the designer of how these units go together. This sequence, or parts of it, may be included in the plans to assist the contractor and resident engineer.

19.5.1 Sequence of Construction for Prestressed Voided Slabs and Box Beams

19.5.1.1 Layout Working Lines

- Lay out working lines for the bridge's entire width on the beam seat. Measure all working lines from a common working point.

- The working lines are to be based on the nominal beam widths.

19.5.1.2 Verify Beam Seat Elevations

- Take elevations at beam seats.
- If seats are high, grind to correct elevations.
- If seats are low, add shims.
- Install bearings.

19.5.1.3 Erect Beams

- Beams shall be placed to fit within the working lines.

- As work progresses, install hardwood wedges between adjacent beams to maintain proper joint opening [a minimum of one wedge at each lateral tie].

19.5.1.4 Install Oakum or Equivalent Joint Filler [backer rod]

- Filler shall be placed below the key's bottom as shown on the Plans.

19.5.1.5 End Details

- Grout Dowel Ends at the Fixed Ends at Bridge Seats and Place Cold Poured Joint Sealer at Expansion End

19.5.1.6 Install Transverse Ties

- A seamless polypropylene sheath shall cover ties [with corrosion inhibitor grease between sheath and strand].

- Feed ties through ducts.

- Verify that hardwood wedges are in place as required to prevent slippage of beams.

- Using calibrated jack, post-tension ties to approximately 5000 lb *(22.2 kN)* to remove sag in the tie and to seat the chuck.
- For stage construction, protect the second stage ducts at the joints, with the second stage strand in place, or Styrofoam over the duct opening.

19.5.1.7 Grout Shear Keys

- Clean joint with an oil free air-blast immediately before grout placement. Then verify that the backer rod is still in place.
- Additional joint preparation and grout placement shall be per manufacturer's recommendations.
- Carefully rod joints to eliminate any possibility of voids.

19.5.1.8 Post-Tension Transverse Ties

- Grout shall attain a minimum compressive strength of 1500 psi *(10.3 MPa)* , based on the manufacturer's recommendations, prior to stressing.
- Using a calibrated jack operated by qualified personnel, post-tension ties to 30,000 lbs *(133.5 kN)*.

19.5.1.9 Finish Work

- Remove wedges, and patch deck and fascia beams at transverse ties.
- Place an overlay [except end detail types "F," "G," and "H" see Figures 19-11 (f), (g) and (h)].
- For end detail types "F," "G," and "H," [see Figures 19-11 (f), (g) and (h)] place a backwall first and then place an overlay.
- Place an approach slab.

19.5.2 Construction Joints

The designer should place a construction joint at the bridge seat on the substructures for their project. Also, the following note should be added to the project plans: "Concrete will not be placed above the bridge seat elevations until the Prestress units have been set."

19.6 REINFORCEMENT

19.6.1 Non-prestressed Reinforcement

Use Grade 60 *(420)* billet steel bars for non-prestressed reinforcement in all prestressed concrete members. All bars shall be epoxy coated.

19.6.1.1 Criteria for Strand Development Length

Determine the development length for all strand sizes up to and including 0.6 inch *(15.24 mm)* diameter strands as 1.6 times AASHTO equation 9-32.

19.7 CONTINUITY

The designer should strive toward designing the superstructure as simple spans, and then place the overlay as if the bridge were continuous.

Occasions arise where the designer must use continuity. If this is true, use the live load condition and super dead load condition as load cases for continuity. To calculate reasonable live load moments in the negative moment region, the designer must make a careful assessment of how to model the continuous structure. The structure has no dead load point of contraflexure.

The negative moment region and the overlay are cast-in-place concrete. Use the AASHTO Section 8 Reinforced Concrete Provisions to design the overlay and to check flexural cracking in the overlay.

There exists research that recommends the use of positive moment reinforcement over a pier. The NCHRP Report 322 covers this topic in detail.

Chapter Twenty

Structural Steel

20.1 GENERAL DESIGN

Refer to AASHTO Section 10 for more information.

Design Methodology—Use the Load Factor Design concept for all structural steel design.

20.2 STRUCTURAL STEEL DESIGN

20.2.1 Standard Steel for Design [Weathering Steel]

Unless otherwise specified, use AASHTO M270, Grade 50W *(M270/M 270M, Grade 345W)* unpainted structural steel in all new construction, with the following exceptions:

20.2.1.1 Tunnel Environments

Bridges built in the so-called tunnel environment should not have unpainted steel. The definition for this environment is a highway bridge over a highway in which the road under has minimal clearance and vertical abutments close to the edge of the pavement.

20.2.1.2 Humid Environments

Do not use unpainted steel in areas of high humidity, such as downstream from dams. For all structures built over streams, do not use weathering steel unless the clearance from Ordinary Low Water level to the bottom of the steel is at least 10'-0" *(3.0 m)*.

20.2.1.3 Submerged or Buried Structures

Avoid weathering steel where the steel may be continuously submerged in water, buried in soil or covered by vegetation or splashed continually by a stream.

20.2.2 Plate Girder

While designing a plate girder with weathering steel, determine the actual thickness of material that the design needs and then add $^{1}/_{16}$" *(2 mm)*. After the addition of the extra thickness for future deterioration, the design thickness plus tolerance shall be rounded up to the reasonable plate thickness available. Do not round up the design value and then add the extra thickness for deterioration, as this can result in over conservative thickness.

20.2.3 Painted Joints

When a bridge is of such length as to require joints either at abutments or piers, protection should be given to the weathering steel in the areas of those joints. Therefore, any bridge constructed with weathering steel which has joints should have all steel components, including cross frames and connection plates that are a distance of 2 times the depth of the web from the end of the beam coated with a protective system according to section 513 of the specifications.

20.3 PAINTED STRUCTURES

For structures requiring painting, use AASHTO M 270 grade 50 or grade 36 *(AASHTO M 270/ M 270M, grade 345 or grade 250).*

20.3.1 Standard Paint Color

For all projects which are primarily constructed of weathering steel, any elements which are to be painted, will be painted brown, color chip 20059. On other painted structures, aethsetics and local opinion should be taken into account in selecting a color. If the bridge rail to be used is black, consider painting the steel black, color chip number 27038. The color chip number for green is 14062.

20.4 SPLICES AND CONNECTIONS

- In general, bolt all field connections. The designer shall avoid the use of field welded details.
- For lengths of 135’ to 150’ *(40 m to 45 m),* a splice is optional and shall not be a pay item. However, the designer shall design the splice and place a detail showing the splice in the plans.

20.4.1 Fasteners

Unless otherwise specified, fasteners shall be $^{7}/_{8}$” *(22 mm)* diameter high strength bolts, AASHTO M 164M *(M 164M),* in $^{15}/_{16}$” *(24 mm)* diameter holes.

- For weathering steel use Type III bolts.
- For painted steel use Type I bolts, galvanized.

20.4.2 Slip Critical Design

Design bolted splices as “slip critical,” as defined in AASHTO 10.24.1.4 and AASHTO 10.56.1.4. Where connections are subject to linear loads [i.e., flange splices], the formula given in 10.57.3.1 shall be checked. In addition, all splices shall be checked as a bearing type connection.

20.4.2.1 Slip Coefficients

Check splices as slip critical connections for Class B or Class C slip coefficients as appropriate.

20.4.3 Bolt Detailing

- Design joints with bolt threads excluded from the shear plane.
- Detail the contact surface of bolted parts as class B [blast clean surfaces.]

20.4.4 Non-Composite Areas

Design bolted splices in non-composite areas according to the following procedure. This procedure requires modifications for the design of a splice in a composite region.

- Determine maximum actual moments and shear values at the splice location [normally near the point of inflection].
- Assume some bolt pattern in flange and web; determine design section properties for the splice based on the net section of the weakest spliced member.
- Determine design moment and design shear force.

The design moment is based on the average of the design section moment capacity plus the actual maximum moment occurring at the splice. This should not be less than 75% of moment capacity of the design section.

20.4.5 Plate Girder

The design shear force is based on the average of the shear force capacity of the web plus actual shear force at the splice. This should not be less than 75% of the shear force capacity.

20.4.6 Rolled Beam

Use the design shear force as the actual maximum shear multiplied by the ratio of the splice design moment divided by the actual moment at the splice. This should not be less than 75% of the shear force capacity of the section. Use full depth of the beam for shear.

20.4.7 Design web splice

The web design moment shall be the sum of 1) total design moment multiplied by the net moment of inertia of the web divided by the net moment of inertia of the entire section; and 2) the moment due to eccentricity of the shear force introduced by the splice connection.

- Investigate bolt load [bolt in double shear].
- Investigate applied loads in splice plates based on both gross and net section of the plates using appropriate capacities.

20.4.8 Design Flange Splice

Design flange splices for that portion of the design moment not resisted by the web.

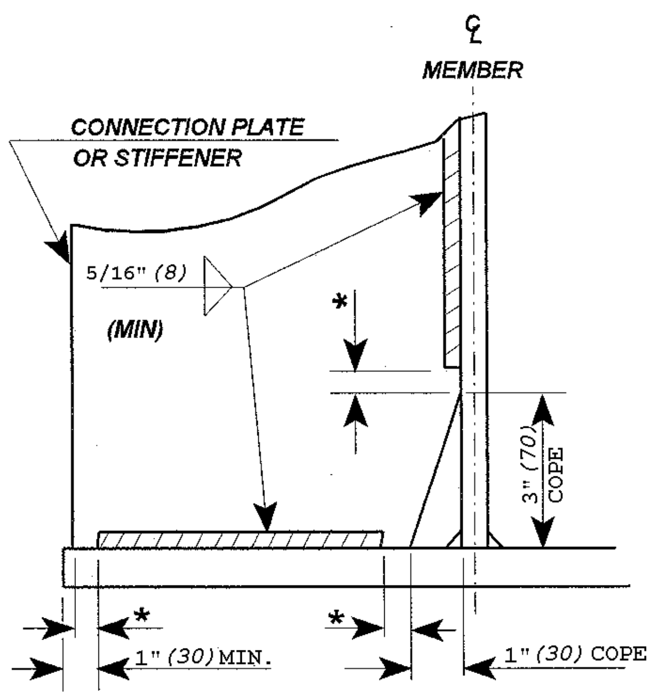
- Investigate bolt load [bolt generally in double shear].
- Investigate applied loads in splice plates, based on net section of the plate, using appropriate capacities.

20.5 WELDING

- Weld design, detail and weld material shall be according to ANSI-AWS-AASHTO D1.5.
- Avoid intersecting welds—cope stiffeners and connection plates 1 ” *(30 mm)* horizontal by 3 ” *(70 mm)* vertical.
- Do not use transverse welds on tension flanges, fracture critical or not, without fatigue analysis.
- Only Shielded Metal Arc Welding [SMAW] processes are acceptable without process and procedure qualification.
- Welds shall terminate $^1/_4$ ” *(6 mm)* minimum, $^1/_2$ ” *(13 mm)* maximum from ends of connection plates and bearing stiffeners. However, maintain a minimum of 1” *(30 mm)* from the edge of a flange. See Figures 20-1 through 20-8 for additional welding details.
- Refer to the manual “Economical and Fatigue Resistant Details, Participant Handbook” for more details on welded connections.

Figure 20-1

Weld termination and coping details for steel members

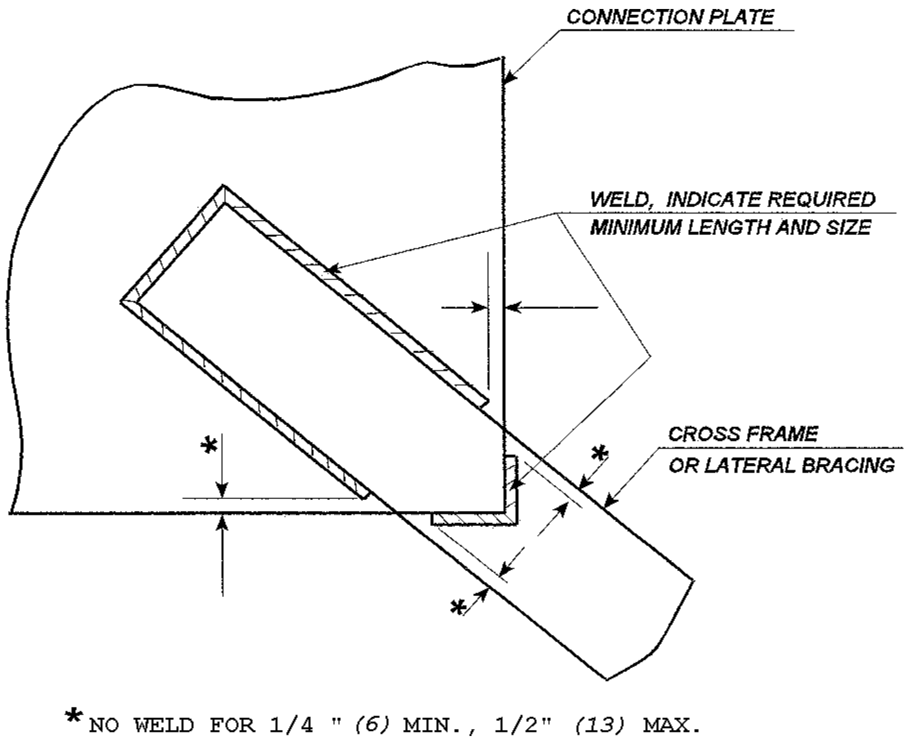


* NO WELD FOR 1/4" *(6)* MIN. 1/2" *(13)* MAX.
[EXCEPT MUST MAINTAIN 1" *(30)* MINIMUM FROM EDGE OF FLANGE]

All dimensions shown in parentheses are in millimeters

Figure 20-2

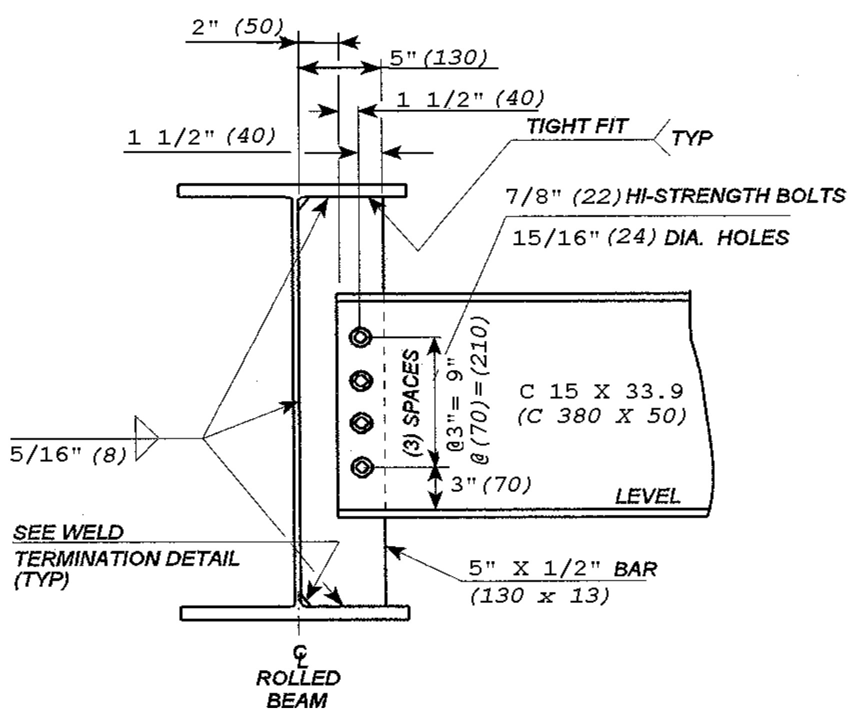
Weld location detail at cross frames and lateral bracing



All dimensions shown in parentheses are in millimeters

Figure 20-3

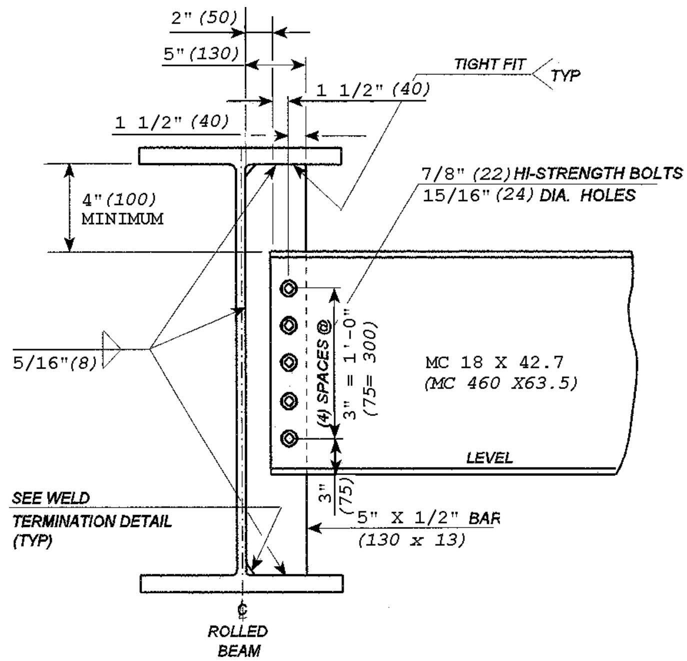
Intermediate diaphragms for 24" thru 30" (600 mm thru 760 mm) rolled beams



All dimensions shown in parentheses are in millimeters

Figure 20-4

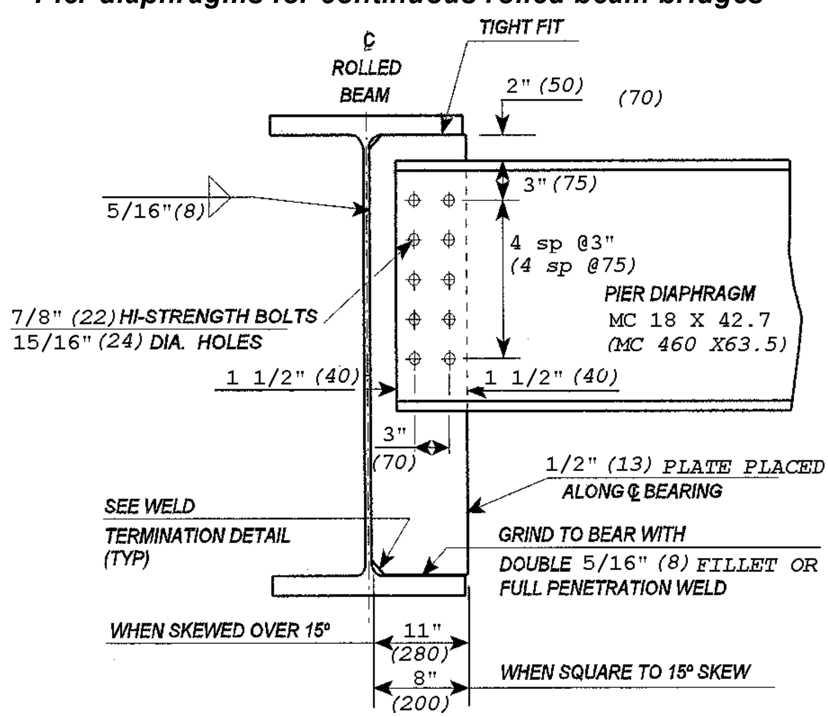
Intermediate diaphragms for 33" thru 36" (840 mm thru 920 mm) rolled beams



All dimensions shown in parentheses are in millimeters

Figure 20-5

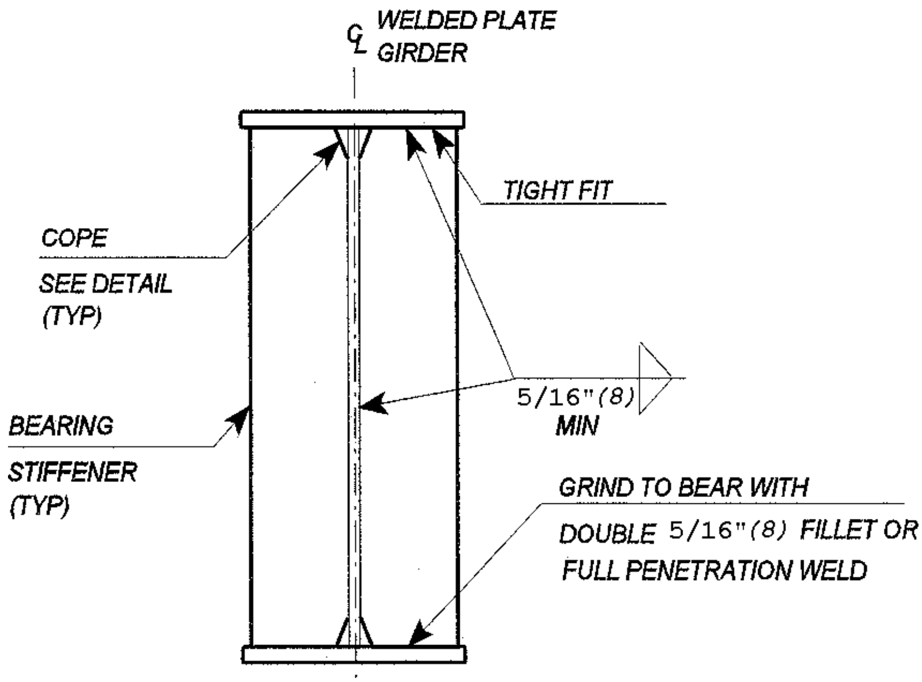
Pier diaphragms for continuous rolled beam bridges



All dimensions shown in parentheses are in millimeters

Figure 20-6

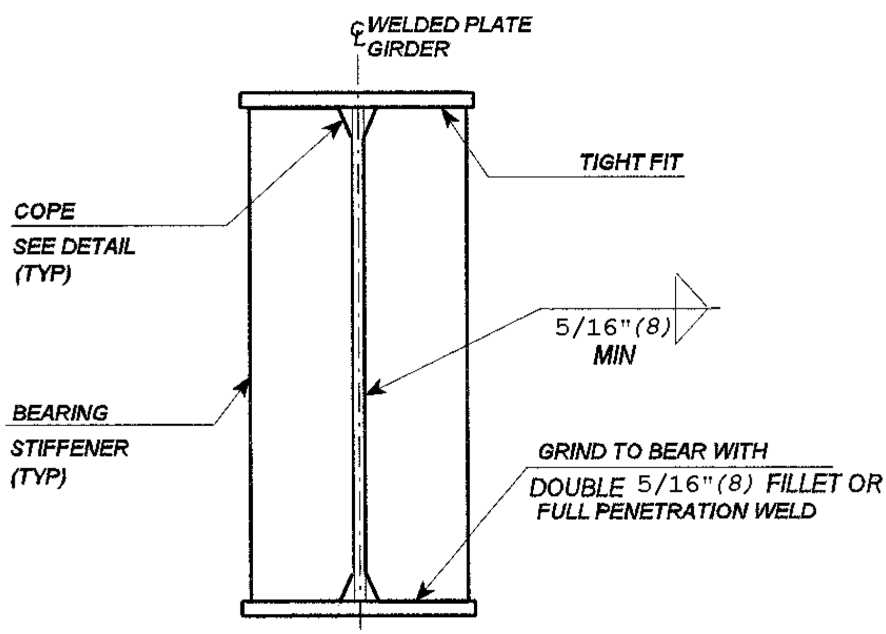
Abutment bearing stiffeners for welded plate girders



All dimensions shown in parentheses are in millimeters

Figure 20-7

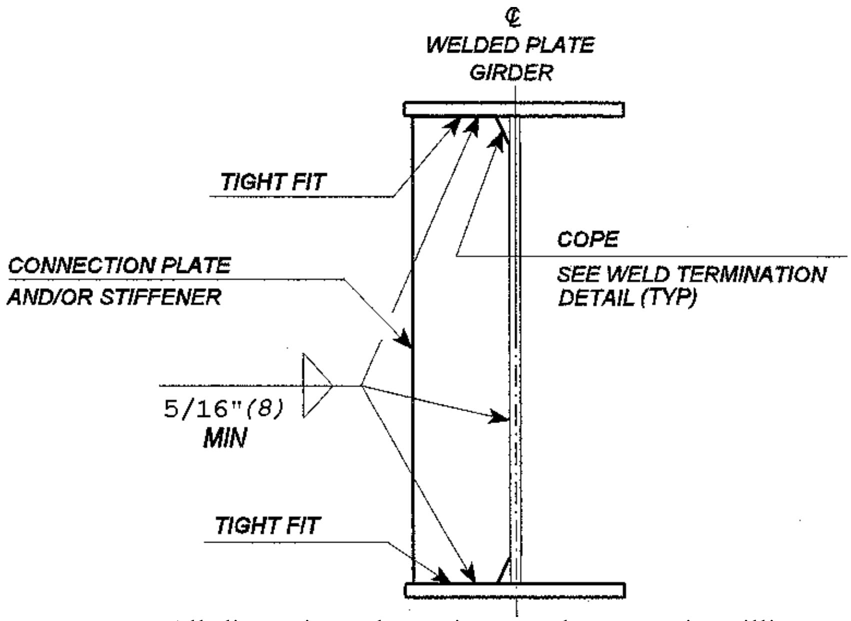
Pier bearing stiffeners for welded plate girders



All dimensions shown in parentheses are in millimeters

Figure 20-8

Intermediate connection plates and/or stiffeners for welded plate girders



All dimensions shown in parentheses are in millimeters

20.6 THICKNESS OF METAL

20.6.1 Minimums

The minimum thickness of structural components shall be as follows unless approved by the Structures Engineer:

- Web plate thickness— $^1/_2$ ” *(14 mm)*
- Flange plate—$^7/_8$ ” *(22 mm)*
- Gusset and diaphragm connection plates— $^1/_2$ ” *(14 mm).*
- Structural Tubing used in pedestrian bridges— $^1/_4$ ” *(6 mm).*

20.6.2 Changes in Flange Thickness and Width

- The minimum flange width shall be 16” *(400 mm)* for plate girders.
- The thickness of the thinner flange plate at a butt joint shall not be less than one half the thicker plate.
- Whenever possible, use the same width of the flange for the full length of each girder rather than varying the width at butt splices. Varying the thickness of the flange can satisfy the need for a different area of steel; however, if the design requires a change in width, it shall be a shop welded butt splice.

- At field connections, the width of a flange plate shall be constant.
- In the interest of simplifying fabrication, extending the flange thickness to girder ends or field splice points, in excess of design requirements, is acceptable if the cost is justifiable. The AISC Marketing has a formula for justifying the costs. In general, the designer should limit shipping lengths to a maximum length of 150 feet *(45 m)*, and have no more than two shop butt welds per flange. Shop flange butt welds and shop web butt welds shall not occur at the same location, and preferably will have a 2'-0" *(600 mm)* offset.
- The designer may haunch the girders for aesthetic reasons. Haunching is acceptable if it proves to be a more economical design, when considering all costs, than that for a rectangular girder.

20.7 FATIGUE DESIGN

The number of cycles to use in determining allowable fatigue stress range shall be as indicated in AASHTO.

20.8 REDUNDANCY

Avoid the use of non-redundant load path members in structures if possible. If use is necessary, test and design it as a fracture critical member.

20.9 SHEAR CONNECTORS

- Generally, use $^{7}/_{8}$" *(22 mm)* diameter x 7" *(180 mm)* [min.] long studs for shear connectors.
- The clear depth of cover over shear connectors shall be the same as required for the top mat of reinforcing. At the very least, shear connectors shall penetrate completely through the bottom mat of the deck reinforcement. Deep haunches may require longer shear studs or stirrup bars.
- Provide shear connectors in negative moment regions at a maximum spacing of 2'-0" *(600 mm)*. This should be done even though the reinforcement embedded in the slab is not considered as contributing to the girder section properties for girder design.
- Shear connector design shall use the same number of cycles according to fatigue design. See AASHTO section 10.38.5.1 for further information.
- Use 36.1 kips *(160 kN)* as the ultimate strength of one $^{7}/_{8}$" *(22 mm)* diameter connector for normal eight concrete and f'_c = 4000 psi *(30 MPa)*.
- Design shear connectors for fatigue and check them using the ultimate strength requirements. Generally, ultimate strength requirements will govern the design.

20.10 CAMBER

In addition to the provisions of AASHTO, the designer shall use the following practice:

- Make an allowance for deviating from the specified camber of welded beams and girders as provided in the Bridge Welding Code. [See Chapter 3—Workmanship, Section 3.5—Dimensional Tolerances.]

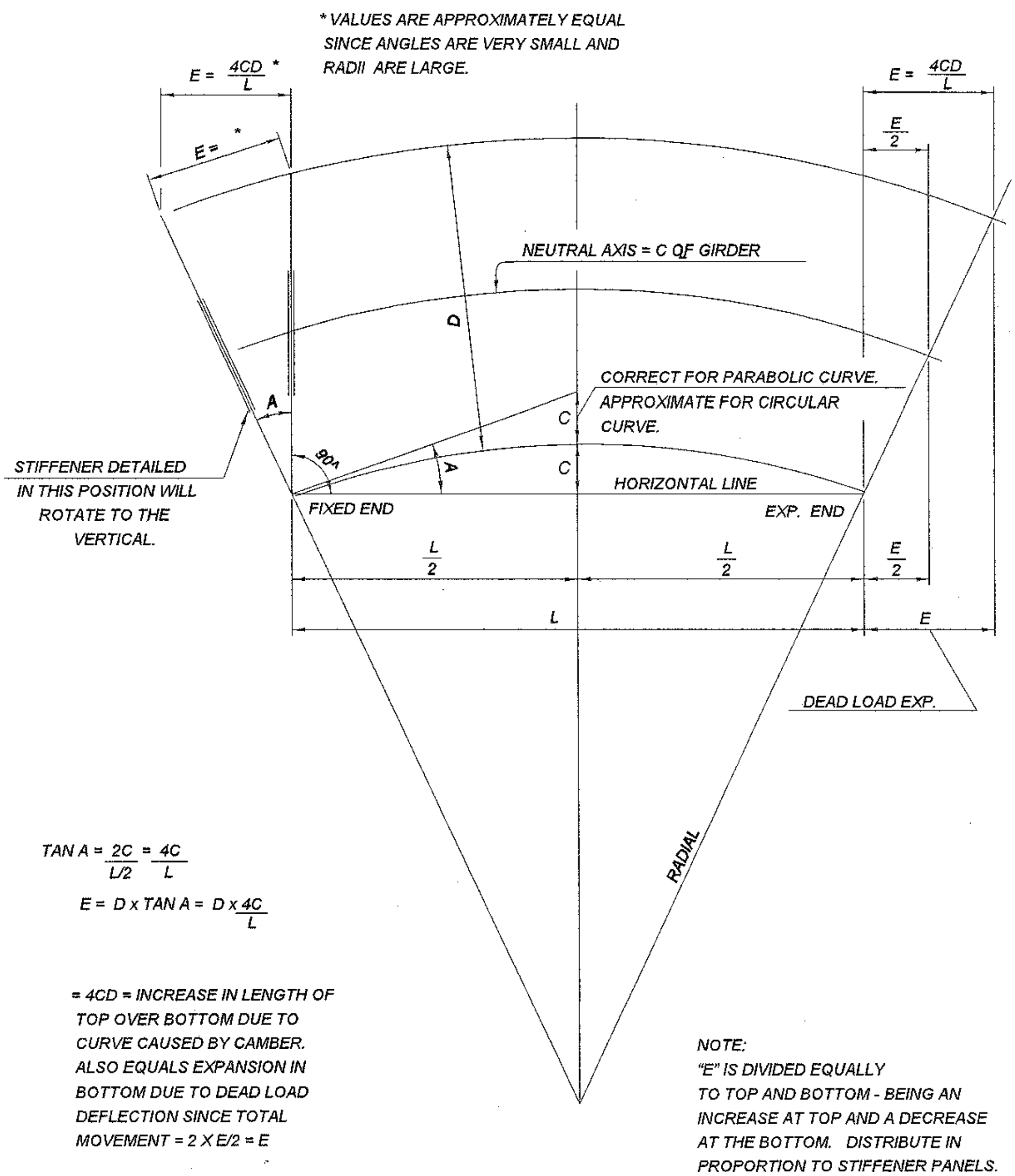
- Provide camber to match crest vertical curves.

- In all cases, whether tangent grade or vertical curve, provide sufficient camber to insure that the residual camber is 1/8" per 10 feet *(1 mm per 1.0 m)* of span length after applying all dead load deflections. The resulting residual camber must be a minimum of 1" *(30 mm)* at the midspan.

- Refer to Figure 20-9 for more detail.

Figure 20-9

Beam of girder camber calculations



20.11 DIAPHRAGMS, CROSS FRAMES AND TRANSVERSE PLATES

The design of connections for secondary members shall be for the average of the calculated loads and the capacity of the particular member, without regard to the 75% minimum restriction.

20.11.1 ROLLED BEAM DIAPHRAGMS

- Pier diaphragms shall be MC 18 x 42.7 *(460 x 63.5)* for all spans and up to 36" *(920 mm)* beams.
- Intermediate diaphragms shall be C 15 x 33.9 *(380 x 50)* for 24" *(600 mm)* through 30" *(760 mm)* beams.
- Intermediate diaphragms shall be MC 18 x 42.7 *(460 x 63.5)* for 33" *(840 mm)* and 36" *(920 mm)* beams.
- See 20.11.2 for additional diaphragm information.

20.11.2 Plate Girder, Diaphragms & Cross Frames

- Diaphragms for plate girders up to 48" *(1200 mm)* in depth will normally be rolled beams with flanges coped for connections.
- For plate girders greater than 48" *(1200 mm)* in depth, cross frames shall be used and fabricated from angles, structural T's, or channels in a configuration as required to resist the design loadings.
- Design cross frames on horizontally curved steel girders as main members. These members shall include adequate provisions for the transfer of lateral forces from the girder flanges.

20.11.3 Intermediate Diaphragms & Cross Frames

- Intermediate diaphragms or cross frames may be parallel to the centerline of bearing for skew angles of 15° or less and shall be 90° to the stringers for skews greater then 15°.
- Generally, intermediate cross frames or diaphragms should be level. If the differential from one end to the other is greater than 6" *(150 mm),* slope them parallel to cross slope.
- The maximum diaphragm or cross frame spacing shall be 25'-0" *(7500 mm)*
- The diaphragm spacing on the fascia beam from a curtain wall to the first diaphragm shall be 14'-0" *(4200 mm)* maximum. Check torsion of construction loads on fascia beams; an additional diaphragm near the beam end may be necessary.

20.11.4 Bearing Diaphragms & Cross Frames

- Bearing diaphragms or cross frames shall be parallel to the centerline of bearing as much as possible.

- Slope cross frames and diaphragms at abutments parallel to cross slope for ease of forming the transverse haunch.

20.11.5 Transverse Intermediate Stiffeners

The designer should preferably design girder webs with sufficient thickness to eliminate the requirement for transverse intermediate stiffeners.

20.11.6 Bearing Stiffeners

Design bearing stiffeners according to AASHTO.

20.11.7 Connection Plates for Diaphragms

Connection plates for diaphragms and cross frames shall extend full depth of the web and be attached to the flanges, as shown in Figures 20-3 through 20-8.

Limit maximum thickness of bent connection plate to $^3/_4$" *(20 mm)*.

20.11.8 Welding

Avoid confined areas for welding, especially for skewed bridges.

20.12 LATERAL BRACING

- The l/r ratio of a lateral bracing member shall be limited to 140.
- All beams and girders shall be checked for lateral bracing according to AASHTO 10.20.2 and 10.21.
- Even if not required by AASHTO, the use of lateral bracing may be warranted to provide stability under construction conditions.

20.13 SCUPPERS

Generally, the designer does not need to use scuppers on structures less than 300 feet *(90 m)* in length. These structures should have a full shoulder width that provides sufficient cross-sectional area to carry the design storm runoff. When the structure requires scuppers, place them where they will not discharge onto a roadway underneath or onto the substructures. Flat grades require more scuppers.

The use of a scupper shall be considered on the upstream side of any joint.

Erosion control along the wingwalls or drop inlets shall account for drainage at the low end of a bridge. In this case, use paving, stone fill, or erosion matting for erosion control materials.

20.14 DESIGN—3-SPAN CONTINUOUS CANTILEVER

A 3-Span continuous cantilever bridge has modified abutments attached to and supported by the superstructure. All abutment dead loads, superstructure dead loads, and live loads are then supported by two piers. This type of design allows a maximizing of the center span over the stream combined with some of the economics of a continuous design.

Use the following criteria for the layout and design of such a structure:

- Establish the span arrangement on a 1-5-1 ratio.
- Establish cantilever end loads required to produce a balance between positive and negative moments.
- Determine an acceptable range of cantilever end loadings. This is due to the uncertainty of support conditions at various loading conditions. [Some support at a cantilever end at loading condition #1—dead load; little or no support—a true cantilever at loadings condition #2 live load].
- Proportion steel girder sections to resist loads caused by the design range of cantilever end loadings.
- Make piers "semi-fixed" by use of slotted holes in sole plates of bearing devices that allow rotation but limits amount of translation to that required for expansion.
- Provide for the expansion at cantilever ends, with the use of closed cell foam behind curtain walls.
- Determine theoretical girder elevations at cantilever ends and splice points at time of girder erection.
- See Section 6.3.3.3 of this manual for more information.

20.15 COVER PLATES

Cover plates on rolled beams shall be 5'-0" *(1500 mm)* minimum and 10'-0" *(3000 mm)* maximum from the ends of the beams. If for any reason, the designer cannot obtain that maximum, bolting the ends of cover plates is an acceptable means of terminating the cover plate connection.

20.16 CHARPY V-NOTCH TEST

Identify all members and plates requiring a Charpy V-Notch test on project plans by the initials "CVN." There should also be a note on the structural detail sheets indicating that only those members or plates identified with the notation "CVN" must meet the Charpy V-Notch requirements for main members. Make further reference to Section 714 of the Vermont Standard Specifications for Construction.

20.17 DESIGN PROGRAMS

The Structures Section uses four different programs for the majority of steel beam or girder designs. These are the MERLIN-DASH, STAAD, BRASS and H211 programs. Each program has their individual advantages and disadvantages. Each designer may have individual preferences to each program, but keep in mind that the designs need consistency. Therefore, either design or check all projects using MERLIN-DASH. The designer has the option of using H211, BRASS or STAAD in conjunction with MERLIN-DASH. However, the designer must run the MERLIN-DASH program on every project to insure consistency.

20.18 CURVED STRUCTURES

Curved beams or girders can be used to accommodate the geometric layout of a project where a curve is needed across a bridge. A curved beam or girder design is more complicated than straight beam or girder design, and steel fabrication is more expensive. For these reasons, use a curved design only where a horizontal tangent across the bridge is not practical. A curved design is also applicable where the degree of curvature is such that the deck's curved fascia on straight beams or girders produces an unacceptable overhang.

20.18.1 Curved Beam or Girder Design

- Design shall be according to the AASHTO "Guide Specifications for Horizontally Curved Highway Bridges" and its latest interims.
- Keep substructures radial if possible, and avoid using extreme substructure skews.
- Use the DESCUS computer program, owned by Opti-mate, Inc. for the design of curved girders. The designer may use the "CUGAR" computer program as a check. This program is available on the mainframe computer. Refer to the program "User's Manual," and be aware that the preparation of input for Live Load Analysis is tedious for CUGAR.
- Use other programs if approved by the Structures Program Manager.

20.18.2 Cross Frames or Diaphragms

Design cross frames or diaphragms on curved girder structures as main load carrying members. These members will require the Charpy V-Notch Test. Cross frames shall provide lateral support for the girder flanges and should attach either to the flanges or as nearly as possible to the flanges. If welding the cross frame connection plate to the flange achieves support, then the allowable fatigue stress range in the flange should be checked.

20.18.3 Lateral Bracing

The need for lateral bracing shall be checked in all curved girder structures, per AASHTO section 10.20. In evaluating the need for lateral bracing, stability during construction should also be considered.

20.18.4 Expansion Bearing Orientation

Expansion shall be allowed to occur according to the provisions of Part I, Section 1.6 of the Guide Specifications for Horizontally Curved Highway Structures. A minimum of two bearings at each substructure unit should be restrained in a direction perpendicular to the direction of expansion.

20.19 TRUSS REHABILITATION POLICY

Use the following steps as a guideline to rehabilitate a steel truss structurally:

- Load rate the existing truss and floor system.
- Design the floor system [floor beam or stringer] to rate slightly less than or equal to the truss at posted rating for the HS *(MS)* truck but not less than an HS 20 *(MS 18)*.
- Re-run the truss rating with the revised loads from the new floor system and design strengthening of individual truss members as necessary to meet a minimum HS 20 *(MS 18)* posted rating.

20.20 LEAD PAINT

When a rehabilitation project is underway, and lead paint was found on the members, the following note shall be placed on the plans.

NOTE: "The existing structural steel on this project was painted with a material which may contain lead. The removed structural steel is the property of the Contractor. The Contractor shall indemnify and hold the state, its officers, and employees harmless concerning the Contractor's use or disposition of the structural steel ."

Chapter Twenty-One
Plate Pipe Structures

21.1 GENERAL DESIGN

Refer to AASHTO Section 12 and Chapter 17 of this manual for more design information.

Design Methodology—Use the Service Load Design concept for all plate pipe structures.

21.2 PLATE PIPE STRUCTURAL DESIGN

21.2.1 Structural Plate Pipe, Pipe Arches, and Arches

- Structural Plate Pipes, Plate Pipe Arches and Arches carrying water shall be aluminum with 9"x 2 $^{1}/_{2}$ " *(230 mm x 64 mm)* corrugations.
- Do not use bevel end cuts to match slopes.
- Do not use skew end cuts.
- Arch footings should be entirely on ledge or entirely on soil.
- Cattle passes shall be a 96" *(2400 mm)* CAAPP, elongated, and have a 3" *(75 mm)* paved invert.
- Elongation of round pipes shall be 5% vertically.
- All pipes shall have a minimum camber of $^{1}/_{4}$ " per 10' *(1 mm per 500 mm)*. Settlement of the fill at the center of the pipe needs to be added to this minimum. Camber shall not pond water at the inlet with flat pipe gradients.

21.2.2 Head Wall Requirement

All pipes 6'-0" *(1800 mm)* and over in diameter shall, as a minimum, have half height gravity head walls at both the inlet and outlet. In some cases, hydraulics requirements may require a full head wall with improved inlet.

21.2.3 Burial Requirement

- Unless otherwise mandated by ANR, all pipes shall have 6” *(150 mm)* of select material placed in the invert. This material is to simulate a native stream bed and baffles may be necessary to retain it.
- Head walls shall be buried 4’-0” *(1200 mm)* minimum.

21.2.4 Design Check

Check full-height head walls for stability.

21.3 DESIGN CRITERIA

Use the following Design Criteria:

- Live Load—HS 25 *(MS 22.5)*
- Dead Load—fill 140 lb/ft^2 *(22 KN/m^3)*
- Plate Wall Thrust—$T = P \times 2R_t$

Where P = Total load above the crown
R_t = Top Arc Radius

21.4 LONG SPANS

Acceptable reinforcement features for long spans shall be:

- Continuous reinforced concrete thrust block or metal longitudinal stiffeners at each side of the top arc.
- Reinforcing ribs consisting of structural shapes attached transversely to the structure at intervals, as required, to obtain the necessary composite moment of inertia.

21.5 PIPE GAUGE TABLES

Use the pipe gauge tables developed by the Hydraulics Unit to determine the required pipe gauge for the design loadings.

The tables cover the normal range of culvert sizes for pipe and pipe arches.

The designer shall individually design the larger structural plate structures.

21.6 MINIMUM COVER

The minimum cover over the pipe for the final condition shall be the Span/8, but not less than 36” *(900 mm)*. Minimum cover of 48” *(1200 mm)* within the traveled way is preferable where possible.

21.7 BACKFILL MATERIALS

The soil envelope shall be Granular Borrow up to 4’-0” *(1200 mm)* above the structure or bottom of subbase, whichever is less.

Backfill all undercut areas with Granular Backfill for Structures or Sand Borrow.

Chapter Twenty-Two

Timber

22.1 GENERAL DESIGN

Refer to AASHTO Section 13, the National Design Specifications for Wood Construction and the USDA Forest Service Timber Manual.

Design Methodology—Use the Service Load Design method in designing all timber structures.

22.2 LIVE LOAD CRITERIA

Evaluate the design live load criteria for covered bridges on a project by project basis. The evaluation shall have the Structures Program Manager's approval. For new timber bridges, live load criteria shall be as for other bridges.

22.3 ALLOWABLE STRESSES

Determine the allowable design stresses for the proposed timber material. Allow for the following:

- Deflections for timber shall be per AASHTO
- Connections may control the timber member size

22.3.1 Allowable Stresses—Temporary

When checking temporary bridges an increase in allowable stresses due to temporary loadings shall be by a factor of 1.19. Do not use this factor while using load duration factors.

When checking shoring, falsework or forming, use AASHTO table stresses as modified by load duration factors.

22.4 TREATED TIMBER

All wood used in new timber structures shall be treated with a preservative unless approved by the Structures Program Manager. Use of treated timber in covered bridge rehabilitation shall be at the discretion of the designer.

22.5 GLUED LAMINATED TIMBER

Design of Glued Laminated Timber shall be according to Section 13 of the AASHTO Specifications. See Section 3.25 for distribution of wheel loads on a glued laminated panel floor.

22.6 WEARING SURFACE

Use either bituminous concrete pavement, runner planks or other treatment to protect all timber decks. The designer may use runner planks for one-way bridges; however, evaluate each project for the most appropriate treatment.

Chapter Twenty-Three
Bearing Devices

23.1 DESIGN OF BEARING DEVICES

Refer to AASHTO Section 14 and Section 15 for more information.

All bearing devices at ends of girders shall provide some means of positive restraint for the superstructure relative to the substructure. This is usually done by extending the anchor bolts up through the sole plate. Avoid the use of high “rocker” type steel expansion bearings.

For prestressed concrete bearings see Chapter 19.

23.1.1 Galvanized or Metalized

All structural steel components of bearing devices shall be galvanized or metalized. Shop drawings must indicate whether the bearing device is to be galvanized or metalized. If metalizing is used, the shop drawings must also denote the type of seal coating that will be placed on the metalizing.

23.1.2 Holes

Holes in the base plates and sole plates shall be a minimum of $^3/_8$ " *(10 mm)* larger in diameter than the nominal diameter of the anchor bolt. Use AASHTO M 270 *Grade 36 (M 270/M 270M Grade 250)* steel for sole and base plates, unless the design requires higher strength steel by design.

Expansion bearings require slotted holes.

23.1.3 Bearing Surfaces

Maximum allowable bearing on concrete or masonry shall be 1000 psi *(7 MPa)*.

Concrete surfaces under bearings shall be level. The designer shall state this requirement on the plans in the general notes.

23.1.4 Sole Plate

Size the sole plate so that the minimum width is the bottom flange width plus 9" *(240 mm)*.

Investigate the beveling of the sole plate, using the following procedure:

- Find the worst case rotation considering:
  - Grade
  - Residual camber
  - A construction tolerance of +/- 0.010 radians.
- Design the sole plate as beveled if this rotation exceeds 0.020 radians.
- To bevel the sole plate, determine the angle at the bearing due to grade, residual camber, and bevel for this amount of rotation.
- Never shall the bevel be less than $^1/_8$" *(3 mm)* across the length of the sole plate.

23.1.5 Rotation

For preformed fabric pad bearings, the minimum design rotation is 0.015 radians.

23.1.6 Friction

The maximum summation of longitudinal forces that can be transmitted through an expansion bearing device is limited to the frictional resistance of the device. The frictional resistance is the product of the dead load reaction and the coefficient of friction for the particular device. Use the coefficients of friction in Figure 23-1.

Figure 23.1 Coefficient factors for bearing materials

Mating Materials	Coefficient
Steel on Steel	0.20
Steel on Lubrite Bronze	0.10
TFE on Stainless Steel	0.06

23.1.7 Curtain Wall Design

Provide a boxout as detailed in Figure 23-2 for bridges designed with a curtain wall.

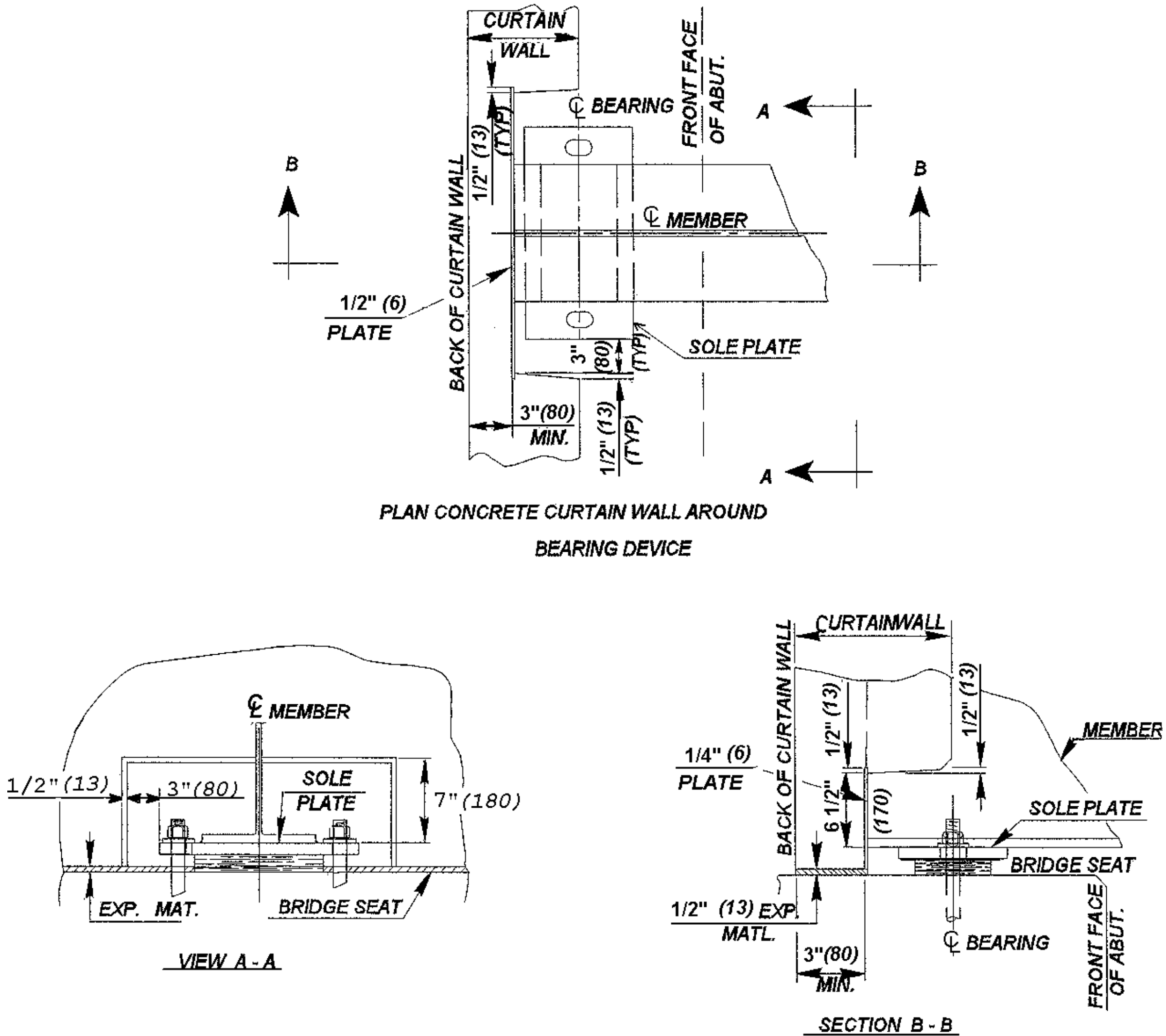
23.2 ANCHOR BOLTS

Anchor bolt diameter and embedment length shall conform to AASHTO section 10.29.6.2. An exception is that the minimum anchor bolt diameter used shall be 1 $^1/_2$" *(38 mm)* and the minimum length of embedment used shall be 15" *(380 mm)*. The fixed end anchor bolts shall be hand tightened with the threads above the nut burred. To determine the number of anchor bolts required at a fixed bearing, use the total bridge length.

For expansion anchor bolts, leave $^1/_8$" *(3 mm)* gap below the nut and burr the threads above the nut.

Figure 23-2

Details for Curtain Wall Boxout for bearings



23.3 PREFORMED FABRIC PADS

Use preformed fabric pads for devices with required vertical capacity up to 200 kips *(890 kN)*. Design the preformed fabric bearing pad for an average compressive stress of not more than 1000 psi *(7 MPa),* due to dead loads and live loads with impact.

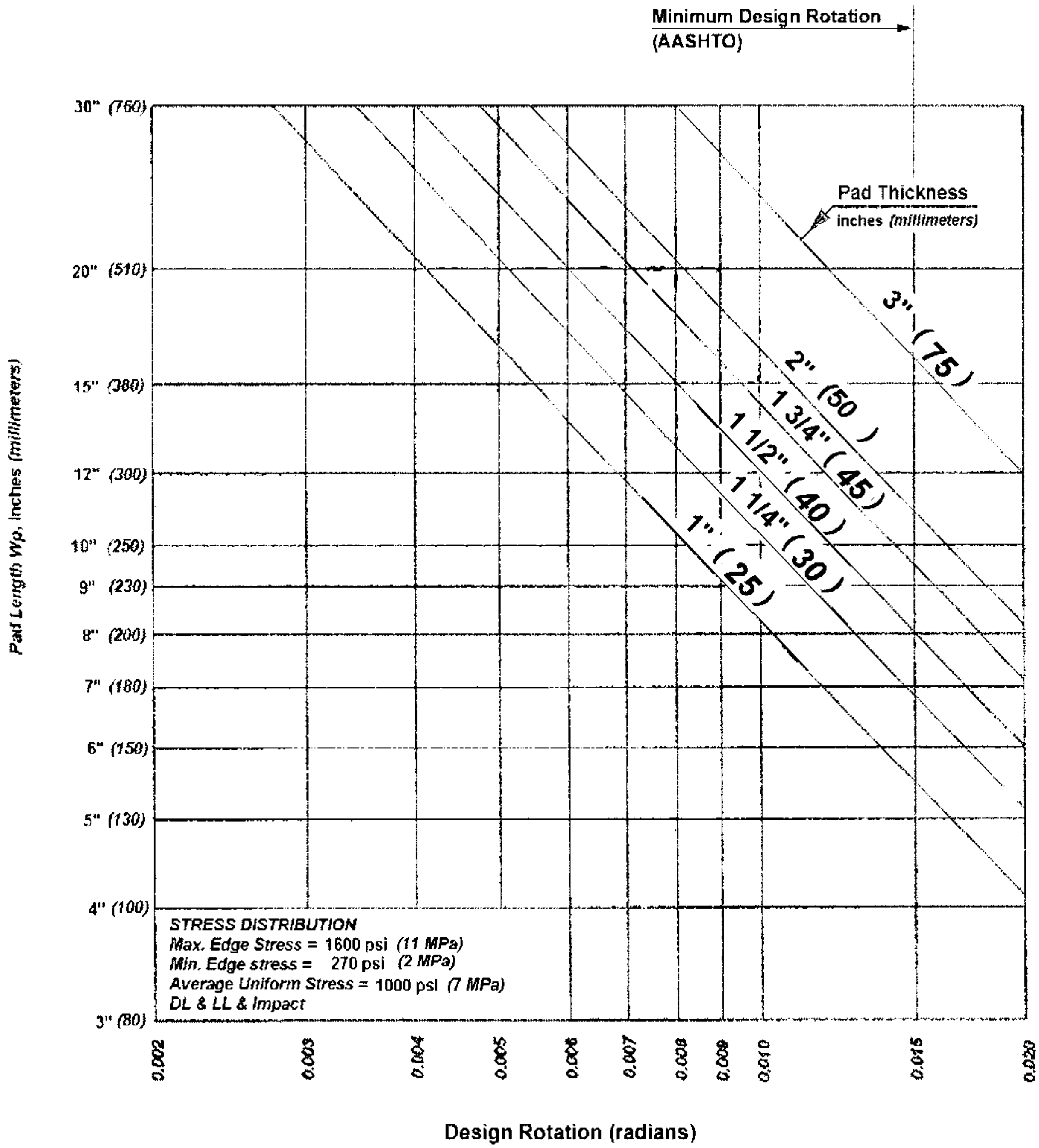
The minimum length of the sole plate is the pad length plus the total travel plus 3" *(80 mm)*.

Expansion bearings using a preformed fabric pad shall have a stainless steel surface attached to the sole plate and a Teflon surface bonded to the fabric pad.

The maximum design rotation equals the construction tolerance of +/- 0.010 radians, plus the rotation due to live load deflection. If this value exceeds 0.020 radians, another type of bearing should be considered. The thickness of the fabric pad shall be based on the design rotation and the length of the pad, and shall be as required by Figure 23-3.

Figure 23-3

Graph to determine pad thickness



23.4 POT BEARINGS

Expansion bearings of the pot type shall have a stainless steel surface attached to the sole plate and a Teflon surface attached to the top of the piston.

Pot bearings may be considered if the required vertical capacity exceeds 200 kips *(890 kN),* or for structures where the direction of movement is uncertain, as in curved girder structures.

For pot type bearings, the minimum design rotation to be used, is 0.015 radians. The maximum design rotation equals the construction tolerance of +/- 0.010 radians, plus the rotation due to live load deflection.

23.5 STEEL PEDESTALS

Steel pedestals may be considered for fixed bearings only.

Chapter Twenty-Four
Load Rating

24.1 LOAD RATINGS

24.1.1 Working Stress and Load Factor Designs

- The designer shall do the load rating using the load factor method where possible.
- Load ratings for both the service load and load factor design methods shall be done according to the AASHTO Manual for Condition Evaluation of Bridges, 1994 and Interims.
- Load ratings for new construction shall be based on the actual plan dimensions of the area of material being provided in the construction.
- Design new concrete decks on steel girder or beam structures such that the load rating of the deck slab will not control the load rating.
- Computer programs are available to assist in the load rating of most types of superstructures. For some structure types, such as slant leg steel rigid frames, load ratings must be done manually with the use of live load influence lines.
- On rehabilitation projects, the load rating of the rehabilitated structure shall be at least a posted rating for HS 20 *(MS18),* unless otherwise approved by the Structures Program Manager.

24.1.2 Load Rating Vehicles

- All new and rehabilitated bridge structures shall be load rated for the vehicles shown in Figures 24-1a and 24-1b.
- Include load ratings in the plan set using the table forms as shown in Figure 24-2a and 24-2b as appropriate.

24.1.3 Load Rating Buried Structures

- Buried structures with spans over 20’-0” *(6100 mm)* shall be load rated for all trucks.

Figures 24-1a and 24-1b

Trucks used in Load Rating

Figure 24-1a. Trucks used for load rating - English

Truck	Truck Wt. (Ton)	Perform Load Rating for: I*	P*	O*	Wheel Loads and Spacing for Trucks
H20	20.0	✓	✓		4 k 16 k ●← 14' → ●
HS20	36.0	✓	✓	✓	4 k 16 k 16 k ●← 14' → ● ← 14' →●
3S2	36.0		✓	✓	5 k 7.75 k 7.75 k 7.75 k 7.75 k ●← 11' → ● ← 4' →●← 22' → ●← 4'→●
6 Axle	66.0			✓	6 k 12 k 12 k 12 k 12 k 12 k ●← 11' → ● ← 4' 8" →●←31'→ ●← 4'→●← 4'→●
3 A. Str	30.0		✓	✓	6 k 12 k 12 k ●← 15' → ● ← 4'→ ●
4 A. Str	34.5		✓	✓	6 k 9.5 k 9.5 k 9.5 k ●← 15' → ● ← 4' →● ← 4' → ●
5 A. Semi	38.0		✓		4 k 8.5 k 8.5 k 8.5 k 8.5 k ●← 11' → ● ← 4'→ ● ← 16' → ● ← 4'→ ●

*I = Inventory, P = Posting, O = Operating

Figure 24-1b. Trucks used for load rating - Metric

Truck	Truck Wt. (Metric Ton)	Perform Load Rating for: I*	P*	O*	Wheel Loads and Spacing for Trucks
M18	18.0	✓	✓		17.5 kN 72.5 kN ● ← 4.3 m → ●
MS18	33.0	✓	✓	✓	17.5 kN 72.5 kN 72.5 kN ● ← 4.3 m → ● ← 4.3 m → ●
3S2	32.0		✓	✓	22 kN 34 kN 34 kN 34 kN 34 kN ● ← 3.4 m → ● ← 1.2 m → ● ← 6.7 m → ● ← 1.2 m → ●
6 Axle	59.0			✓	27 kN 53 kN 53 kN 53 kN 53 kN 53 kN ● ←3.4 m → ● ← 1.4m → ● ← 9.5m → ● ← 1.2 m →●← 1.2 m → ●
3 A. Str	27.0		✓	✓	27 kN 53 kN 53 kN ● ← 4.6 m → ● ← 1.2 m → ●
4 A. Str	31.0		✓	✓	27 kN 42 kN 42 kN 42 kN ● ← 4.6 m → ● ← 1.2 m → ● ← 1.2 m → ●
5 A. Semi	35.0		✓		17.5 kN 37.5 kN 37.5 kN 37.5 kN 37.5 kN ● ← 3.4 m → ● ← 1.2 m → ● ← 4.9 m → ● ← 1.2 m → ●

*I = Inventory, P = Posting, O = Operating

Figure 24-2a Example of a Working Stress Load Rating Table

WORKING STRESS LOAD RATING (TONS)

STRESS LEVELS	TRUCK						
	H *(M)*	HS *(MS)*	3S2	6 AXLE	3A STR	4A STR	5A SEMI
**INVENTORY 0.55 Fy = 27.5 ksi *(190 Mpa)*	42	48					
**POSTED 0.67 Fy = 33.5 ksi *(230 Mpa)*	65	74	110		85	86	100
**OPERATING 0.75 Fy = 37.5 ksi *(260 Mpa)*		83	124	148	95	96	

Figure 24-2b. Example of a Load Factor Load Rating Table

LOAD FACTOR LOAD RATING (TONS)

LOAD LEVELS (LOAD FACTOR)	TRUCK						
	H *(M)*	HS *(MS)*	3S2	6 AXLE	3A STR	4A STR	5A SEMI
INVENTORY A = 2.17; B = 1.00	26*	42*					
POSTED A = 1.55; B = 1.40	37*	59*	75*		44*	45*	74*
OPERATING A = 1.30; B = 1.67		70*	88*	82*	53*	54*	

$$\text{Strength RF} = \frac{\phi M_N - 1.3\ M_{DL}}{A\ x\ M_{LL+I}} \quad \text{*Servicability RF} = B\left[\frac{0.95\ F_Y\ S_{LL+I} - M_{DL}\dfrac{S_{LL+I}}{S_{DL}} - M_{SDL}\dfrac{S_{LL+I}}{S_{SDL}}}{1.67\ M_{LL+I}}\right]$$

- Design buried structures with spans in the range of 6'-0" to 20'-0" *(1800 mm to 6100 mm),* for an HS 25 *(MS 22.5)* truck. These designs need not be load rated.

24.2 THE GENERAL LOAD RATING FORMULA

- The general formula for the strength load rating factor is:

$$RF = \frac{C - A_1\ x\ DL}{A_2\ x\ LL + I} \qquad (24-1)$$

where

RF = Rating factor

C = Capacity, note that under service load design this is the allowable stress, and under load factor design it is the nominal capacity

DL = The dead load effect [in service load design this would be a stress, in load factor design it would be a bending moment, or a shear force, etc.]

LL+I = The live load plus impact effect [in service load design this would be a stress, in load factor design it would be a bending moment, or a shear force, etc.]

A1, A2 = Factors given in Figure 24-3.

Figure 24-3. Load Rating Factors			
LOAD FACTOR DESIGN			
Loading Condition	**A1**	**A2**	**B**
Inventory	1.3	2.17	1.00
Posting	1.3	1.55	1.40
Operating	1.3	1.3	1.67
WORKING STRESS DESIGN			
Loading Condition	**C (A1 and A2 = 1)**		
Inventory	0.55 Fy		
Posting	0.55 Fy		
Operating	0.55 Fy		

- The design and load rating for beams and girders under load factor design must also be checked for serviceability using AASHTO 10.50.1.2 or 10.50.2.1 in the Standard Specifications for Design of Highway Bridges. For composite beams and girders, this condition will usually control the design and the load rating.

- The general formula for serviceability load rating factor is:

$$RF = \left[\frac{0.95\ F_y\ S_{LL+I} - M_{DL}\ \frac{S_{LL+I}}{S_{DL}} - M_{DL}\ \frac{S_{LL+I}}{S_{DL}}}{1.67\ M_{LL+I}} \right]$$

where

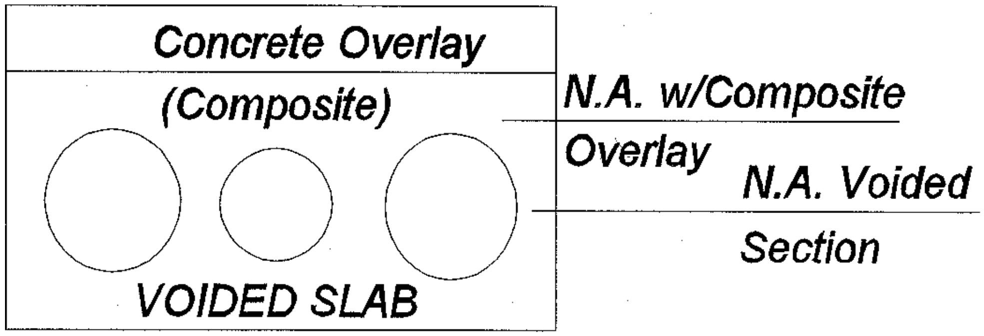
F_y = yeild strength
S_{DL} = governing elastic section modulus for non-composite dead load
S_{LL+I} = governing elastic section modulus for live load
S_{SDL} = governing elastic section modulus for composite dead load
M_{DL} = bending moment caused by non-composite dead load
M_{LL+I} = bending moment caused by live load plus impact
M_{SDL} = bending moment caused by composite dead load

24.3 LOAD RATING PRESTRESSED VOIDED SLABS

The following is a procedure for load rating prestressed concrete voided slabs. In the design of these units, the designer shall assume that the concrete will fail before the prestressing strands. Tests on these units seem to support this theory. Therefore, only the concrete is load rated. The allowable stresses listed in Figure 24-5 are a compilation of those suggested by the AASHTO Manual for Condition Evaluation of Bridges, and Agency practices.

Figure 24-4

Neutral Axis locations for a voided slab



24.3.1 Process for Load Rating Voided Slabs

24.3.1.1 Regions to be Load Rated

- Bottom of the voided slab [Tension]
- Top of the voided slab [Compression]
- Top of the concrete overlay [Compression]

24.3.1.2 Required Information

The designer may either calculate or pull the dead load moments, stresses and section properties of tables from design manuals or accepted computer software. Refer to Chapter 19 of this manual for accepted properties of prestressed voided slabs.

24.3.1.3 Inventory Rating

- Refer to Figure 24-5 under Inventory Rating for calculating the allowable stresses [f_{all}].
- Obtain the dead load stresses from calculations [f_{dl}]. [See 24.2.1.2]
- Calculate live load stresses at the bottom of the voided slab, the top of the voided slab and the top of the overlay [f_{ll}].
- Do a load rating for bottom and top of the voided slab and the top of the overlay. Use formula 24.3.

$$RF = \frac{f_{all} - f_{dl}}{f_{ll}} \text{ x Truck} \qquad (24-3)$$

24.3.1.4 Operating Rating

This rating is similar to Inventory except use the allowable stresses under Operating Rating in Figure 24-5

24.3.1.5 Posting Rating

Calculate the allowable stresses for posting levels by multiplying the operating allowable stresses by the ratio [$^{.67}/_{.75}$] as shown in Figure 24-5.

Figure 24-5 Allowable Stresses in Concrete for Load Rating Voided Slabs

	Normal Concrete	Prestressed Concrete	Bonded Reinforcement*	
INVENTORY RATING				
Compressive Stresses	$f_c = 0.40f'_c$ (1)	$f_c = 0.40f'_c$ (2)	$f_t = 6\sqrt{f'_c}$ (2)	$\left(f_t = 0.5\sqrt{f'_c}\right)$ (2)
Tensile Stresses	$f_c = 0$	--		
POSTED RATING				
Compressive Stresses	$f_c = \left({}^{0.67}/_{0.75}\right)0.55f'_c$ (3)	--	----	-----
Tensile Stresses	--	--	$f_t = \left(\frac{0.67}{0.75}\right)7.5\sqrt{f'_c}$ (3)†	$\left(f_t = \left(\frac{0.67}{0.75}\right)0.62\sqrt{f'_c}\right)$ (3) †
OPERATING RATING				
Compressive Stresses	$f_c = 0.55f'_c$ (4)	--	----	-----
Tensile Stresses	--	--	$f_t = 7.5\sqrt{f'_c}$ (5)†	$\left(f_t = 0.62\sqrt{f'_c}\right)$ (5) †

* Use f'_c from prestressed concrete
1. AASHTO 1996-Section 8.15.2.1.1
2. AASHTO 1996-Section 9.15.2.2
3. Vermont Agency of Transportation Standard Practice
4. AASHTO 1994 Section 6.6.2.4 Manual for Condition Evaluation of Bridges
5. AASHTO 1996-Section 9.15.2.3

† Cracking Stress

24.4 MOMENT FOR SIMPLE SPAN BEAMS

Figure 24-6 contains moments for all trucks used by the VAOT.

The 3S2, 6-Axle, 3-Axle straight, 4-Axle straight, and 5-Axle semi are not AASHTO trucks. The Structures Section developed them for use in Vermont. Figure 24-6 contains definitions of these trucks.

Figure 24-6a. Moment for a variety of simple spans calculated from the H20 and HS20 AASHTO trucks and the standard VAOT trucks - English Units

SPAN (ft)	H20-44 (ft-kips)		HS20-44 (ft-kips)	3S2 (ft-kips)	6 AXLE (ft-kips)	3A. STR (ft-kips)	4A. STR (ft-kips)	5A. STR (ft-kips)
6.0	48.00		48.00	24.00	36.00	36.00	28.50	25.50
8.0	64.00		64.00	36.00	54.00	54.00	42.76	38.26
10.0	80.00		80.00	51.20	84.00	76.80	66.50	54.40
12.0	96.00		96.00	66.66	120.00	100.00	95.00	70.84
14.0	112.00		112.00	82.28	156.00	123.42	123.50	87.42
16.0	128.00		128.00	98.00	192.00	147.00	152.00	104.12
18.0	144.00		144.00	113.78	228.00	170.66	180.50	120.88
20.0	160.00		160.00	129.60	264.00	194.40	209.00	137.70
22.0	176.00		176.00	145.46	300.00	218.18	237.50	154.54
24.0	192.00		192.70	164.00	336.00	242.00	266.00	174.00
26.0	208.00		222.20	184.00	372.00	265.84	294.50	195.00
28.0	226.80		252.00	204.00	408.00	289.72	323.00	216.00
30.0	246.60		282.10	224.00	444.00	313.60	351.50	237.00
32.0	266.50		312.50	244.00	480.00	342.76	380.00	258.00
34.0	286.30		343.50	264.00	516.00	372.70	408.50	279.00
36.0	306.20		378.90	284.00	552.00	402.66	437.00	302.22
38.0	326.10		414.30	304.00	588.00	432.64	470.24	337.48
40.0	346.00		449.80	324.00	624.00	462.60	504.50	374.70
42.0	365.90		485.30	344.00	660.00	492.58	538.78	412.00
44.0	385.80		520.90	364.00	696.00	522.54	573.10	449.36
46.0	405.70		556.50	384.00	732.00	552.52	607.42	486.78
48.0	425.60		592.10	412.66	768.00	582.50	641.76	524.26
50.0	445.60		627.90	447.68	804.00	612.48	676.10	561.76
52.0	465.50		663.60	482.76	840.00	642.46	710.46	599.30
54.0	485.50		699.30	517.92	876.00	672.44	744.84	636.88
56.0	505.40	II	735.10	553.14	912.00	702.42	779.22	674.50
58.0	530.10	II	770.80	588.42	948.00	732.42	813.60	712.14
60.0	558.00	II	806.50	623.74	984.00	762.40	848.00	749.80
62.0	586.50	II	842.40	659.10	1020.00	792.38	882.40	787.48
64.0	615.70	II	878.10	694.50	1056.00	822.38	916.82	825.18
66.0	645.50	II	914.00	729.94	1095.64	852.36	951.22	862.90
68.0	675.90	II	949.70	765.42	1148.32	882.36	985.64	900.64
70.0	707.00	II	985.60	800.92	1206.82	912.34	1020.08	938.40
72.0	838.20	II	1128.98	836.44	1265.40	942.34	1054.50	976.16
74.0	771.40	II	1057.20	872.00	1324.08	972.32	1088.94	1013.94
76.0	804.40	II	1093.06	907.58	1382.80	1002.32	1123.36	1051.74
78.0	838.20	II	1128.98	943.18	1441.60	1032.30	1157.80	1089.54
80.0	872.00	II	1164.90	978.80	1500.46	1062.30	1192.26	1127.36
82.0	907.40	II	1200.82	1014.44	1562.88	1092.30	1226.70	1165.18
84.0	942.80	II	1236.74	1050.10	1626.94	1122.28	1261.14	1203.00
86.0	979.00	II	1272.64	1085.76	1691.12	1152.28	1295.60	1240.84
88.0	1016.00	II	1308.52	1121.46	1755.36	1182.28	1330.04	1278.68
90.0	1053.00	II	1344.40	1157.16	1819.68	1212.26	1364.50	1316.54
92.0	1091.60	II	1380.28	1192.86	1884.08	1242.26	1398.96	1354.40
94.0	1130.20	II	1416.16	1228.60	1948.54	1272.26	1433.42	1392.26
96.0	1169.60	II	1452.08	1264.34	2013.08	1302.26	1467.88	1430.12
98.0	1209.80	II	1488.04	1300.08	2077.66	1332.24	1502.34	1468.00
100.0	1250.00	II	1524.00	1335.84	2142.30	1362.24	1536.80	1505.88
102.0	1292.60	II	1559.92	1371.60	2207.00	1392.24	1571.26	1543.76
104.0	1335.20	II	1595.84	1407.38	2271.76	1422.24	1605.74	1581.66
106.0	1377.80	II	1631.76	1443.16	2336.56	1452.22	1640.20	1619.54
108.0	1420.40	II	1667.68	1478.98	2401.40	1482.22	1674.66	1657.44
110.0	1463.00	II	1703.60	1514.76	2466.28	1512.22	1709.14	1695.34
112.0	1508.80	II	1739.54	1550.58	2531.20	1542.22	1743.60	1733.26
114.0	1554.60	II	1775.48	1586.38	2596.16	1572.22	1778.08	1771.16
116.0	1600.40	II	1811.42	1622.20	2661.16	1602.20	1812.56	1809.06
118.0	1646.20	II	1847.36	1658.04	2726.18	1632.20	1847.02	1846.98
120.0	1692.00	II	1883.30	1693.86	2791.24	1662.20	1881.50	1884.90

NOTE: IMPACT IS NOT INCLUDED. "II" DENOTES LANE LOAD CONTROLS, OTHERWISE TRUCK LOAD CONTROLS.

Figure 24-6b. Moment for a variety of simple spans calculated from the M18 and MS18 AASHTO trucks and the standard VAOT trucks - Metric Units

SPAN (m)	M18 (kN-m)		MS18 (kN-m)		3S2 (kN-m)	6 AXLE (kN-m)	3A. STR (kN-m)	4A. STR (kN-m)	5A. STR (kN-m)
1.0	36.3		36.3		17.0	26.5	26.5	21.0	19.0
1.5	54.4		54.4		25.5	39.8	39.8	31.5	28.5
2.0	72.5		72.5		34.0	53.0	53.0	42.0	38.0
2.5	90.6		90.6		49.1	76.5	76.5	60.7	54.9
3.0	108.8		108.8		65.3	111.3	101.8	88.2	73.0
3.5	126.9		126.9		81.7	151.1	127.4	119.7	91.3
4.0	145.0		145.0		98.3	190.8	153.2	151.2	109.8
4.5	163.1		163.1		114.9	230.6	179.1	182.7	128.4
5.0	181.3		181.3		131.7	270.3	205.2	214.2	147.1
5.5	199.4		199.4		148.4	310.1	231.4	245.7	165.9
6.0	217.5		217.5		165.2	349.8	257.6	277.2	184.7
6.5	235.6		235.6		182.1	389.6	283.8	308.7	203.5
7.0	253.8		253.8		200.3	429.3	310.1	340.2	222.4
7.5	271.9		276.7		222.8	469.1	336.4	371.7	245.9
8.0	290.0		310.1		245.2	508.8	362.8	403.2	269.4
8.5	310.9		343.9		267.7	548.6	389.1	434.7	292.9
9.0	333.2		378.0		290.1	588.3	415.5	466.2	316.3
9.5	355.6		412.3		312.6	628.1	445.4	497.7	339.8
10.0	377.9		446.8		335.0	667.8	478.6	529.2	363.3
10.5	400.2		482.5		357.5	707.6	511.8	560.7	386.8
11.0	422.6		522.4		380.0	747.3	544.9	592.2	413.9
11.5	445.0		562.3		402.5	787.1	578.1	629.3	452.6
12.0	467.4		602.3		424.9	826.8	611.3	667.3	494.2
12.5	489.8		642.4		447.4	866.6	644.5	705.3	535.8
13.0	512.2		682.5		469.9	906.3	677.8	743.3	577.6
13.5	534.6		772.6		492.4	946.1	711.0	781.3	619.4
14.0	557.0		762.8		514.9	985.8	744.2	819.3	661.2
14.5	579.4		803.0		537.3	1025.6	777.4	857.4	703.1
15.0	601.8		843.2		573.1	1065.3	810.6	895.4	745.0
15.5	624.3		883.5		611.7	1105.1	843.8	933.5	787.0
16.0	646.7		923.8		650.4	1144.8	877.1	971.6	829.0
16.5	669.2		964.1		689.2	1184.6	910.3	1009.7	871.1
17.0	691.6		1004.4		728.0	1224.3	943.5	1047.8	913.1
17.5	714.0		1044.7		766.8	1264.1	976.7	1085.9	955.2
18.0	738.3	I	1085.1		805.7	1303.8	1010.0	1124.1	997.3
18.5	769.6	I	1125.4		844.6	1343.6	1043.2	1162.2	1039.4
19.0	801.5	I	1165.8		883.5	1383.3	1076.4	1200.3	1081.6
19.5	833.9	I	1206.2		922.5	1423.1	1109.7	1238.5	1123.8
20.0	867.0	I	1246.6		961.5	1463.6	1142.9	1276.6	1410.3
21.0	934.9	I	1327.4		1039.5	1581.7	1209.4	1352.9	1250.4
22.0	1005.0	I	1408.3		1117.7	1711.0	1275.8	1429.2	1334.8
23.0	1077.6	I	1489.2		1195.9	1840.5	1342.3	1505.6	1419.3
24.0	1152.5	I	1570.2		1274.2	1970.3	1408.8	1581.9	1503.9
25.0	1229.7	I	1651.1		1352.5	2103.5	1475.3	1658.3	1588.5
26.0	1309.2	I	1732.1		1430.9	2245.2	1541.7	1734.7	1673.1
27.0	1391.1	I	1813.1		1509.3	2387.2	1608.2	1811.1	1757.7
28.0	1475.3	I	1894.1		1587.8	2529.5	1674.7	1887.5	1842.4
29.0	1561.9	I	1975.2		1666.3	2672.1	1741.2	1963.9	1927.1
30.0	1650.8	I	2056.2		1744.8	2814.9	1807.7	2040.3	2011.8
33.0	1931.4	I	2299.5		1980.6	3244.5	2007.1	2269.5	2266.1
36.0	2233	I	2542.8		2216.6	3675.4	2206.6	2498.8	2520.5
39.0	2555.8	I	2786.2		2452.8	4107.4	2406.1	2728.2	2774.9
42.0	2899.5	I	3029.6		2689.1	4540.3	2605.5	2957.5	3029.5
45.0	3264.2	I	3273.1		2925.4	4973.9	2805.0	3186.9	3284.1
48.0	3649.9	I	3649.9	II	3161.9	5408.0	3004.5	3416.3	3538.7
51.0	4056.7	I	4056.7	II	3398.4	5842.6	3204.0	3645.7	3793.4
54.0	4484.4	I	4484.4	II	3635.0	6277.6	3403.5	3875.1	4048.2
57.0	4933.2	I	4933.2	II	3871.6	6712.8	3602.9	4104.5	4302.9
60.0	5403.0	I	5403.0	II	4108.2	7148.4	3802.4	4333.9	4557.7
65.0	6232.7	I	6232.7	II	4501.9	7874.8	4137.1	4716.9	4980.8
70.0	7120.8	I	7120.8	II	4896.5	8601.8	4469.6	5099.3	5405.5
75.0	8067.2	I	8067.2	II	5291.1	9329.1	4802.1	5481.8	5830.3
80.0	9072.0	I	9072.0	II	5685.8	10056.8	5134.6	5864.2	6255.1
85.0	10135.2	I	10135.2	II	6080.5	10784.7	5467.1	6246.6	6679.9
90.0	11256.8	I	11256.8	II	6475.2	11512.9	5799.6	6629.1	7104.7

NOTE: IMPACT IS NOT INCLUDED. "I" DENOTES LANE LOAD CONTROLS, OTHERWISE TRUCK LOAD CONTROLS.

Part IV

Estimates and Quantities

Chapter Twenty-Five

Quantities

25.1 QUANTITIES

Compute all quantities to the best possible precision consistent with the available information. Use the average end area method when calculating earthwork quantities. Use odd stations when appropriate. Refer and adhere to the measurement methods and payment basis for each pay item listed in the specifications, or as modified by the General Special Provisions. When necessary, describe all modifications in the Special Provisions for the particular project.

25.2 PRELIMINARY QUANTITY ROUNDING

- Earthworks—Round up to next 10 yd^3 *(10 m^3)*
- Structural Steel—Round up to next 10lb *(5 kg)*
- Reinforcing Steel—Round up to next 10lb *(5 kg)*
- Concrete—Round up to next yd^3 *(m^3)*
- Bituminous Concrete—Round up to next ton

25.3 PLACING QUANTITIES ON QUANTITY SHEET

Quantities should be broken down and listed on the Quantity Sheet as follows:

- Superstructure
- Abutments
- Approach slabs
- Piers
- Channel
- Roadway
- Utilities [participating and non-participating] Waterline, Sewer line, Street Lighting, Gas line
- Erosion Control
- Other categories, as appropriate

25.3.1 Roadway Items Computed by the Structures Section

Structures Section computes and lists the following quantities on the Bridge quantity sheet:

- Granular Borrow [back to back of abutments]—List unfactored volume
- Bituminous Concrete Pavement on the superstructure

25.4 BASIS OF QUANTITY COMPUTATION

The measurement method and payment basis for the various pay items shall be as stated in the Standard Specifications. The Supplemental Specifications, General Special Provisions, Special Provisions or a note on the plans may modify these items.

25.4.1 Weights and Application Rates

25.4.1.1 Weights

Use the following weights for estimating the quantity of various items:

- Structural Steel — 490 lb/ft^3 *(7850 kg/m^3)*
- Bituminous Concrete Pavement—2 Tons/yd^3 *(2.4 tons per cubic meter)*

25.4.1.2 Structural Steel Pay Mass Computation

Consider all welding as incidental to the cost of fabrication. In addition, make no provisions for payment of the weight *(mass)* of weld metal used. The weight *(mass)* of shop and field bolts, nuts and washers shall be subsidiary to the structural steel item. Make payment based on the extended weights *(masses)* submitted by the Fabricator.

25.4.1.3 Application Rates

Use the following application rates for estimating the quantity of various items:

- Water Repellent— 1 gallon/14 yd^2 *(0.3 liter per square meter)*
- Emulsified Asphalt— 0.015gallons/yd^2 *(0.07 liter per square meter)*

25.4.2 Subsidiary Items

Some items are generally not paid for under their own item number and are made subsidiary to another item.

25.4.2.1 Reasons for Subsidiary Items

Reasons for making an item subsidiary to another item include:

- Very small quantity of the item is to be used
- Unit cost of an item is small
- Field measurement for payment under the actual item number is labor intensive and not justified

25.4.2.2 Examples of Subsidiary Items

Examples of items that are generally made subsidiary to other items are:

- Polyurethane Joint Sealer—made subsidiary to the adjacent concrete item.
- Epoxy Bonding Compound—made subsidiary to the concrete item.
- Expansion joint materials [cork, closed cell foam, etc.]—made subsidiary to the concrete item.
- P.V.C. water stop made subsidiary to concrete.
- On-project construction signs are paid subsidiary to another item, usually mobilization.

25.5 EMULSIFIED ASPHALT [TACK COAT]

Use Emulsified Asphalt, Item 404.65 for a tack coat. The Agency will pay for this as a separate item rather than being subsidiary to the item of Bituminous Concrete Pavement.

Contract estimates for all projects shall include a quantity of tack coat for use between all courses of paving.

25.6 TRENCH EXCAVATION OF EARTH

The use of trench excavation of earth will be a non-bid item on projects that do not carry it as a bid item.

25.7 LEDGE

Allow ledge over-breakage to the following limits:

- Vertically— 6” *(150 mm)* average.
- Horizontally— 12” *(300 mm)* average.

Include quantities for Structure Excavation and concrete in the estimate to the above indicated limits only when the item “cofferdam” is not used. When using the cofferdam item, the limits apply to concrete only.

25.8 ESTIMATED PILE LENGTHS

Calculate pile lengths in increments of 5 feet *(1500 millimeters).*

25.9 HYDRO-DEMOLISHER

The use of hydro demolition may be considered for removal of concrete on all deck rehabilitation projects. The designer may request cores of the deck in question to evaluate the appropriateness of using hydro demolition.

25.10 EROSION CONTROL

The designer shall use erosion control items for each project.

Use Stone Fill, as directed by the Hydraulics Engineer, on all wet crossings. Also, use Geotextile Under Stone Fill and Grubbing Material on all wet crossings. Plans shall indicate typical channel section. [See Chapter 13.]

The designer shall consider the use of erosion matting or Stone Fill Type I on steep ditches.

Add seed, fertilizer, limestone and mulch following the formula in Figures 25-2a and 25-2b, to all areas where soil is disturbed.

25.10.1 Temporary Erosion Control

Include temporary erosion control with the use of hay bales on all projects. See minimum that should be provided. Figure 25-3 contains a listing of the erosion control and temporary erosion control items.

Figure 25.1 Erosion Control Item Descriptions

Seed Mixture	Shall not have a weed content exceeding 0.40% by weight and shall be free of all noxious seed.
Seed	To be applied per seeding formulas or 60 lb/acre (*70 kg/hectare*) or as directed by the engineer.
Fertilizer Formula	10-20-10 to be used with seed, applied at the rate of 500 lb/acre (*560 kg/hectare*). [Hydro seeders may use 19-19-19 formula].
Agricultural Limestone	To be applied at the rate of 2 tons/acre (*4500 kg/hectare*), or as directed by the engineer.
Hay Mulch	To be placed on earth slopes at the rate of 2 tons/acre (*4500 kg/hectare*), or as directed by theengineer.
Topsoil	To be used with seed as indicated on the plans, or as directed by the engineer.
Marker Posts	To be placed as indicated or as directed by the engineer.
Slope Rounding	All cut slopes to be rounded in accordance with Standard Sheet B-5.B-5
Pay Limits of Sand Borrow	When used in conjunction with under drain - See Standard Sheet D-2.D-2

Figure 25.2a Seeding Formula for Urban Areas

% Wt.	lb/acre	*(kg/ha)*	Name	Pur %	Germ %
42.5	34	*(38)*	Creeping Red Fescue	98	85
10.0	8	*(9)*	Perennial Rye Grass	95	90
42.5	34	*(38)*	Kentucky Blue Grass	85	85
5.0	4	*(5)*	Annual Rye Grass	95	85
100.0	90	*(90)*			

Figure 25.2b. Seeding Formula Rural Areas

% Wt.	lb/acre	*(kg/ha)*	Name	Pur %	Germ %
37.5	22.5	*(26)*	Creeping Red Fescue	98	85
37.5	22.5	*(26)*	Tall Fescue	95	90
5.0	3.0	*(4)*	Red Top	95	90
15.0	9.0	*(10)*	Birds Foot Trefold	98	85
5.0	3.0	*(4)*	Annual Rye Grass	95	85
100.0	60.0	***(70)***			

25.11 MISCELLANEOUS QUANTITIES

25.11.1 Pavement

All projects with the item "Removal of Structure" or "Partial Removal of Structure" shall also have the item "Removal of Bridge Pavement," if pavement exists.

25.11.2 Sign Posts

Calculate sign posts at 3 lb/lf *(1.4 kg per meter)*.

25.11.3 Clearing and Grubbing

When using the item Clearing and Grubbing on small projects, add the statement in parentheses "Including Individual Trees and Stumps." This statement will cover any individual trees that the designer has noted for being removed. This eliminates the use of the item Removing Small or Large Trees. On the plan sheet circle the trees that are to be removed and use a legend that indicates the circle denotes removal of trees.

When Clearing and Grubbing is paid as a lump sum item, show the number of acres *(hectares)* in parentheses on the estimate only.

Figure 25-3. Erosion Control Items

Item	Description	Amount	Rount to Next
651.15	Seed	60 lb/acre (*70 kg/ha*) [Rural] 60 lb/acre (*90 kg/ha*) [Urban]	10 lb (*5 kg*) 10 lb (*5 kg*)
651.18	Fertilizer	500 lb/acre (*560 kg/ha*)	100 lb (*50 kg*)
651.20	Agricultural Limestone	2 tons/acre (*5 tons/ha*)	1 Ton (*1 Ton*)
651.25	Hay Mulch	2 tons/acre (*5 tons/ha*)	1 Ton (*1 Ton*)
651.35	Topsoil	2" Depth [Rural] * Slope Area yd3 (*50 mm Depth [Rural] * Slope Area m3*)	10 yd^3 (*10 m^3*)
		6" Depth [Urban]* Slope Area yd3 (*100 mm Depth [Urban]* Slope Area m3*)	10 yd^3 (*10 m^3*)
651.40	Grubbing Material	Area of covered stone fill ft^2 (*Area of covered stone fill m^2*)	10 yd^2 (*10 m^2*)
Temporary Erosion Control Items			
204.20	Trench Excavation of Earth	100 yd^3/mi (*50 m^3/km*)	10 yd^3 (*10 m^3*)
301.xx	Subbase Material	500 yd^3/mi (*250 m^3/km*)	10 yd^3 (*10 m^3*)
608.10	Bulldozer Rental Type I and/or	10 hr/mi (*6 hr/km*)	1 hr (*1 hr*)
608.25	All purpose Excavator {Rental} Type I	10 hr/mi (*6 hr/km*)	1 hr (*1 hr*)
613.10	Stone Fill Type I	50 yd^3/mi (*30 m^3/km*)	10 yd^3 (*10 m^3*)
649.51	Geotextile for Silt Fence	1000 ft/mi = 444 yd^2/mi (*200 m/km = 250 m^2/km*)	10 yd^2 (*10 m^2*)
651.26	Hay Bales for Erosion Control	50 bales/mi (*30 bales/km*) minimum of 10 bales	10 bales (*10 bales*)
651.15	Seed or	20 lb/mi (*5 kg/km*)	10 lb (*5 kg*)
651.17	Seed - Winter Rye (preferred)	20 lb/mi (*5 kg/km*)	10 lb (*5 kg*)
654.10	Erosion Matting	200 yd^2/mi (*100 m^2/km*)	10 yd^2 (*10 m^2*)

Chapter Twenty-Six
Estimates

26.1 ESTIMATES

Include estimated costs for preliminary engineering, right-of-way acquisition, construction items, construction engineering and contingencies in all estimate prepared for the various step submittals.

26.1.1 Conceptual Plans Cost Estimates

Bridge cost estimates for Conceptual Plan Submittals are generally computed on a per square foot *(meter)* basis. The area consists of the back to back of abutment distance and fascia to fascia width, multiplied by a current cost per square foot *(meter)*.

If the project requires substantial roadway work, calculate rough quantity estimates for each of the required items and apply the appropriate item price. Add these prices to the square foot *(meter)* estimate of the bridge for a total Conceptual cost estimate.

26.1.2 Preliminary Plans Cost Estimates

Bridge cost estimates for Preliminary Plan submittals are based on approximate quantities with applied current unit costs. The designer shall balance the expediency of developing this estimate with enough accuracy to obtain a reasonable estimated cost. Do not go to extremes in accuracy. This will be done at the Final Plan stage once the project has become final and be free of further significant changes.

26.1.3 Final Plans and Contract Plans Cost Estimates

Use the Estimator estimating software in preparing all Final Plan and Contract Plan Estimates.

Use the current unit costs, with allowance for site specific considerations, in computing the Final Plans estimate. Calculate the quantities accurately. If the project has not faced significant changes, a check with the Preliminary Plans Quantities will help determine if the amount is reasonable or if an error was made.

26.2 CONSTRUCTION ENGINEERING PERCENTAGE

All estimates shall have the percentages shown in Figure 26-1 added for CE [Construction Engineering].

Figure 26-1. Construction Engineering Cost Percentages

Project Estimated Cost	CE Percentage
Under $500,000	10%
$500,000 and Over	8%

Figure 26-2. Full Construction Engineering Items

Item No.	Description	Quantity
631.10	Field Office - Engineers	LS
631.11	Field Office - Soils & Materials	LS
631.12	Combined Engineers and Soils Office	LS
631.16	Testing Equipment - Concrete	LS
631.17	Testing Equipment - Bituminous	LS
631.18	Testing Equipment - Protective Coatings	LS
631.25	Field Office Telephone	LS

26.3 SUBSTANTIAL INCREASE IN COST

The designer shall follow current Agency policy. “Substantial” for the purpose of approval to proceed to contract shall mean:

26.3.1 Estimated Construction Cost is:

- 50 percent over last approved cost of less than $1,000,000; and
- 35 percent over last approved cost of more than $1,000,000, excepting a project with last approved cost of more than $5,000,000 and the increase is due to significant change in project scope or character and then 20 percent over last approved cost.

26.4 CONTINGENCY

Implement the 5% contingency for construction on all projects as follows:

- The 5% contingency item will be a line item in the estimate summary.
- The basis for calculating the 5% will be the total cost of all the construction items [do not include full Construction Engineering items nor Construction Engineering costs] regardless of whether they are participating or non-participating.

- In the Estimator estimates, a separate category titled “5% Contingency” will be set up by the designer. If possible, also show this amount in PPMS.

26.5 PRELIMINARY ENGINEERING

Costs for Preliminary Engineering are determined by the Project Manager on a project by project basis. This is the cost for performing the design work, along with any preliminary data collection or testing.

26.6 Right of Way

Costs for Right of Way are determined by the project manager on a project by project basis.

26.7 Sample Estimate Calculation

The following example shows the steps in calculating an estimate for a project, at any step in the design process.

1. A designer calculated the estimated cost of the quantities as **$238,419.80.**

2. The full Construction Engineering Items totaled **$14,100.00**.

3. The project estimate minus the Construction Engineering items is [**1**] - [**2**].

$238,419.80 - 14,100.00 = **$224,319.80**

4. As indicated in the price item book, the mobilization for this small project is 8%, which equals [**3**] x 0.08.

$224,319.80 x 0.08 = **$17,945.58**

5. Therefore the total estimate minus Construction Engineering items is [**3**] + [**4**]

$224,319.80 + 17,945.58 = **$242,265.38**

6. Use 10% as Construction Engineering percentage. [See figure 26-1]

7. Apply this percentage to the total estimate minus Construction Engineering items [as calculated in step 5]. This is the Construction Engineering costs in addition to the Construction Engineering items. [[**5**] x **[6]**] / 100

[$242,265.38 x 0.10] = **$24,226.54**

8. Using the total estimate minus Construction Engineering items, apply 5% to calculate the Contingency for the project. [**5**] x 0.05

$242,265.38 x 0.05 = **$12,113.27**

9. For the total project cost estimate sum the total estimate with the Construction Engineering items, the 10% Construction Engineering costs and the 5% Contingency costs. [**5**] + [**2**] + [**7**] + [**8**]

$242,265.38 + $14,100. + $24,226.54 + 12,113.27 = **$292,705.19**

10. Preliminary Engineering is another cost associated with the project. The Project Manager estimated the amount at **$50,000.00**.

11. The project manager estimated the amount of **$24,000.00** for Right of Way Costs.

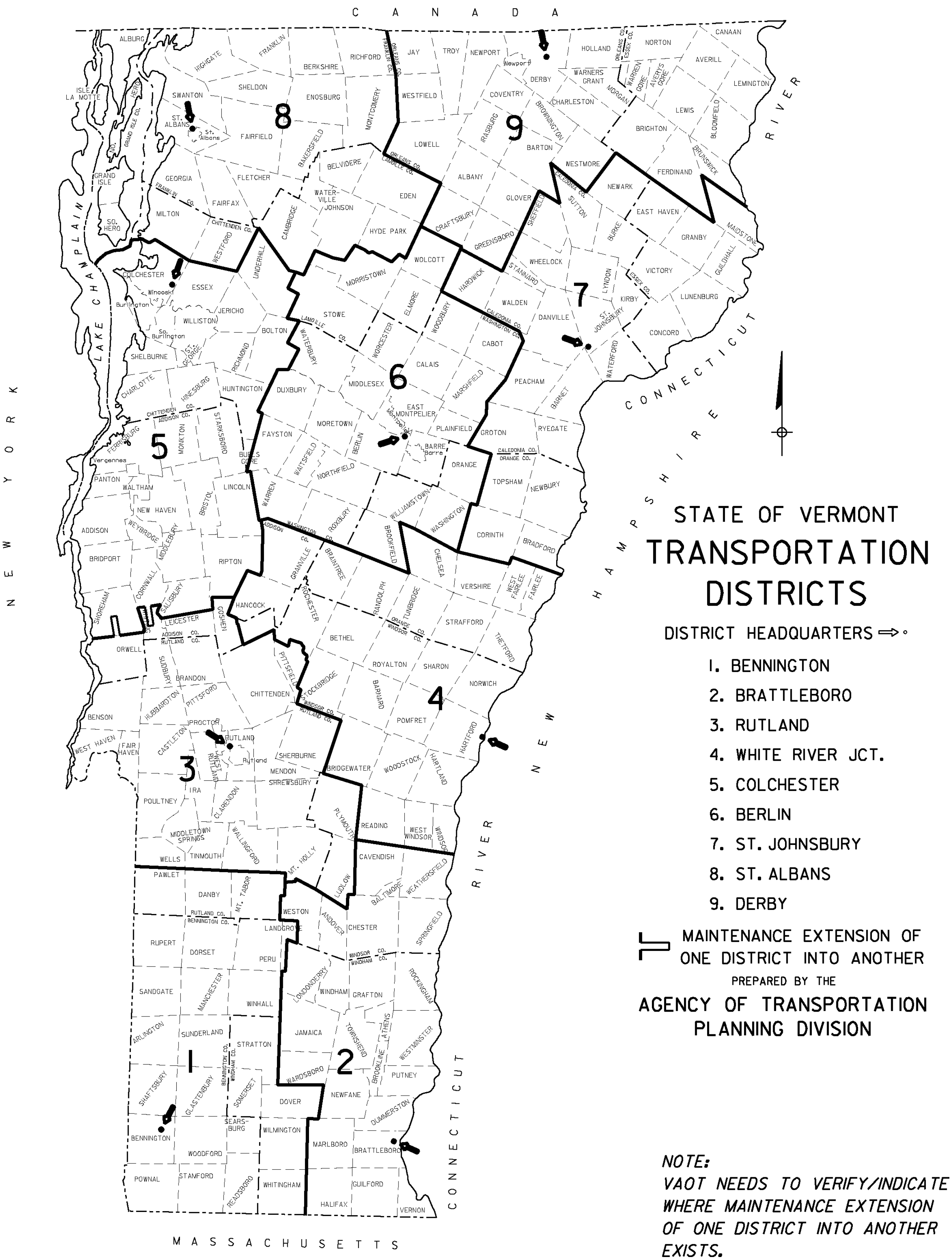
12. The cost Estimate of the project is $366,705.19. The data calculated here is summarized in Figure 26-3.

Figure 26-3. Estimate Summary

Description	Amount	Sub-total
Sub Total w/o Construction Engineering Items	$242,265.38	$242,265.38
Full Construction Engineering Items (2)	$14,100.00	
Sub Total with full construction engineering items		$256,365.38
10% Construction Engineering	$24,226.54	
5% Contingency	$12,113.27	
Sub-total including Construction Engineering and Contingencies		$292,705.19
Preliminary Engineering costs *	$50,000.00	
Right of way costs *	$24,000.00	
Total Project Cost Estimate		$366,705.19

* These costs are not included with the Estimator or BAMS estimates. However, include these when making step submittals in order to provide a more accurate picture of the total project costs.

Map of Vermont Transportation Districts



Appendix A

STATE OF VERMONT AGENCY OF TRANSPORTATION DISTRICT MAP AND ADDRESSES

If mailing roll of plans or anything weighing more than one pound *(half a kilogram),* use these addresses and not box numbers. This material is usually handled by a delivery service such as U.P.S. or FedEx and the charge is more if they have to look up the street address.

	Address	Phone Number
DISTRICT 1	Wayne Gammell Agency of Transportation 359 Bowen Road, Bennington, VT 05201	**(802) 447-2790**
DISTRICT 2	Floyd N. Roberts Agency of Transportation 870 US Rte 5, North Brattleboro, Vermont 05304	**(802) 254-5011**
DISTRICT 3	Dave E. Lathrop Agency of Transportation 122 State Place, Rutland, VT 05701	**(802) 786-5826**
DISTRICT 4	George Spilak Agency of Transportation 221 Beswick Drive POBox 977, White River Jct., VT 05001	**(802) 296-5564**
DISTRICT 5	Richard Hosking Agency of Transportation 5 Barnes Ave, Colchester, VT 05446	**(802) 655-1580**
DISTRICT 6	Earnest Englehardt Agency of Transportation 186 Industrial Lane Rd. Berlin, Barre, Vermont 05641	**(802) 828-2691**
DISTRICT 7	Sidney Achilles Agency of Transportation 1068 US Rte 5, Suite 2, St. Johnsbury, VT 05819	**(802) 748-6670**
DISTRICT 8	Gilbert Newbury Agency of Transportation 680 Lower Newton Rd., St. Albans, VT 05478	**(802) 524-5926**
DISTRICT 9	Dale Perron Agency of Transportation 4611 US Rte 5, Newport, VT 05855	**(802) 334-4340**

Appendix B

Vermont County and Town Codes

Addison 0100

Addison	**0101**
Bridport	**0102**
Bristol	**0103**
Cornwall	**0104**
Ferrisburg	**0105**
Goshen	**0106**
Granville	**0107**
Hancock	**0108**
Leicester	**0109**
Lincoln	**0110**
Middlebury	**0111**
Monkton	**0112**
New Haven	**0113**
Orwell	**0114**
Panton	**0115**
Ripton	**0116**
Salisbury	**0117**
Shoreham	**0118**
Starksboro	**0119**
Vergennes	**0120**
Waltham	**0121**
Weybridge	**0122**
Whiting	**0123**

Bennington 0200

Arlington	**0201**
Bennington	**0202**
Dorset	**0203**
Glastenbury	**0204**
Landgrove	**0205**
Manchester	**0206**
Peru	**0207**
Pownal	**0208**
Readsboro	**0209**
Rupert	**0210**
Sandgate	**0211**
Searsburg	**0212**
Shaftsbury	**0213**
Stamford	**0214**
Sunderland	**0215**
Winhall	**0216**
Woodford	**0217**

Caledonia 0300

Barnet	**0301**
Burke	**0302**
Danville	**0303**
Groton	**0304**
Hardwick	**0305**
Kirby	**0306**
Lyndon	**0307**
Newark	**0308**
Peacham	**0309**
Ryegate	**0310**
St Johnsbury	**0311**
Sheffield	**0312**
Stannard	**0313**
Sutton	**0314**
Walden	**0315**
Waterford	**0316**
Wheelock	**0317**

Chittenden 0400

Bolton	**0401**
Buel's Gore	**0402**
Burlington	**0403**
Charlotte	**0404**
Colchester	**0405**
Essex	**0406**
Hinesburg	**0407**
Huntington	**0408**
Jericho	**0409**
Milton	**0410**
Richmond	**0411**
St. George	**0412**
Shelburne	**0413**
S. Burlington	**0414**
Underhill	**0415**
Westford	**0416**
Williston	**0417**
Winooski	**0418**

Essex 0500

Averill	**0501**
Avery's Gore	**0502**
Bloomfield	**0503**
Brighton (Island Pond)	**0504**

Town and County Codes (continued)

Brunswick **0505**
Canaan **0506**
Concord **0507**
East Haven **0508**
Ferdinand **0509**
Granby **0510**
Guildhall **0511**
Lemington **0512**
Lewis **0513**
Lunenburg **0514**
Maidstone **0515**
Norton **0516**
Victory **0517**
Warners Grant **0518**
Warren's Gore **0519**

Franklin 0600

Bakersfield **0601**
Berkshire **0602**
Enosburg **0603**
Fairfax **0604**
Fairfield **0605**
Fletcher **0606**
Franklin **0607**
Georgia **0608**
Highgate **0609**
Montgomery **0610**
Richford **0611**
St. Alban's City **0612**
St. Alban's Town **0613**
Sheldon **0614**
Swanton **0615**

Grand Isle 0700

Alburg **0701**
Grand Isle **0702**
Isle LaMotte **0703**
North Hero **0704**
South Hero **0705**

Lamoille 0800

Belvidere **0801**
Cambridge **0802**
Eden **0803**
Elmore **0804**
Hyde Park **0805**
Johnson **0806**
Morristown **0807**
(Morrisville)
Stowe **0808**
Waterville **0809**
Wolcott **0810**

Orange 0900

Bradford **0901**
Braintree **0902**
Brookfield **0903**
Chelsea **0904**
Corinth **0905**
Fairlee **0906**
Newbury **0907**
Orange **0908**
Randolph **0909**
Strafford **0910**
Thetford **0911**
Topsham **0912**
Tunbridge **0913**
Vershire **0914**
Washington **0915**
West Fairlee **0916**
Williamstown **0917**

Orleans 1000

Albany **1001**
Barton **1002**
(Orleans Village)
Brownington **1003**
Charleston **1004**
Coventry **1005**
Craftsbury **1006**
Derby **1007**
Glover **1008**
Greensboro **1009**
Holland **1010**
Irasburg **1011**
Jay **1012**
Lowell **1013**
Morgan **1014**
Newport City **1015**
Newport Town **1016**

Town and County Codes (continued)

Troy	**1017**
Westfield	**1018**
Westmore	**1019**
Rutland	**1100**
Benson	**1101**
Brandon	**1102**
Castleton	**1103**
Chittenden	**1104**
Clarendon	**1105**
Danby	**1106**
Fair Haven	**1107**
Hubbardton	**1108**
Ira	**1109**
Mendon	**1110**
Middletown Springs	**1111**
Mount Holly	**1112**
Mount Tabor	**1113**
Pawlet	**1114**
Pittsfield	**1115**
Pittsford	**1116**
Poultney	**1117**
Proctor	**1118**
Rutland City	**1119**
Rutland Town	**1120**
Sherburne	**1121**
Shrewsbury	**1122**
Sudbury	**1123**
Tinmouth	**1124**
Wallingford	**1125**
Wells	**1126**
West Haven	**1127**
West Rutland	**1128**
Washington	**1200**
Barre City	**1201**
Barre Town	**1202**
Berlin	**1203**
Cabot	**1204**
Calais	**1205**
Duxbury	**1206**
E. Montpelier	**1207**
Fayston	**1208**
Marshfield	**1209**
Middlesex	**1210**
Montpelier	**1211**
Moretown	**1212**
Northfield	**1213**
Plainfield	**1214**
Roxbury	**1215**
Waitsfield	**1216**
Warren	**1217**
Waterbury	**1218**
Woodbury	**1219**
Worcester	**1220**
Windham	**1300**
Athens	**1301**
Brattleboro	**1302**
Brookline	**1303**
Dover	**1304**
Dummerston	**1305**
Grafton	**1306**
Guilford	**1307**
Halifax	**1308**
Jamaica	**1309**
Londonderry	**1310**
Marlboro	**1311**
Newfane	**1312**
Putney	**1313**
Rockingham (Saxton's River) (Bellow's Falls)	**1314**
Somerset	**1315**
Stratton	**1316**
Townshend	**1317**
Vernon	**1318**
Wardsboro	**1319**
Westminster	**1320**
Whitingham	**1321**
Wilmington	**1322**
Windham	**1323**
Windsor	**1400**
Andover	**1401**
Baltimore	**1402**
Barnard	**1403**
Bethel	**1404**
Bridgewater	**1405**
Cavendish	**1406**
Chester	**1407**
Hartford	**1408**

Town and County Codes (continued)

(White River Junction)
Hartland **1409**
Ludlow **1410**
Norwich **1411**
Plymouth **1412**
Pomfret **1413**
Reading **1414**
Rochester **1415**
Royalton **1416**
Sharon **1417**
Springfield **1418**
Stockbridge **1419**
Weathersfield **1420**
Weston **1421**
West Windsor **1422**
Windsor **1423**
Woodstock **1424**

Appendix C
Plans Content

The following is a compilation of what is expected on a complete set of plans. Part II of this manual contains portions of this list in the various chapters. Refer to these lists for the individual step submittals, respective to that step's chapter. This list should be referred to once Final Plans are complete and are being prepared for a Contract Plan submittal.

C.1 TITLE SHEET

C.1.1 Plan View

- Existing edges of roads [dashed] with directions to adjacent towns labeled.
- Existing Highway/Route names and/or numbers.
- Existing edges of river with river name and flow direction.
- Existing building outlines.
- Existing bridge or structure [dashed].
- Proposed centerline with mainline stations only, no subtangents.
- Begin and end project stations.
- Begin and end bridge stations.
- North arrow.
- Bar scale.

C.1.2 Horizontal and Vertical Datum

C.1.3 Project Information

- Town, County, Route No. [show class if a town highway], Bridge No.
- Project Location [same as shown on the Finance & Maintenance Agreement].

- Project Description [same as shown on the Finance & Maintenance Agreement].
- Length of Structure, Length of Roadway, Length of Project.

C.1.4 Location Map

- Large enough to be legible when reduced to half size.
- Identifiable features [i.e., State route, or rivers] labeled.
- Project location circled and labeled with project name and number.

C.1.5 Indexes of Sheets Including Standards & Reference Sheets

C.1.6 Title Block

Completely filled in.

C.2 PRELIMINARY INFORMATION SHEET

C.2.1 Typical Bridge Section [As applicable for type of superstructure]

- Thickness of pavement and/or deck and height & width of curbs.
- Types and thickness of pavement lifts.
- Cross slope information.
- Width to curb, face of rail, fascia.
- Type of bridge rail, with reference to standard.
- Beam spacing and fascia overhangs.
- Girder web depth or size of rolled beams.
- Number, size and type of prestressed members including depth of overlays.
- Sheet membrane waterproofing.
- Haunch, chamfers and drip notches.
- Typical diaphragms or cross-frames.
- Centerline and location of grade.
- Scale: 3/8" = 1'-0" preferred, 1/4" = 1'-0" minimum. *(1:40 preferred, 1:50 minimum)*

C.2.2 Typical Roadway Section

- The following tolerances shall be shown on the Roadway Typical Section:

Figure 7-2. Material Tolerances

Material Item	Tolerance
Surface Course	
- Pavement	±1/4" (±5mm)
- Aggregate Surface Course	±1/2" (±10mm)
Base Course	±1/2" (±15mm)
Subbase	±1" (±30mm)
Sand Borrow	±1" (±30mm)
Granular Borrow	±1" (±30mm)

- Thickness of pavements, subbase and frost-free material.
- Type and thickness of pavement lifts.
- Cross slope information.
- Width of travel lanes and shoulders with and without guardrail.
- Type of guardrail with reference to Standard.
- Side slope ratios [1:2, 1:3 etc.] and ditch information.
- Grade point and centerline.
- Additional details as required [i.e., sidewalks, curbs, under-drain, etc.].
- Scale: 3/8" = 1'-0" preferred, 1/4" = 1'-0" minimum *(1:40 preferred, 1:50 minimum)*.
- Clear Zone

C.2.3 Typical Abutment Earthwork Section

- Theoretical cofferdam limits
- Excavation and Backfill limits

C.2.4 Typical Channel Section

- Excavation
- Stone Fill
- Grubbing Material
- Geotextile limits

C.2.5 Final Hydraulics Report

C.2.6 Design Criteria

- Live Load.
- Design Span.

- Structural Steel Type.
- Concrete Type.
- Design Stresses for Steel and Concrete.
- If using piling, show average pile length rounded to the next 5 foot *(1500 mm)* increment for each substructure unit [use the word average for each length shown]

C.2.7 Traffic Maintenance

- Fill in all lines.

C.2.8 Load Rating Table

Place an appropriate table and fill in.

C.2.9 Traffic Data

- Place data.

C.2.10 Temporary Bridge Sketch

Schematic showing the horizontal and vertical requirements for size of opening.

C.2.11 Title Block

Fill every line.

C.3 BRIDGE AND ROADWAY QUANTITY SHEET

C.3.1 Quantity Breakdown

- Quantities should be broken down and listed on the Quantity Sheet as follows:
  - Superstructure
  - Abutments
  - Approach slabs
  - Piers
  - Channel
  - Roadway
  - Utilities [participating and nonparticipating] Waterline, Sewer line, Street Lighting, Gas line
  - Erosion Control
  - Other categories, as appropriate
- Items
  - List in numerical order
  - Shear Connector—Total Number; i.e., [1322 - 7/8” X 7” *(22 mm x 180 mm)*]

- Include Mobilization Item

C.3.2 Earthwork Summary

- Fill required
  - Planimetered fill [= A]
  - Less factored solid rock excavation [factor is 1.3] [= B]
  - Less displacement of any large buried structures [= C]
  - Net planimetered fill [A - B - C = D]
  - 1.15 x net planimetered fill = factored fill [1.15 x D = E]
- Planimetered material available for fill
  - Earth excavation x 1.0 [= F]
  - Channel excavation 0.3 [= G]
  - Structure excavation or excavation within cofferdams x 0.3 [= H]
  - Total material available for fill [F + G + H = I]
- Borrow or Waste = factored fill less total material available for fill [E - I]

C.3.3 Temporary Erosion Control Items

List in numerical order w/ quantity.

C.4 RIGHT-OF-WAY LAYOUT SHEETS [NON-FEDERAL PROJECTS]

C.4.1 Contents

- Existing Right-of-Way
- Take lines
- Construction easements
- Rights
- Legend

C.5 TIE SHEET

C.5.1 Upper Section—Geodetic Control Information [if provided.]

- GPS control point name
- Northing and Easting coordinates and elevation
- Description of point location
- Swing ties to point if provided

C.5.2 Middle Section—Traverse Tie Information

- Swing ties shown in individual boxes with proper orientation but not necessarily to scale
- Topo and tie distances

- Description of a point
- Northing and Easting coordinates and elevation

C.5.3 Lower Section—New Alignment Tie Information

- Swing ties shown in individual boxes with proper orientation but not necessarily to scale
- Topo and tie distances
- Description of a point in station
- Northing and Easting coordinates
- Not necessary to have these ties before proceeding to next step

C.5.4 Horizontal and Vertical Datum

C.6 PLAN SHEET [LAYOUT SHEET]

C.6.1 Bench Marks

- Label each benchmark with number, description, and elevation in individual boxes.
- Horizontal alignment data with traverse points labeled as on the Tie Sheet

C.6.2 Existing Topography

- Label all features used for control ties and only critical features near project area [i.e., existing structures, edge of woods, fence lines, guard rail, stone walls, power/telephone poles with numbers, existing drainage and water courses with the name and a direction-of-flow arrow.]
- Direction arrows to nearest town or route.
- Existing ROW lines
- Additional critical features
- Existing Highway/Route names and/or numbers.

C.6.3 Proposed mainline alignment

- Regular and cardinal stations.
- Curve data [if applicable].
- Show lines at begin and end of bridge on appropriate skew.
  - Label with station and finished grade elevations.
- Begin/End project stations
- Begin/End approach stations

- Face of guard rail, guard rail flares and shoulder break lines from beginning to end of the project.

C.6.4 Proposed Channel Line Alignment

- Regular and cardinal stations.
- Mainline/channel line intersection labeled with stations and delta angles.

C.6.5 Proposed Construction

- Construction item notes [ie bridge rails, guard rails, drives, etc.]
- New drainage complete with labels
- Drive and side road radii
- Approximate centerline of a temporary bridge detour with related construction limits
- Project construction limits
- Stone fill and related channel work
- Face of guard rail, guard rail flares and shoulder break lines
- The outline of new structure including deck, approach slabs, wingwalls and face of abutments [do not show footings]

C.6.6 Miscellaneous Information

- Existing bridge data
- North arrow
- Bar scale
- Temporary Bridge Center Line, only when necessary.
- Clear zones [See section 13.1.7.1]

C.7 PROFILE SHEET

C.7.1 Profile

- Existing ground along proposed line [dashed and labeled].
- Proposed vertical alignment.
- Vertical and cardinal stations and elevations.
- Tangent grades [to 4 decimal places].
- Vertical curve information [showing length, stopping sight distance and k values.]

- Begin/end project station.
- Begin/end approach station.
- Begin/end bridge stations and finished grades.
- Existing ground elevations at left of vertical grid lines to 1 decimal place *(to 2 decimal places - metric)*.
- Proposed finish grade elevations at right of vertical grid lines to 2 decimal places *(to 3 decimal places - metric)*.
- Title.
- Scale use 2 to 1 vertical exaggeration, 20-scale horizontal and 10-scale vertical *(2.5 to1 vertical exaggeration, 250-scale horizontal and 100-scale vertical)*.
- Abutments, including footings with bottom of footing elevations
- Approach slabs
- Do not show material transitions
- Do not show Stone Fill
- Banking diagram [may be shown here or on Roadway cross sections]

C.7.2 Title Block

- Project name.
- Project number.
- Sheet name.

C.8 TRAFFIC CONTROL SHEETS

Traffic and Safety has provided many details for traffic control during construction. The designer may consult these for assistance in developing traffic control for a project. This sheet shall include:

- Layout of project
- General plan of temporary traffic patterns
- If there will be a detour, clearly show this detour on the plan.
- If there will be a phased traffic pattern in a bridge rehabilitation project, detail these phases on the plan. Also provide cross sections detailing the expected phases on the bridge.

C.9 BORING INFORMATION SHEET

Include information provided from Materials and Testing Section.

C.9.1 Layout

- Existing edges of road and structure [dashed]
- A new centerline with regular stations
- North arrow
- Stream name with flow direction
- New bridge abutments outlined
- Location of bore holes marked with appropriate nomenclature
- Bore holes numbered
- Title and scale

C.9.2 Boring Chart

- Boring numbers
- Station
- Offset from the centerline
- Elevation of bedrock if applicable

C.10 BORING LOG SHEET

C.10.1 Boring Logs

- Place logs beside one another without regard to vertical elevation
- Bottom of footing elevation applicable to each log
- Estimated pile tip elevation, if applicable

C.11 PLAN & ELEVATION

C.11.1 Plan

- Preferred scale is 1”= 10’-0” *(1:100 metric)*
- Wingwall numbers but no lengths or angles
- Abutment askew angles
- Limits and type[s] of Stone Fill
- All slope ratios [roadway and channel]
- Guard rail with flares [if within limits of drawing] and only first post off bridge
- First bridge rail post at each end of bridge [with distances to them, from the end of the bridge. If the layout detail does not show distances, refer to sheet where they may be found]
- Edge of shoulders [and pavement if applicable]
- Stream name and show direction of flow

- North arrow
- Point of minimum clearance if dry crossing [road or railroad]
- Mainline, channel line and sideline[s] with stations
- Equated stations at line intersection points with delta angles
- Substructure outlines with footings
- Cardinal stations [i.e., PC, PT, etc.] in area of bridge
- Any adjacent drainage or remaining landmarks in area of bridge
- Begin and end bridge stations, the centerline of bearing stations where applicable, and finish grades at each
- Major chord [if applicable]
- The plan need not show curve data
- Title and bar scale

C.11.2 Elevation View

- Drawn as if looking from the stream toward the right fascia
- Existing ground and approximate ledges [if applicable] shown and labeled
- Do not show below ground information [i.e., dashed footing, bottom of the stone fill, etc.]
- Do not show roadway percent grades or vertical curve information
- Do not show girder or beam information
- Fixed or expansion ends if applicable
- Span length[s]
- Guard rail schedule[s]
- Design “Q” or the highest “Q” that will pass under the structure
- New Stone Fill labeled with the type and thickness [shown just down to existing ground]
- New bridge rail and the length of it for each side [if the view does not show length, refer to sheet where it may be found]
- The first guard rail post off each corner
- Approach rail [may be partially shown]
- Elevation Bar Scale on each side of drawing

C.12 EROSION CONTROL SHEET

Refer to the erosion control procedures and measures recommended in the Erosion and Sediment Control chapter in the VAOT “Hydraulics Manual” and in the Handbook for “Soil Erosion and Sediment Control on Construction Sites” [Vermont Geological Survey, 1987].

C.12.1 Erosion Control Site Plan

- Use the grading of the site as a base
- Show the location of all erosion control measures [e.g., vegetation, dikes, sediment diversions, sediment basins, silt fences, etc.]
- Show a timetable chart of the sequencing of the control measures

C.13 GENERAL NOTES

This sheet shall include notes for the contractor. Write these notes clearly. Any note requiring a pay item shall include the pay item and it’s description. Fully describe any modification to a pay item on this sheet.

C.14 SUPERSTRUCTURE DETAILS

The following details are generic and are provided for guidance. The designer is responsible for showing all necessary details for each specific project.

C.14.1 Bridge Typical Section

C.14.2 Deck or Slab Reinforcing

- Begin & End Bridge
- All necessary reinforcing details

C.14.3 Concrete Placement Schedule

- Show desired deck concrete placement segments and sequence for continuous spans, with direction of placement indicated, usually low to high end.
- List options, if any are available

C.14.4 Bridge End Detail

- Deck reinforcing shown & labeled
- Beam, end diaphragm and end haunch steel
- Pavement on and off bridge with joint detail [if required]
- PVC water stop with all curtain walls [etail curtain wall reinforcing]
- Approach Slab Bracket
    - Reinforcing, including dowels to abutment

- Thickness of the slab
- 1/2” X 6” *(12 mm x 150 mm)* expansion material under the edge of the slab

- Closed cell foam expansion material at the end of slab, if required

- Detail at the interface of abutment top, the back wall base and the curtain wall

- Detail the half-section elevation of the curtain wall, parallel to the centerline of bearing. Show the reinforcing configuration in this view.

C.14.5 FRAMING PLAN

- Centerline bearing at abutments & piers
- Beam splice locations
- Beam/girder number, size and spacing [normal & skew]
- Member size and spacing of diaphragms
- Bridge centerline, major chord, and askew angle
- Scupper locations
- Detail locations for connection details
- Drip plate location

C.14.6 Beam/Girder Elevation

- Exaggerated scales [horizontal & vertical]
- Sizes of web, flanges, or beams and stiffeners, or connection plates
- Centerline bearings & splices
- Steel designation
- Shear connector details
- Charpy V-notch requirements and locations
- Girder end details, overhangs
- Cover plates with dimensions
- Drip plate location [use CADD cell for detail]

C.14.7 CAMBER DIAGRAM AND DEAD LOAD DEFLECTION

- Detailing simple spans with only a note is allowable.

- Exaggerated scales [horizontal & vertical]
- Draw dead load deflection down, camber up
- Centerline of bearing at abutments or piers
- Numbers of spaces and spacing between ordinates, dimensions between base and curve

C.14.8 BEAM SPLICE DETAILS

- Elevation and Plan Views
- All plates with sizes
- Bolt spacing
- Bolt & hole sizes

- Detail filler plates

C.14.9 BEARING DEVICE DETAILS

- Plan View
  - Centerline girders, centerline bearing, skew angle
  - Beam flange and exposed plate dimensions
  - Anchor bolt size & hole size in plates [typical hole size is 3/8” *(10 mm)* greater than the anchor bolt diameter]
  - Bearing stiffeners
  - Face of abutment or pier
  - A temperature setting table
  - Block out plate if required
- Section normal to beam at the centerline of bearing device
  - Label bearing pad, bolts, welds, and TFE and stainless steel surfaces
  - Dimension anchor bolt spacing, overall depth of bearing, thread projection, plate thickness
- Section along the centerline of the beam
- Show welds, plate thickness [including both ends of any beveled plates], washers, blockout plates and overall depth
- Notes and list of design loads, both vertical and horizontal and pertinent notes

C.14.10 BEAM HAUNCH AND SHEAR CONNECTOR DETAIL

- Chamfer beam haunch 1” X 1” *(25 mm x 25 mm)*
- Shear connectors designed as per AASHTO.

C.14.11 BRIDGE JOINT DETAILS

Use Vermont joint for spans 90 feet *(27 m)* and over.

C.14.12 Approach Slab Details

See details in chapter 18 of this manual for assistance in detailing approach slabs.

C.14.13 Diaphragm Details

- Design according to AASHTO.
- Detail with a 25’-0” *(7500 mm)* maximum spacing for straight girders.

C.14.14 Prestressed Superstructure

- Plan view of all members

- Detail a specific typical section for the prestressed member indicating:
  - A section showing a strand pattern
  - Location of the strand pattern on the span.
  - Geometric dimensions of the section.
  - Position and spacing of the deformed concrete reinforcement, including size and clearance of bars.
- Elevation view of member indicating:
  - Geometric dimensions
  - Position of the eccentricity of the strands at the ends of the member, points of tie down, or other locations of change.
- The following information shall be tabulated or noted:
  - The fabricator may submit alternate members [variation in the Section geometrics] for approval provided the overall depth and width of the typical section are no greater than that detailed.
  - Minimum concrete strength f'_c.
  - Concrete stress at transfer f'_{ci}.
  - Approximate weight of each unit.
  - Maximum live load plus impact moment and live load reaction.
  - Maximum superimposed dead load moment and dead load moment reactions and dead load and SDL.
  - Size and grade of prestressing strand used in the design.
  - Number of prestressing strands used in the design.
  - Initial prestressing force.
  - Final prestressing force.
  - Provide weep holes in bottom of all voids.
  - See standard cells for longitudinal joint connection details.
  - Use minimum of 5” *(130 mm)* structural overlay with either a bare deck or with membrane and paving.
  - Method of transverse tensioning
- Plan view of overlay reinforcing
- Appropriate end detail

C.15 CADD CELL SUPERSTRUCTURE DETAILS

Various typical superstructure details are available on CADD. Use these cells when appropriate.

C.16 SUBSTRUCTURE DETAILS

C.16.1 Detail Order

- Abutments
- Wing walls
- Piers

C.16.2 Details

- Plan views with dimensions
- Centerline girders or beams with skews and dimensions
- Beginning/End Bridge or centerline bearing with station & finish grades
- Footing reinforcing plans
- Pile plans [denote battered piles] and size, spacing, and batter
- Elevation views
- Reinforcing Steel
- Weep holes
- Elevations—beam seats, construction joint, ends of wingwalls, footings
- Typical Sections
- Reinforcing bars with splice lengths
- Approximate ledge, if applicable
- Corner detail
- Appropriate notes

C.17 OTHER SHEETS OR DETAILS

- Curb and rail
- Bridge railing detail sheets
- Sign and striping details
- Sign summary sheets
- Drainage and Drainage layouts
- Mailbox details

C.18 REINFORCING STEEL SCHEDULE

C.18.1 General Items

- Avoid detailing bar lengths greater than 40’-0” *(12 000 mm)* where practical.

- Denote epoxy coated bars with the Prefix E.

- List bar groups by structural components such as superstructures, abutments, wingwall, pier, approach slabs, etc.

C.18.2 List Bars

List bars within a group as follows:

- Straight bars
  - #5 *(16)* bars
  - #6 *(19)* bars
  - etc.
- Bent bars
  - #5 *(16)* bars
  - #6 *(19)* bars
  - etc.

C.18.3 Bar Nomenclature:

- Example 1EA1105
  - 1EA denotes an epoxy coated bar for abutment 1
- Other Units:
  - S—deck or slab
  - AS—approach slab
  - P—pier
  - W—wingwall
  - B—barrel in R.C. box
- 11 denotes bar size [i.e., #11 bar.]
- 05 denotes bar identification number [i.e., the fifth #11 bar.]

C.18.4 Test Bars

- Provide extra bars for testing. Provide at least four test bar segments for every 100,000 pounds *(45 000 kg or 45 Tonne)* of each coated and uncoated bar size for each structural unit [i.e., abutments, piers, decks and approach slabs]. Each extra bar may provide a maximum of two test segments. The segments must be straight and at least 30" *(770 mm)* long.
- If there are more than 100,000 pounds *(45 000 kg)* of reinforcing required in any one size, provide additional two test bars for testing in that size.
- Avoid indicating two test bars in a line on schedule if possible. Distribute test bars evenly to get a better test sampling.
- Test bars shall be designated as one additional bar added to the number required for a detailed bar on the reinforcing bar schedule.

- The actual bar used for testing should be randomly selected from those supplied under the detail bar mark.

C.19 ROADWAY CROSS SECTIONS

C.19.1 Cross sections

- Shown at 50 foot *(10 meter)* intervals and at critical sections
- Existing ground [dashed]
- Fully templated with finish grades, side slopes and cross slopes labeled
- Template all material [pavement, subbase, sand borrow, etc.] but don't label them
- Do not show begin/end stations for materials
- Label side slopes and cross slopes at least once per sheet and anytime they change
- No need to show existing drainage unless the project requires the modification
- Do not show full bridge typical section; show only backbone in bridge area
- Begin/end stations for bridge, project and approaches
- Show invert elevations for all new culverts
- Cross reference to appropriate location[s] on Drive & Culvert Cross Section Sheet

C.19.2 Material Transition Details

Show for both begin and end bridge and begin and end project

C.19.3 Banking Transition Details

If not already shown on the Profile Sheet

C.19.4 Drive & Culvert Cross Section Sheet[s]

- Use a separate sheet at the end of the Roadway Cross Sections
- Show drive and culvert sections and/or profiles
- Cross reference to appropriate location[s] on Roadway Cross Sections

C.19.5 Title block

- Project name
- Project number
- Sheet name

C.20 CHANNEL CROSS SECTIONS

C.20.1 Cross sections

- Shown at 25 foot *(5 meter)* intervals

- Existing ground [dashed]
- Template with Stone Fill, Granular Backfill for Structures, Unclassified Channel Excavation and Grubbing Material
- Template new substructures with any undercut[s] and piling
- Label the begin/end stations [on both sides of the channel] for the following items:
  - Unclassified Channel Excavation
  - Stone Fill
  - Geotextile for Stone Fill
  - Grubbing Material
- Template [pattern] ledge when a substructure is founded directly on the ledge
- When a channel line cross section intersects a roadway, template only enough of the roadway to clarify any quantities involved
- Do not template any of the superstructure
- Do not show cofferdam limits
- Do not label items on x-sections unless they differ from the typical channel section

C.20.2 Title block

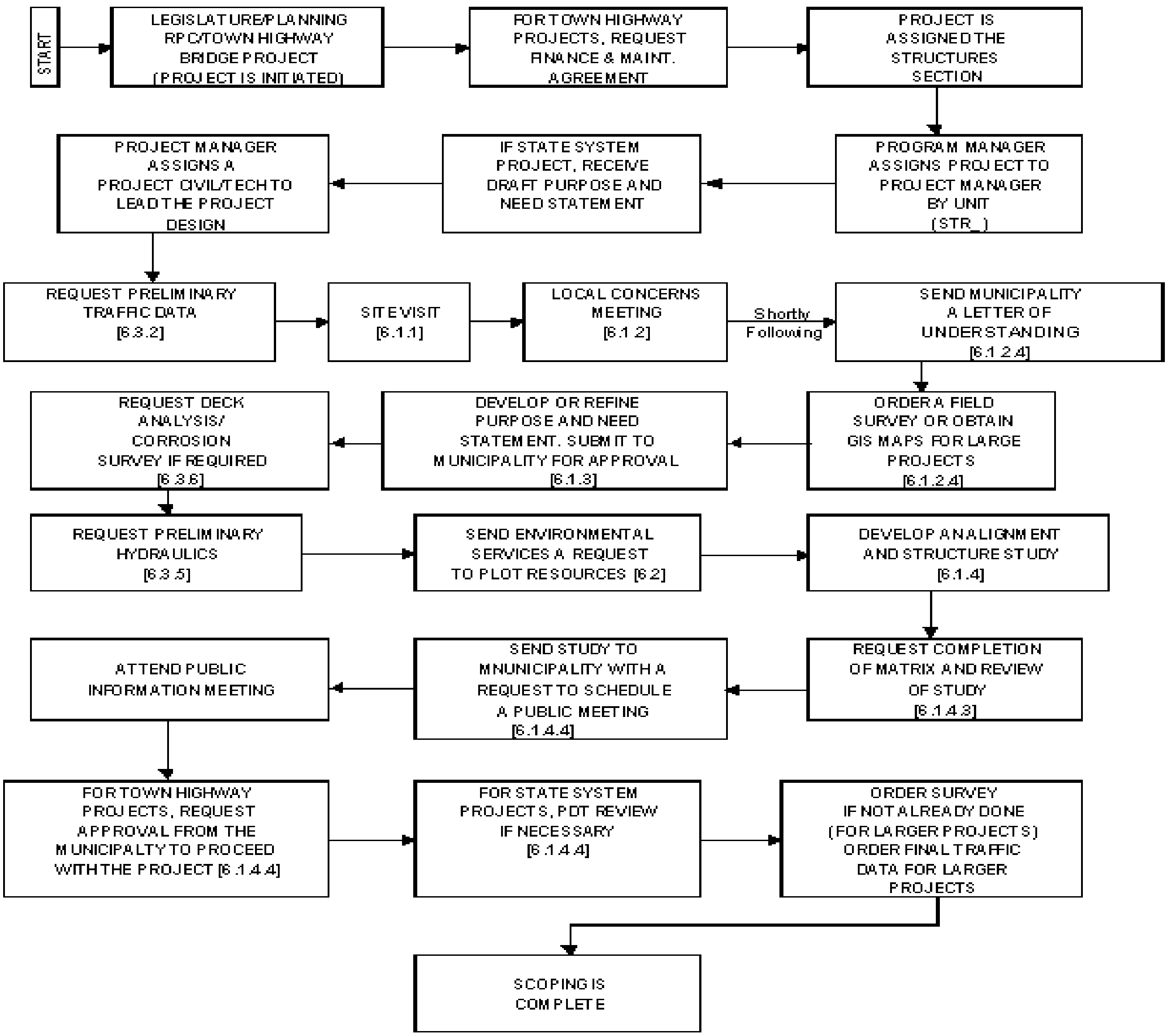
- Project name
- Project number
- Sheet name

Appendix D

Project Flow Chart

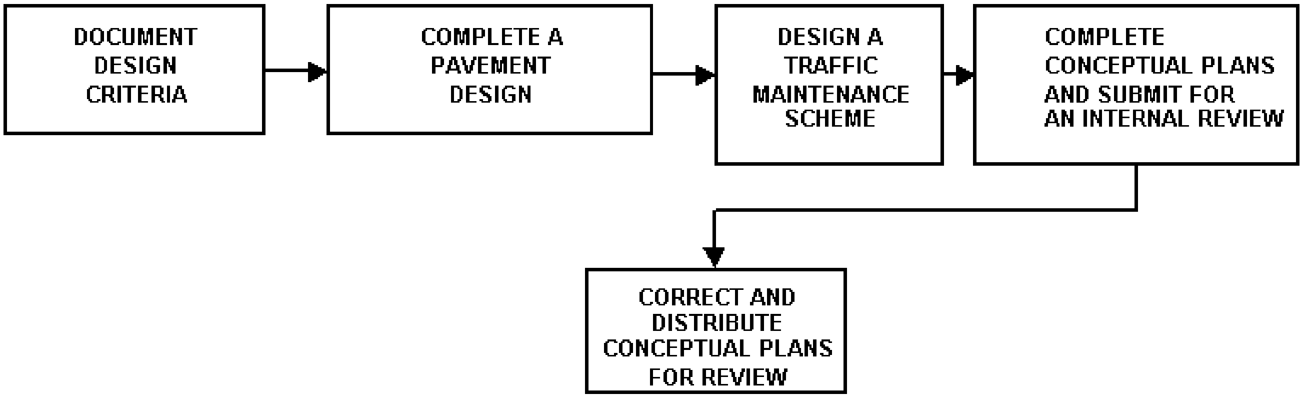
Use this flow chart to assist in developing a project. Certain processes must occur for a variety of different project types. This chart can be referred to plan for future activities for a project.

Scoping Process



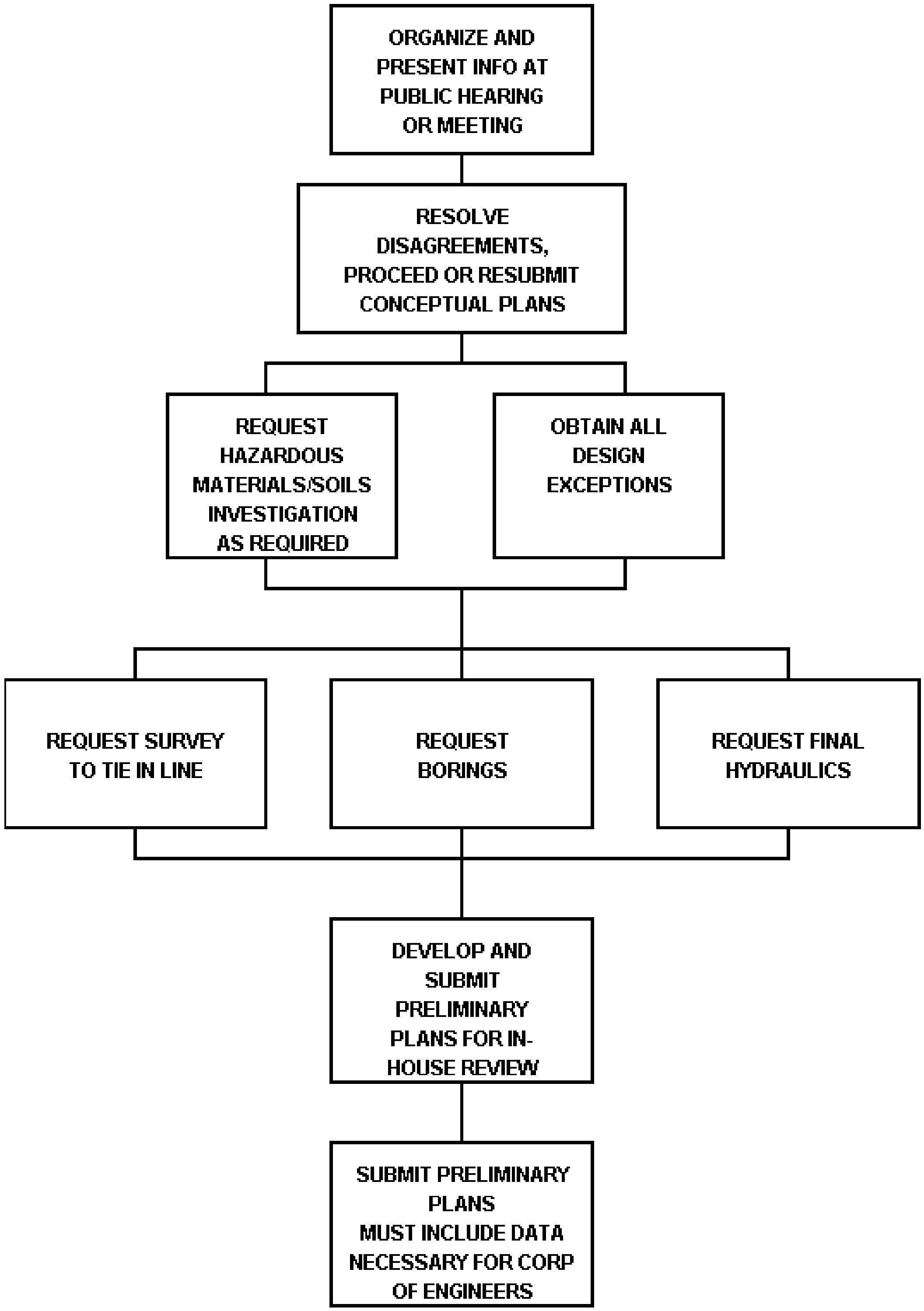
Continue on to Conceptual Plan Step

Conceptual Plan Step



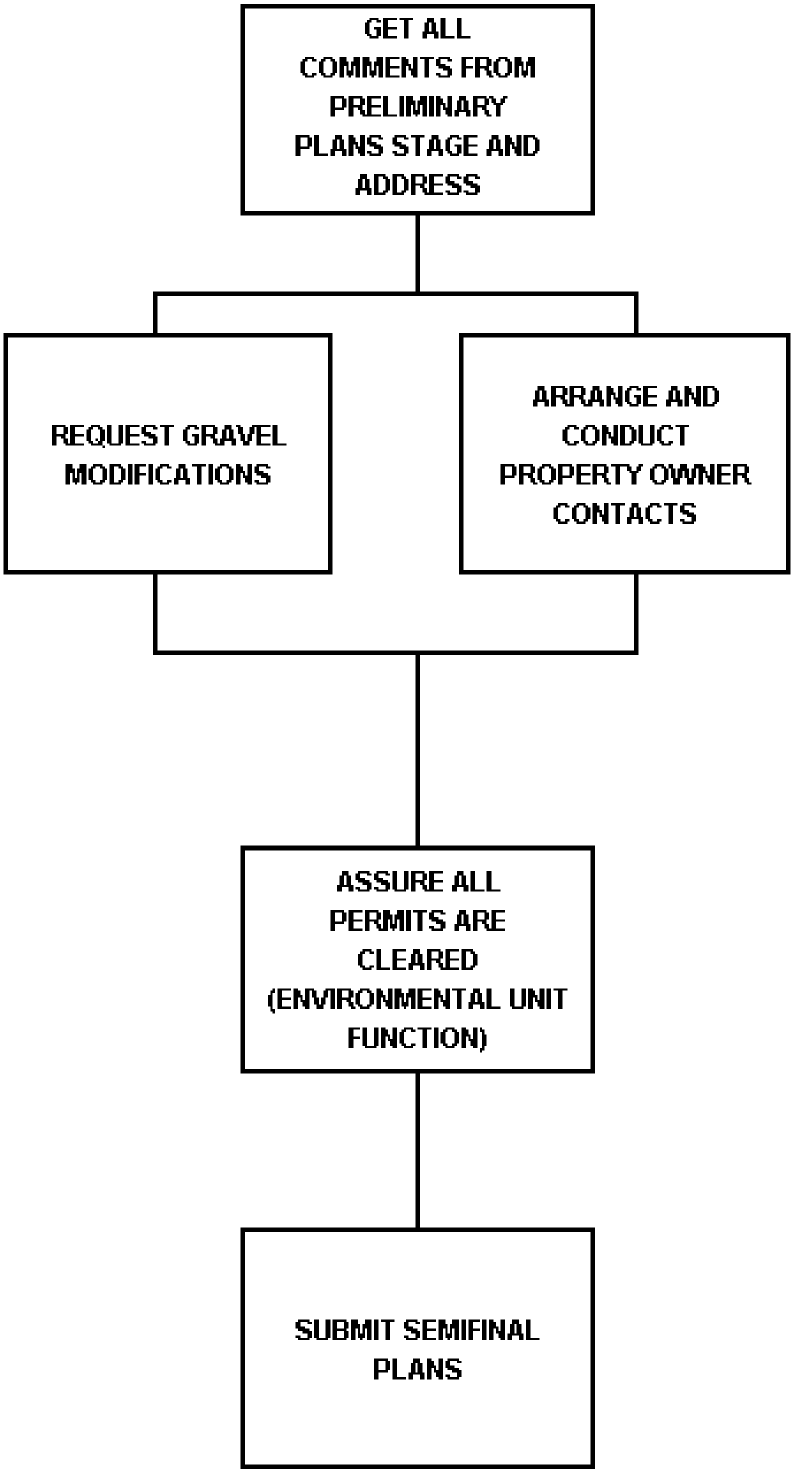
Continue on to Preliminary Plan Step

Preliminary Plan Step



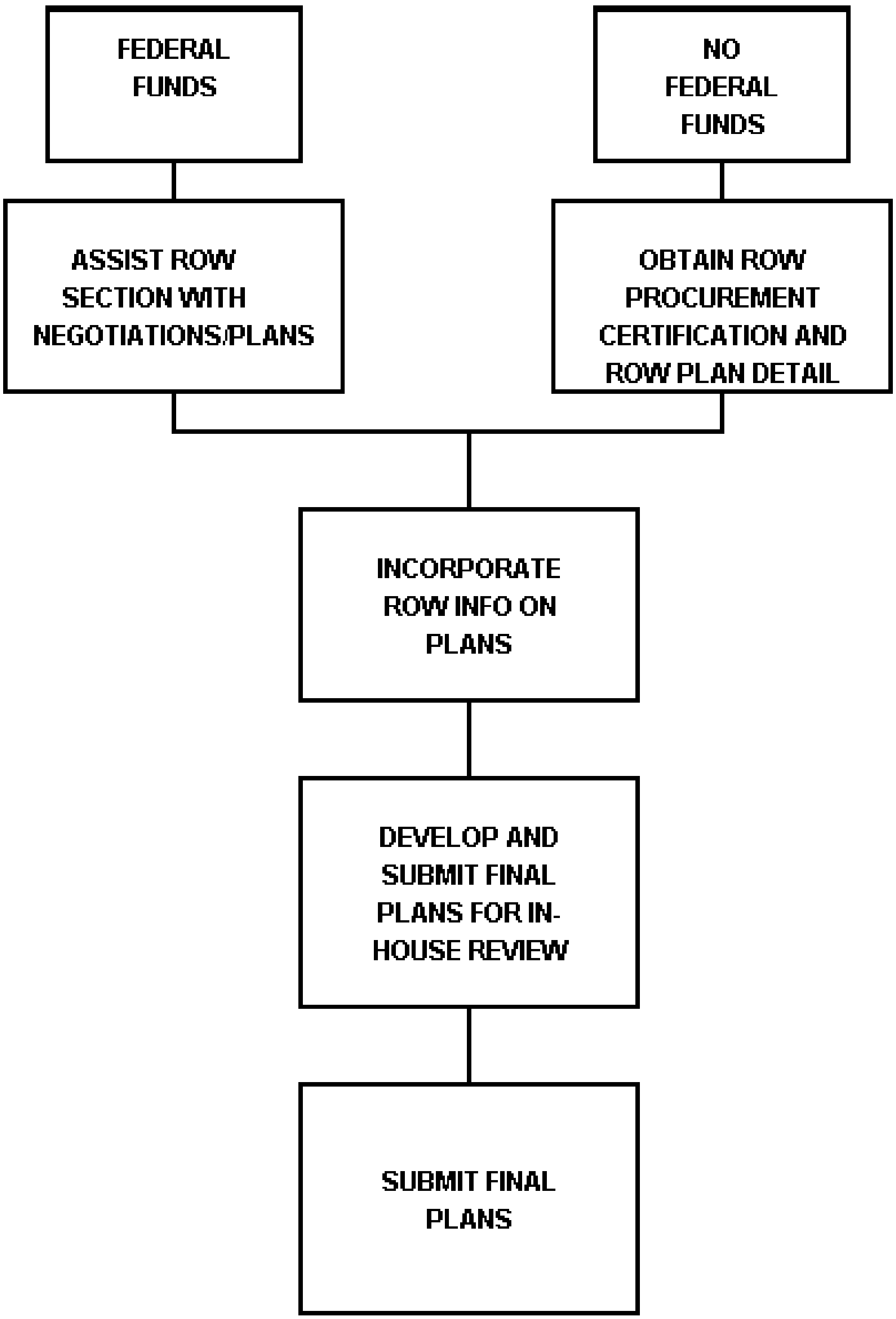
Continue to Semi-Final Plan Step

Semi-Final Plans Step



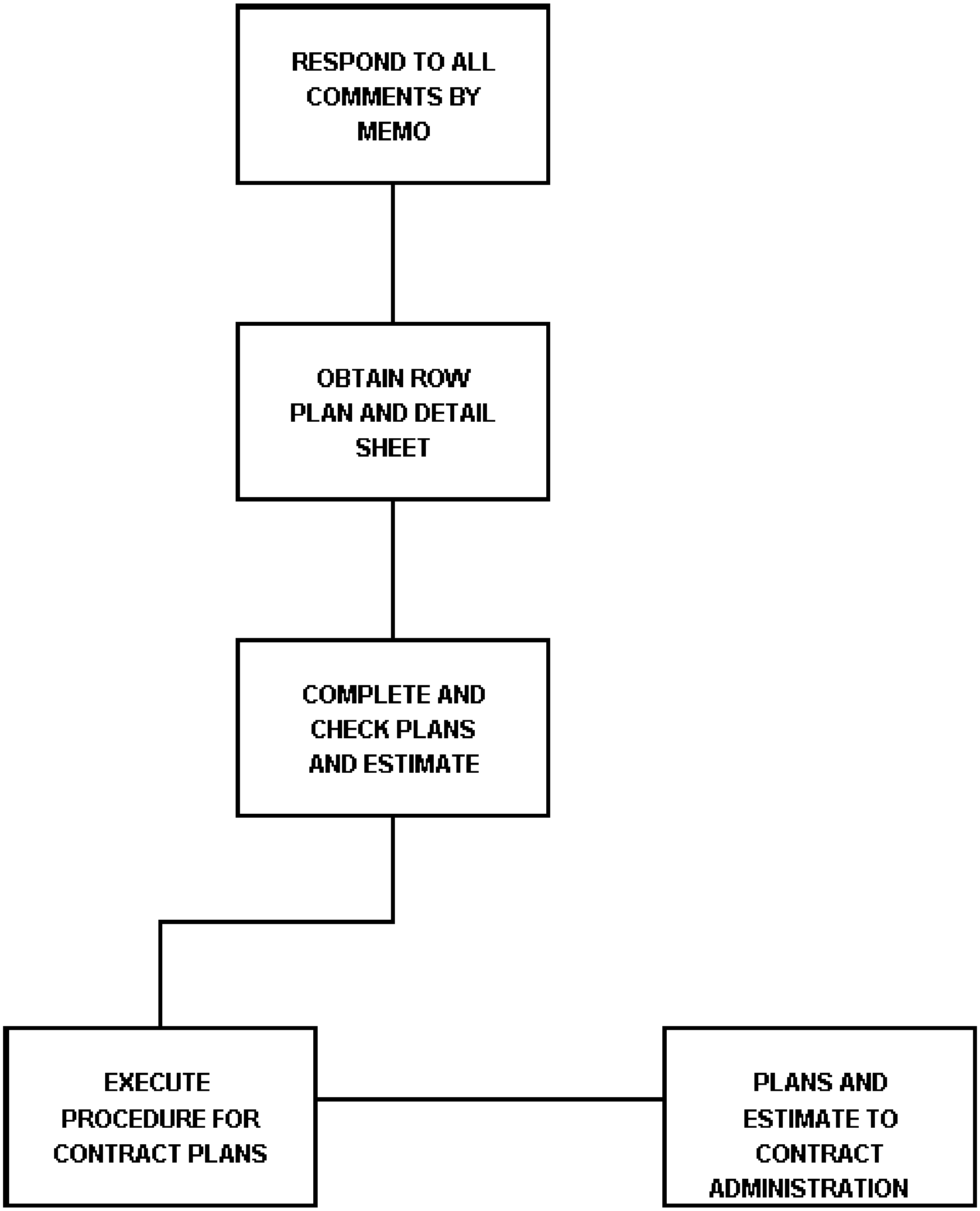
Continue to Final Plan Step

Final Plan Step



Continue to Contract Plan Step

Contract Plan Step



The Project is now complete and ready for Construction.

Appendix E
Submittal Process

Use this checklist to determine project progression. The designer may copy this list and insert it into the design book to assist others who may continue the necessary work for that project. This table should be supplemented by Part II of this manual. Some of the following activities will need to be done before a particular step submittal is started. The activities are grouped according to the appropriate step level. The various chapters in Part II describes the chronology of the following activities. The designer may write “NA” in any blank that is not required for the project.

Conceptual Plan Submittal Process

NFF	F	D	Form number or type	Description	Date Designer Sent	Date Reply Recieved
✔	✔		4†	District - one set of plans.		
✔	✔		4†	Planning, two half size sets of plans marked to show the area of involvement. Exact construction limits are not required.		
	✔		4†	Property Administration - one set of plans, requesting that existing ROW be plotted.		
✔	✔		4†	Utilities - one set of plans.		
	✔		iib_town*†	Town - one set of plans.		
✔			iib_town*†	Town - one set of plans. (Request existing ROW and include a ROW procedure letter.)		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

*- This is the name of the form. Use specific form from the two choices.

D = Design Division Lead

FF = Federally Funded

NFF = Non-Federally Funded

[redacted] Preliminary Plan Submittal Process					
NFF	**F**	**Form number or type**	**Description**	**Date Designer Sent**	**Date Reply Recieved**
✔	✔	7[†]	District - one set with a preliminary total cost estimate.		
✔	✔	7[†]	District - one set with a preliminary total cost estimate.		
	✔	7[†]	Property Administration - One set of plans.		
	✔	. 7[†]	Design - One set of plans. (Only on projects with complex approach work)		
✔	✔	7[†]	Hydraulics - Two sets of plans.		
✔	✔	7[†]	Construction - Two sets of plans.		
✔	✔	7[†]	Traffic Design - One set of plans.		
	✔	iii_town*[†]	Town - one set of plans and estimate.		
✔		iii_town*[†]	Town - one set of plans and estimate. (Include ROW procedure letter and request a letter to authorize road closure if necessary.)		
✔	✔	8[†]	Planning - Send memo, and one full size and two half size sets of plans.		
	✔	✍[†]	FHWA - Plans and estimate when appropriate, by special letter.		
✔	✔	✍[†]	RAPT - Plans and estimate when appropriate.		
			For projects managed by Design, the following shall be done: a) Add the Final Hydraulics information to the Preliminary Information Sheet. Also develop any sheet that is particular to the structure. (ie, Pipe Sheet for large pipe culvert structures.) b) Create new layout drawings referencing the Design layout that shows the new structure or shows the modifications to the existing structure. Also show limits of channel work and stone fill. c) Add all necessary modifications to the Design cross section sheets.		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

*- This is the name of the form. Use specific form from the two choices in iii_town.

FF = Federally Funded

NFF = Non-Federally Funded

✍ This submittal requires a letter to be drafted.

[redacted] Semi-Final Plan Submittal					
NFF	**FF**	**Form number or type**	**Description**	**Date Designer Sent**	**Date Reply Received**
✔	✔	11	District- memo only		
	✔	11	Property Administration - on projects where the Agency is responsible for purchasing right-of-way: One complete set of plans plus mylar of Title Sheet and Plan and Profile Sheets, if plans are not on CADD. If plans are on CADD, send the memo only with full path names.		
✔	✔	11	Utilities - if plans were sent to Utilities at Preliminary Plan stage, send them one set of Semi-Final plans.		
✔	✔	11	Planning - memo only.		
✔		12	Contract Administration - memo only.		
	✔	iv_town*†	Town - one set of plans.l.		
✔	✔	iv_town*†	Town - one set of plans and ROW Procedure Sheet.		

† - This submittal requires a Project Sign-off Sheet. Use form Signoff.

* - This is the name of the form.

NFF = Non-Federally Funded

FF = Federally Funded

Final Plan Submittal

NFF	FF	Form number or type	Description	Date designer sent	Date reply recieved
✔	✔	13✚	District - one set with a detailed estimate, and a copy of the special provisions.		
✔	✔	13✚ and 14	Construction - one set with a detailed estimate, and a copy of the special provisions. (omit this submittal on a force account project). Include Form 14 to get information on field offices.		
✔	✔	13✚	Materials & Research - one set, and a copy of the special provisions.		
✔	✔	13✚	Property Administration - memo only, with a copy of the special provisions.		
✔	✔	13✚	Hydraulics - one set.		
✔	✔	13✚	Utilities - if project includes Water and Sewer or other underground items - one set, with a copy of the special provisions. If project only includes overhead utilities - Title Sheet, all layout sheets, and the special provisions.		
✔	✔	13✚	Environmental Services - a copy of memo, and a copy of the special provisions.		
✔	✔	13✚	Traffic Design - one set of plans, and a copy of the special provisions.		
✔	✔	13✚	Construction, Paving Engineer - copy of the memo only, along with a copy of the special provisions.		
✔	✔	13✚	Director of Maintenence - Memo and a copy of the special provisions.		
✔	✔	v_town❖	Town - plans.		
✔	✔	✍✚	FHWA - plans, special provisions, and estimate of the total construction costs, when appropriate, by special letter.		
✔	✔	✍✚	Rail and Air - contact Rail and Air unit to check on status of agreement and to determine if plans need to be submitted.		
	✔	15✚	Design - Plans, a detailed estimate, and a copy of the special provisions.(design led projects only)		

✚ This submittal requires a Project Sign-off Sheet. Use form called "signoff".

❖ This is the name of the form

✍ This submittal requires a letter to be drafted.

NFF = Non-Federally Funded

FF = Federally Funded

[redacted] **Contract Plan Submittal**

NFF	FF	Form number or type	Description	Date designer sent	Date reply recieved
✔	✔	print-reque-st submittal	Request 1/2 size set of plans from Reprographics. This should be done through rp_iparm. The plans should be considered complete before continuing. See Section 11.2.		
		CA52❖ plus others	Once plans are complete and ready for Contract Administration, see contract plan submital process contained in Section 11.2.		
✔	✔	16(S/T)	Contract Administration - only if the project will not extend beyond the Right of Way. Send appropriate form for State(S) or Town (T).		
✔	✔	17	Director of Project Development - To request signature on Title Sheet. See section 11.2.		
✔	✔	18	Contract Administration - once Title sheet is signed.		
The following activities follow the bid advertisement.					
✔	✔	bid data sheet	Structures will attend the bid letting of the project. This person will record the awarded bid prices for later review.		
✔	✔	19	Upon reception of the bid results from Contract Administration, the project designer will analyze the results. Any Price difference between the estimated item and its corresponding bid price which exceeds 1% of the total bid price shall be studied and justified.		
		20	In-House - Square meter (Square Foot) cost survey. Use form (a) for conventional bridges and (b) for buried structures.		

❖ This is the name of the form

NFF = Non-Federally Funded

FF = Federally Funded

Appendix F
Structures Section Time Codes

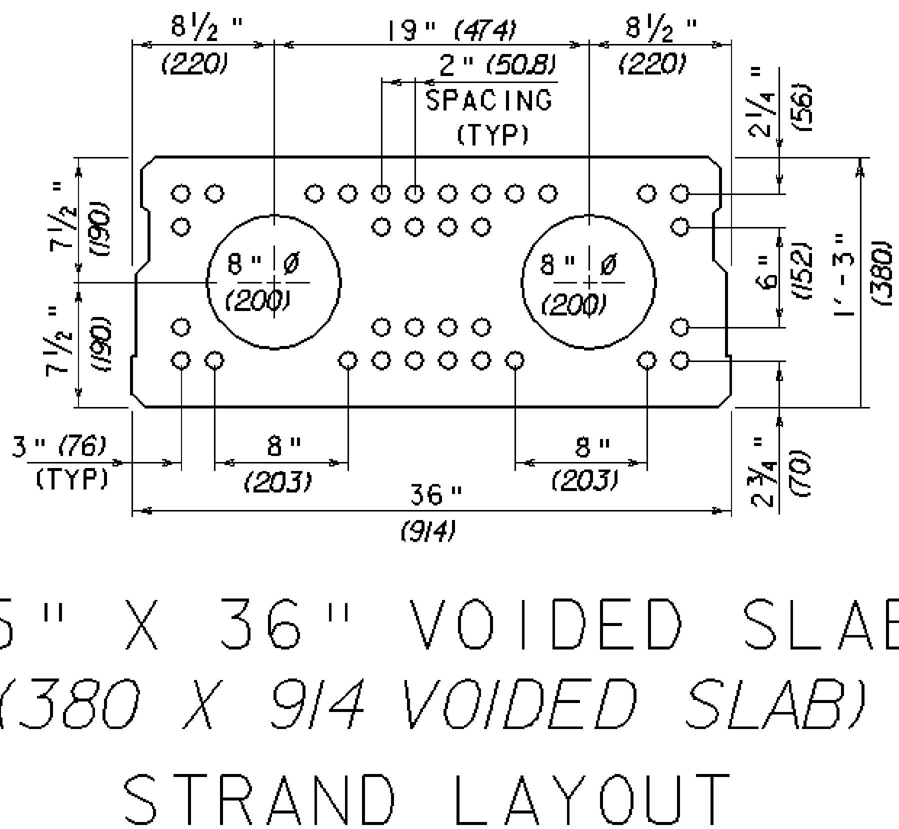
The following codes are to be used for allocating time for particular tasks as listed below. These codes are to be entered onto the time sheet of every employee in Structures.

STARS	OLD CODE	DESCRIPTION	PPMS
	2400	Structures-design Work by Other Sections	N/A
0017	2401	Structures-structures Management	Admin.
0001	2402	Structures-training-educ Leave W/pay	Admin.
1095	2409	Structures-computer Development re:fed Part.	N/A
1065	2410	Structures-bridge Inspection	60
1995	2411	Structures-project Survey by Agency Forces	110
1845	2414	Structures-initiate Project Structures	60
1105	2420	Structures-concept Plans Design by Agency Forces	90
1110	2421	Structures-concept Plans Review of Consultant Plans	90
1105	2423	Roadway-concept Plans Design by Agency Forces	100
0150	2424	Structures-soil Exploration (Borings)	150
1100	2425	Structures-concept Plans Design by Consultant	N/A
1690	2430	Structures-prelim Plans Design by Agency Forces	170
1695	2431	Structures-prelim Plans Review of Consultant	170
	2435	Structures-prelim Plans Design by Consultant	N/A
1690	2438	Roadway-prelim Plans Design by Agency Forces	180
1870	2440	Structures-semi Final Plans Design by Agency Forces	270
1865	2441	Structures-semi Final Plans Review of Consultant Plan	270
1875	2445	Structures-semi Final Plans by Consultant	N/A
1870	2446	Roadway-semi Final Plans Design by Agency Forces	280
1240	2450	Structures-final Plans Design by Agency Forces	340
1245	2451	Structures-final Plans Review of Consultant Plan	340
1235	2455	Structures-final Plans Design by Consultant	N/A
1240	2456	Roadway-final Plans Design by Agency Forces	350
1130	2460	Structures-contract Plans Design by Agency Forces	440
1140	2461	Structures-contract Plans Review of Consultant Plan	440
	2465	Structures-design for Other Sections	N/A
1135	2466	Structures-contract Plans Design by Consultant	N/A
1130	2468	Roadway-contract Plans Design by Agency Forces	450
0390	2470	Structures-row by Agency Forces	390
	2471	Structures-row by Others	N/A
1000	2478	Structures-consultant Contract Admin.	Admin.
1120	2480	Structures-construction Engineering	N/A
1885	2481	Structures-shop Inspection	N/A
1880	2482	Structures-shop Drawings	N/A
2065	2483	Structures-truck Route Studies	N/A
1945	2484	Structures-specifications	N/A
1960	2486	Structures-standards	N/A
	2488	Structures-design Manual	N/A
	2489	Structures-awlb (Avg. Weighted Low Bid)	N/A
0017	2490	Structures-other Structure Administration	Admin.
0017	2491	Structures-purchase of Equipment	Admin.
1095	2492	Structures-computer Development	Admin.
0006	2495	Structures-hearings	Admin.
0002	2496	Structures-training	Admin.
0003	2497	Structures-meetings	Admin.
0004	2498	Structures-conferences	Admin.
	2499	Structures-other	Admin.

Appendix G

Prestressed Concrete Details

All of these details are available at: Transfans on vaot_cadd/structures/manual/prestress.dgn, The details are drawn and labeled in English units. The metric measurements are in millimeters and are given in parentheses.

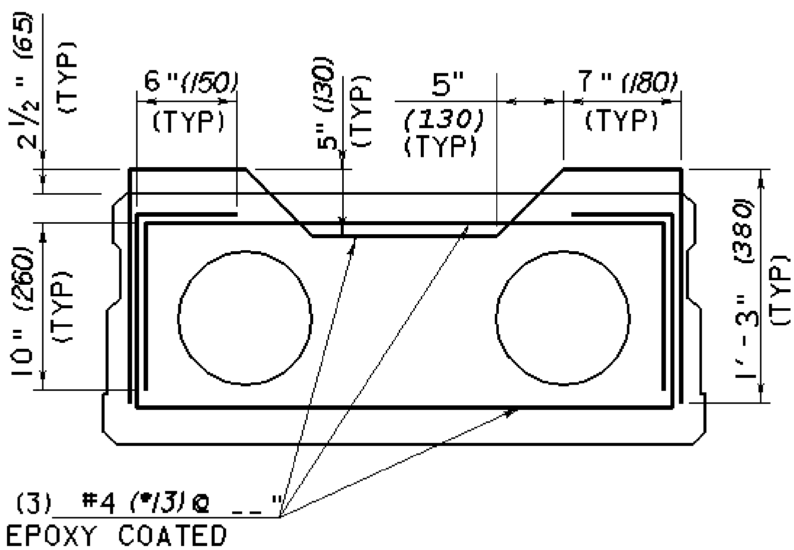


15" X 36" VOIDED SLAB
(380 X 914 VOIDED SLAB)
STRAND LAYOUT

MAX NUMBER OF STRANDS FOR
15" *(380)* SLAB

ROW*	NO. OF STRANDS
1 @ 2¾" *(70)*	10 STRANDS
2 @ 4¾" *(121)*	6 STRANDS
5 @ 10¾" *(273)*	6 STRANDS
6 @ 12¾" *(324)*	12 STRANDS

*ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT

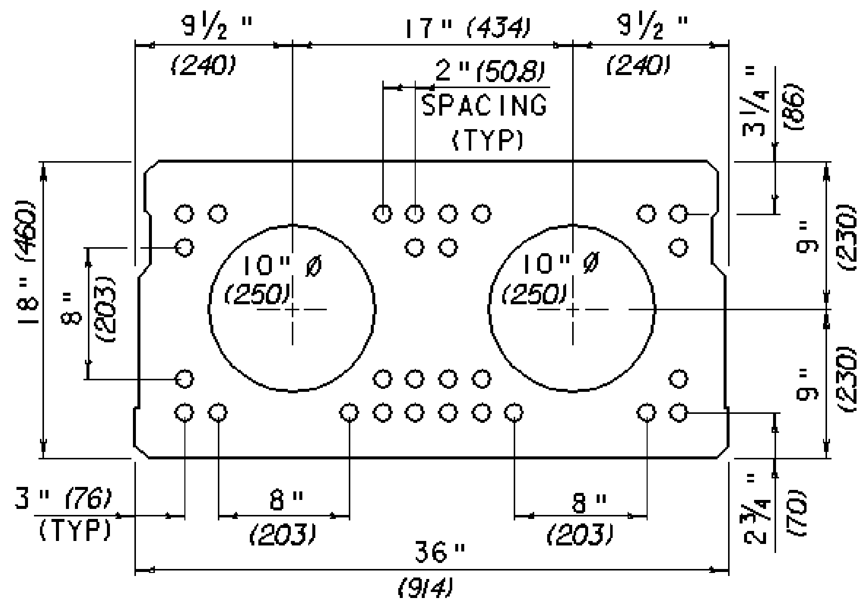


15" X 36" VOIDED SLAB
(380 X 914 VOIDED SLAB)
REINFORCING LAYOUT

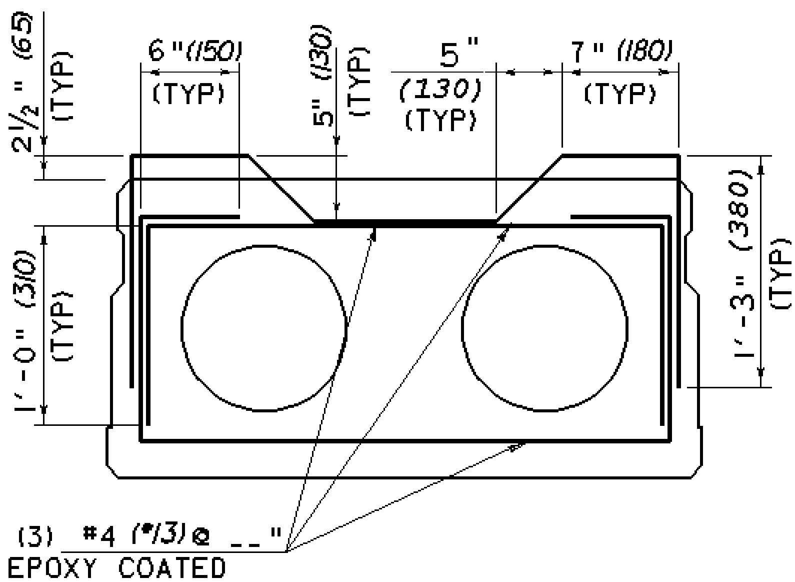
MAX NUMBER OF STRANDS FOR
18" *(460)* SLAB

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	10 STRANDS
2 @ 4¾" *(121)*	6 STRANDS
6 @ 12¾" *(324)*	4 STRANDS
7 @ 14¾" *(375)*	8 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



18" X 36" VOIDED SLAB
(460 X 914 VOIDED SLAB)
STRAND LAYOUT

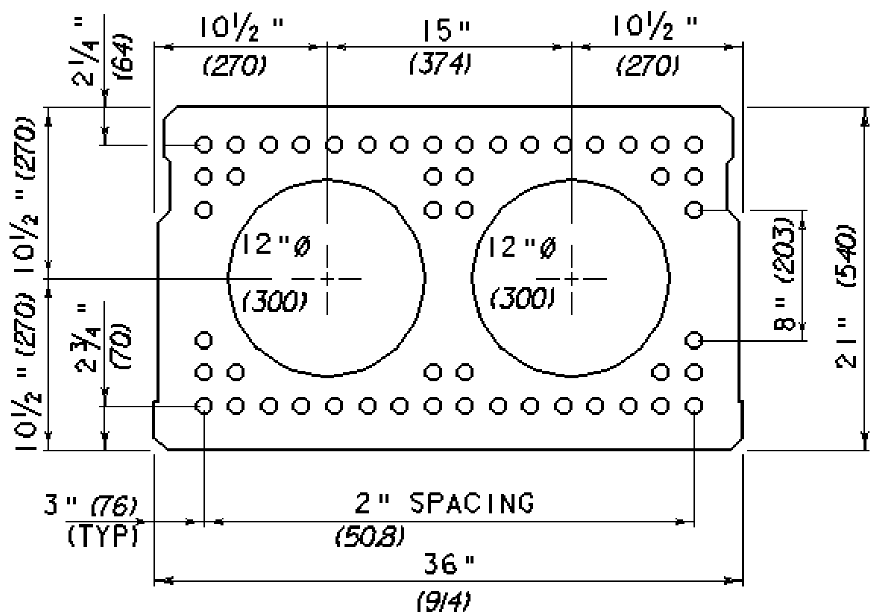


18" X 36" VOIDED SLAB
(460 X 914 VOIDED SLAB)
REINFORCING LAYOUT

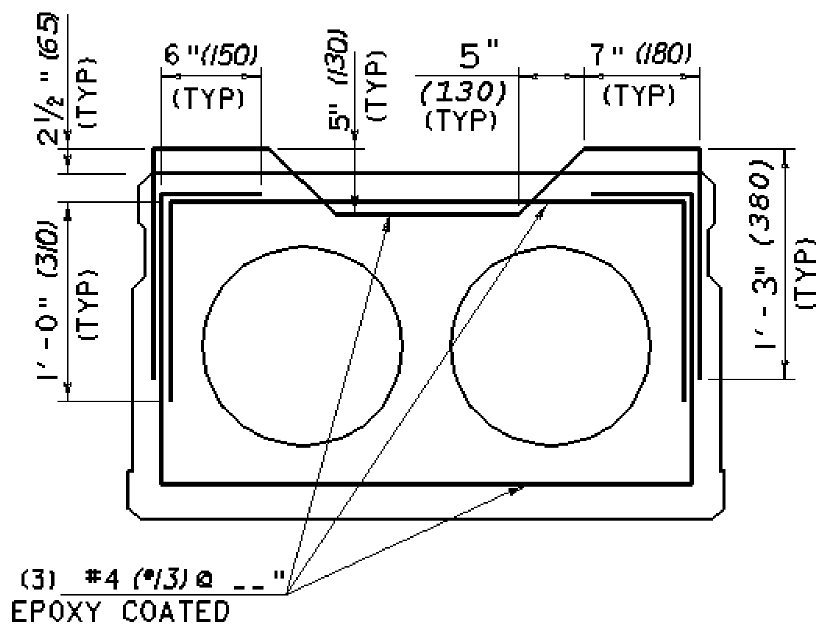
MAX NUMBER OF STRANDS FOR
21" *(540)* SLAB

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	16 STRANDS
2 @ 4¾" *(121)*	6 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
7 @ 14¾" *(375)*	4 STRANDS
8 @ 16¾" *(426)*	6 STRANDS
9 @ 18¾" *(476)*	16 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



21" X 36" VOIDED SLAB
(540 X 914 VOIDED SLAB)
STRAND LAYOUT

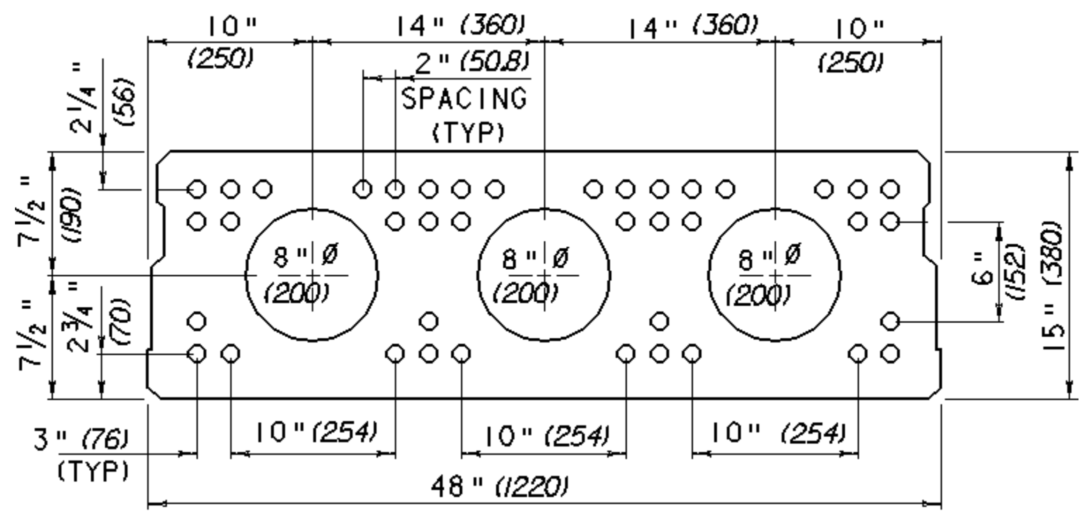


21" X 36" VOIDED SLAB
(540 X 914 VOIDED SLAB)
REINFORCING LAYOUT

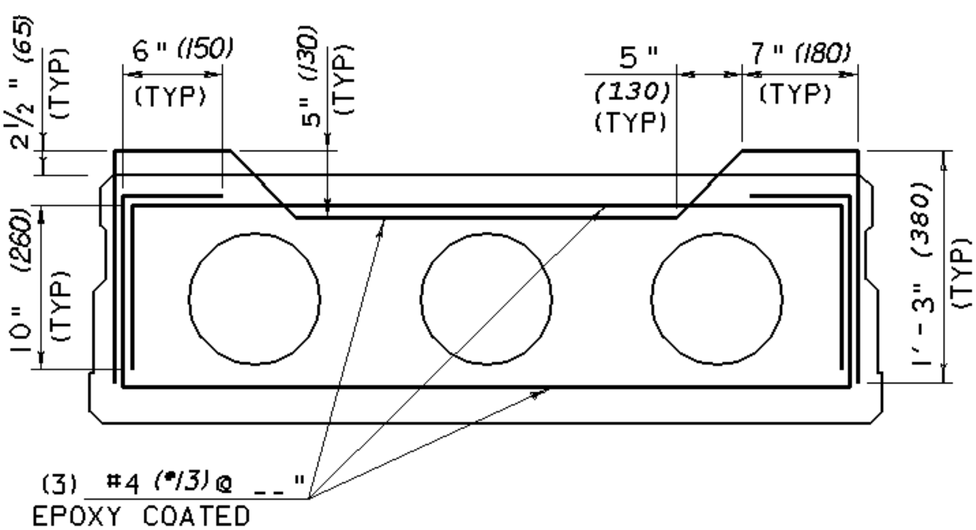
MAX NUMBER OF STRANDS FOR
15" (380) SLAB

ROW*	NO. OF STRANDS
1 @ 2¾" (70)	10 STRANDS
2 @ 4¾" (121)	4 STRANDS
5 @ 10¾" (273)	10 STRANDS
6 @ 12¾" (324)	16 STRANDS

*ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



15" X 48" VOIDED SLAB
(380 X 1220 VOIDED SLAB)
STRAND LAYOUT

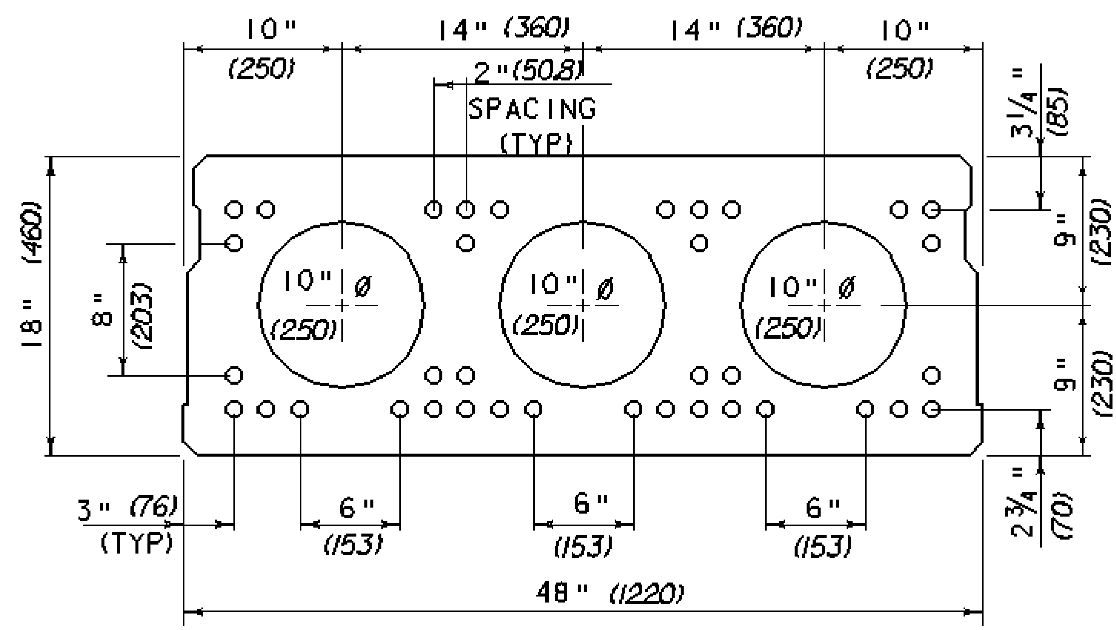


15" X 48" VOIDED SLAB
(380 X 1220 VOIDED SLAB)
REINFORCING LAYOUT

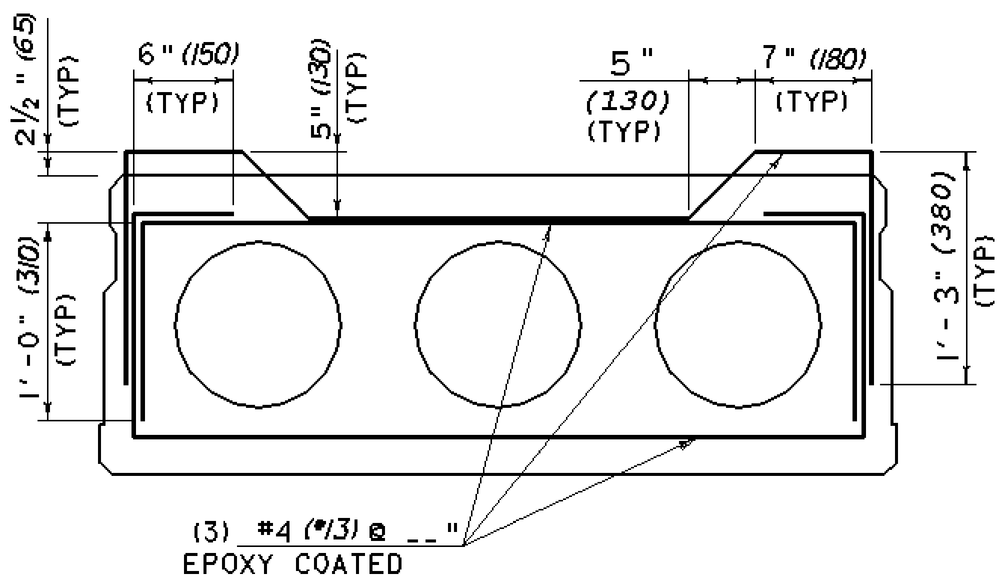
MAX NUMBER OF STRANDS FOR
18" *(460)* SLAB

ROW *		NO. OF STRANDS
1 @ 2¾"	*(70)*	16 STRANDS
2 @ 4¾"	*(121)*	6 STRANDS
6 @ 12¾"	*(324)*	4 STRANDS
7 @ 14¾"	*(375)*	10 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



18" X 48" VOIDED SLAB
(460 X 1220 VOIDED SLAB)
STRAND LAYOUT

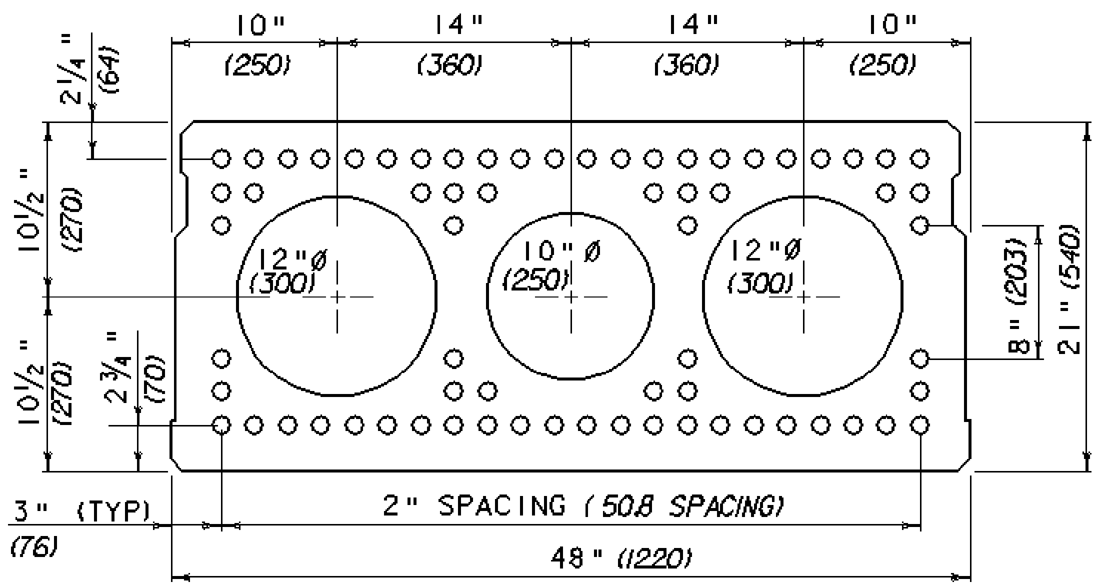


18" X 48" VOIDED SLAB
(460 X 1220 VOIDED SLAB)
REINFORCING LAYOUT

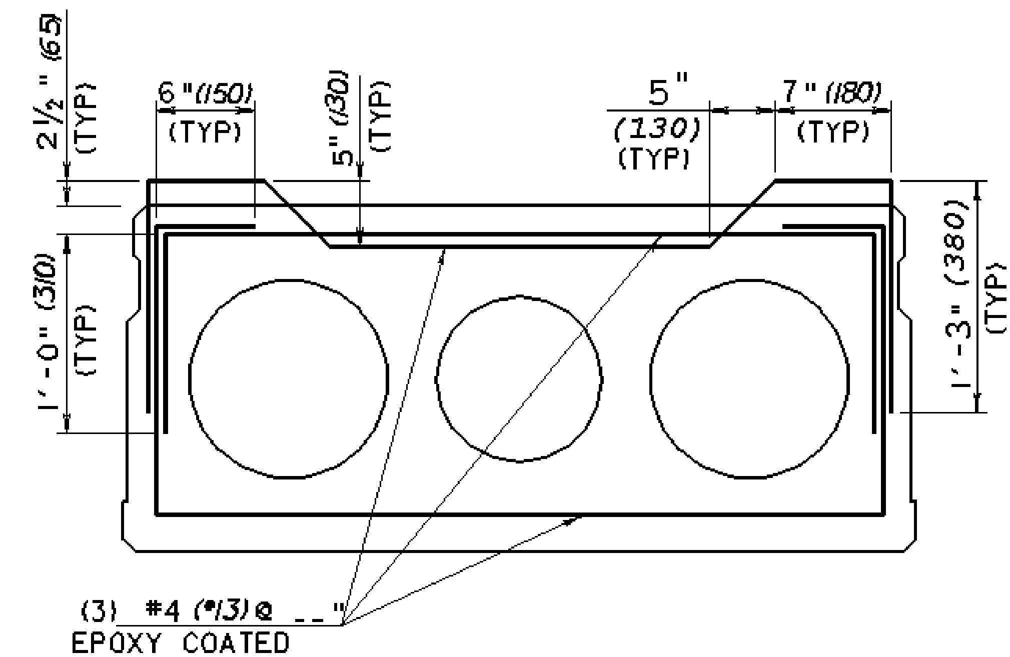
MAX NUMBER OF STRANDS FOR
21" *(540)* SLAB

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	22 STRANDS
2 @ 4¾" *(121)*	6 STRANDS
3 @ 6¾" *(172)*	4 STRANDS
7 @ 14¾" *(375)*	4 STRANDS
8 @ 16¾" *(425)*	10 STRANDS
9 @ 18¾" *(476)*	22 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



21" X 48" VOIDED SLAB
(540 X 1220 VOIDED SLAB)
STRAND LAYOUT

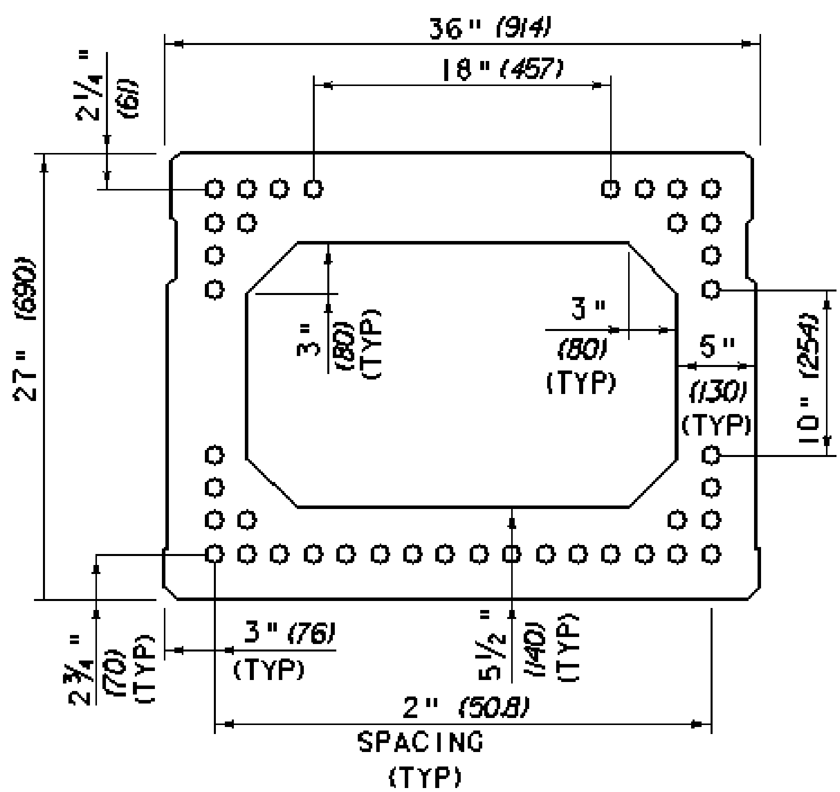


21" X 48" VOIDED SLAB
(540 X 1220 VOIDED SLAB)
REINFORCING LAYOUT

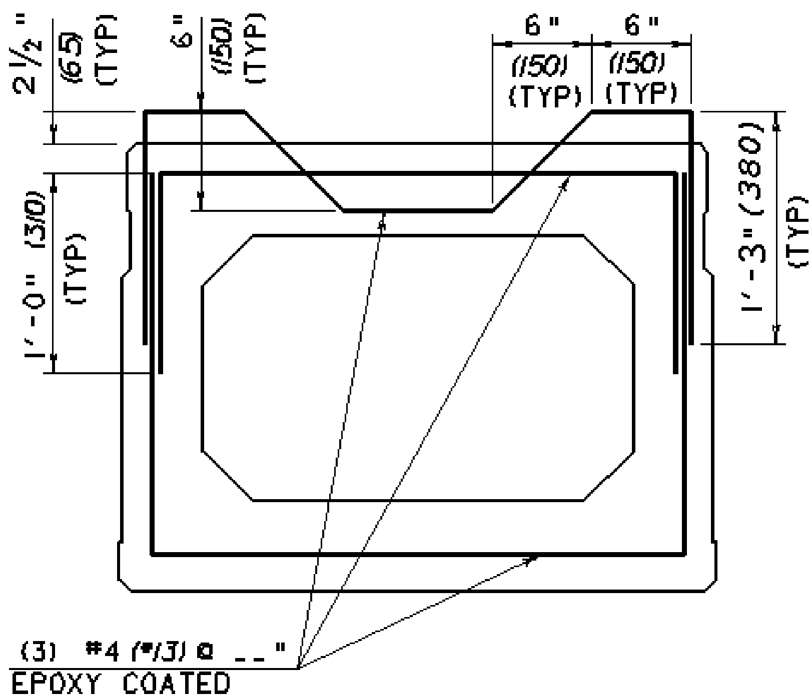
MAX NUMBER OF STRANDS FOR 27" *(690)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	16 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
9 @ 18¾" *(476)*	2 STRANDS
10 @ 20¾" *(527)*	2 STRANDS
11 @ 22¾" *(578)*	4 STRANDS
12 @ 24¾" *(629)*	8 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



27" X 36" BOX BEAM
(690 X 914 BOX BEAM)
STRAND LAYOUT

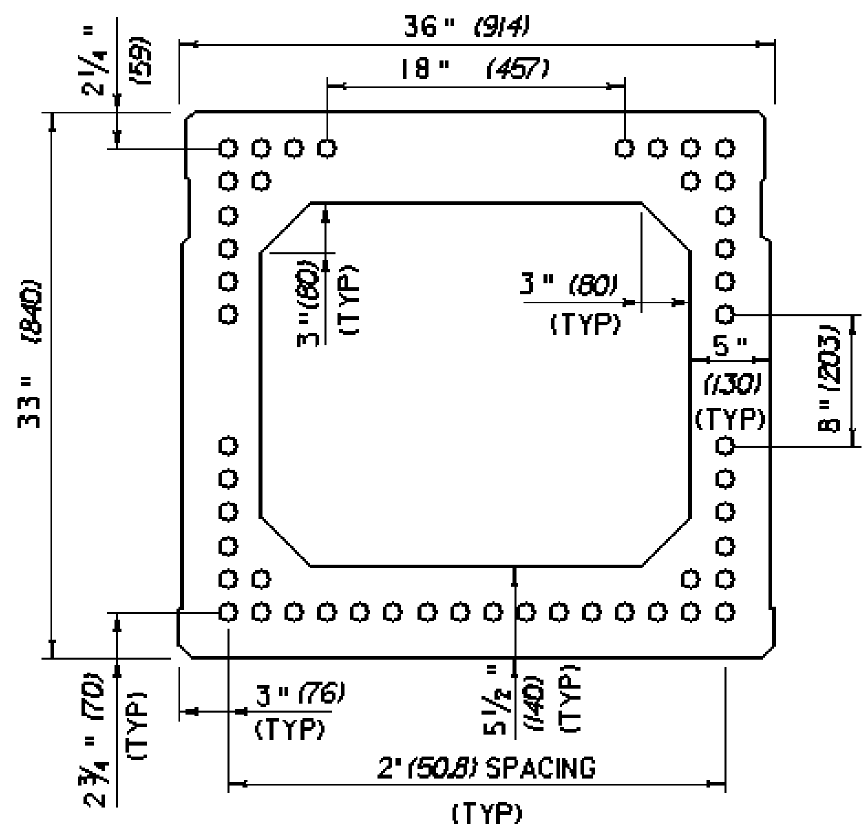


27" X 36" BOX BEAM
(690 X 914 BOX BEAM)
REINFORCING LAYOUT

MAX NUMBER OF STRANDS FOR 33" *(840)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	16 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
5 @ 10¾" *(273)*	2 STRANDS
6 @ 12¾" *(324)*	2 STRANDS
10 @ 20¾" *(527)*	2 STRANDS
11 @ 22¾" *(578)*	2 STRANDS
12 @ 24¾" *(629)*	2 STRANDS
13 @ 26¾" *(680)*	2 STRANDS
14 @ 28¾" *(730)*	4 STRANDS
15 @ 30¾" *(781)*	8 STRANDS

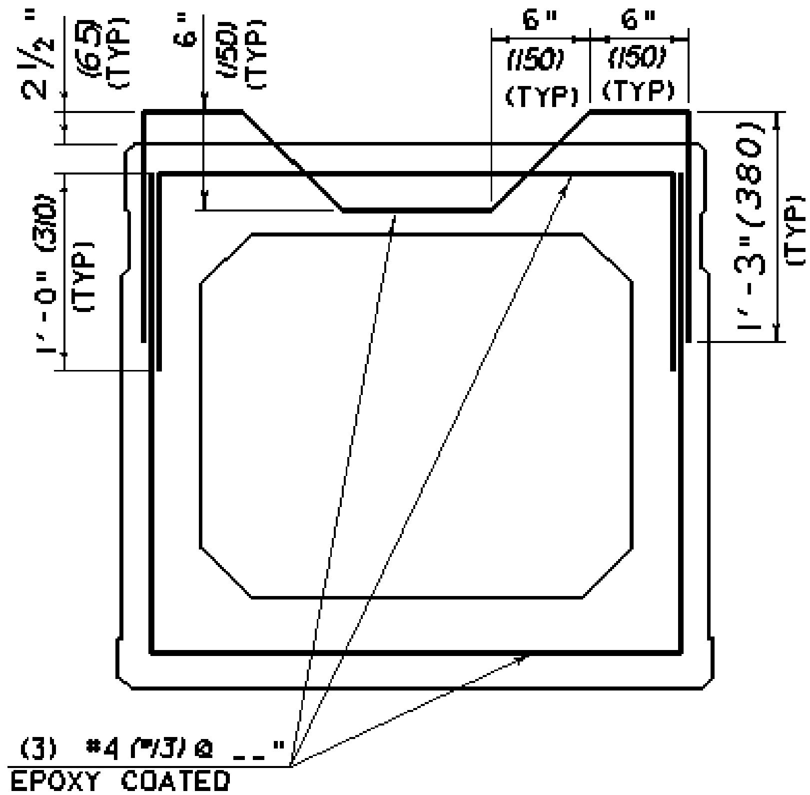
* *ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT*



33 " X 36 " BOX BEAM

(840 X 914 BOX BEAM)

STRAND LAYOUT



33" X 36" BOX BEAM

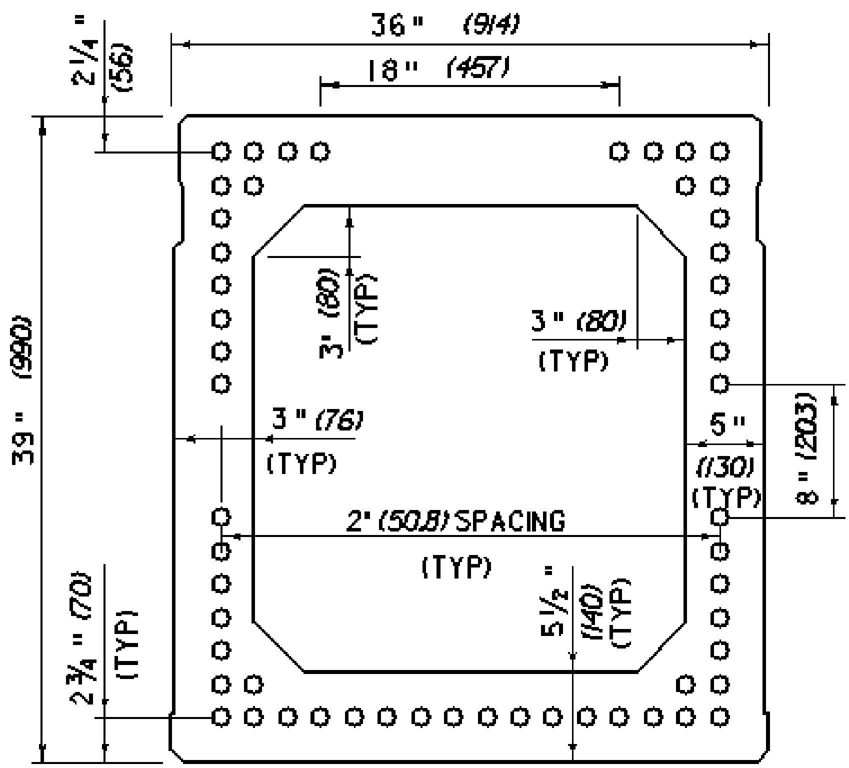
(840 X 914 BOX BEAM)

REINFORCING LAYOUT

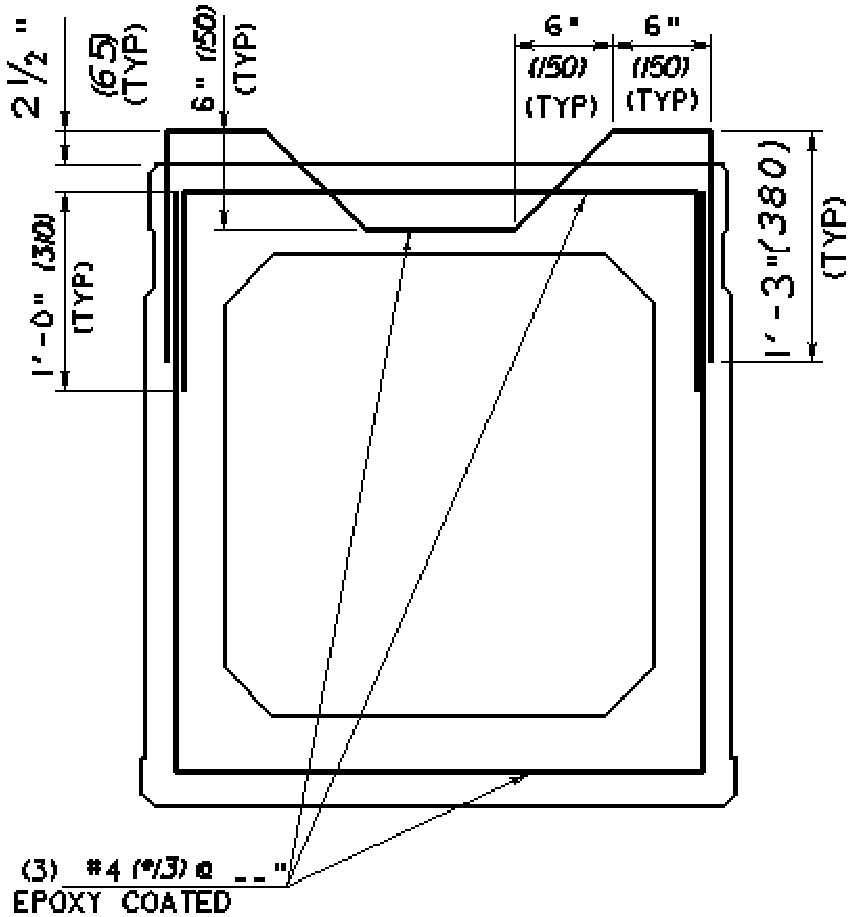
MAX NUMBER OF STRANDS FOR 39" *(990)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	16 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
5 @ 10¾" *(273)*	2 STRANDS
6 @ 12¾" *(324)*	2 STRANDS
7 @ 14¾" *(375)*	2 STRANDS
11 @ 22¾" *(578)*	2 STRANDS
12 @ 24¾" *(629)*	2 STRANDS
13 @ 26¾" *(680)*	2 STRANDS
14 @ 28¾" *(730)*	2 STRANDS
15 @ 30¾" *(781)*	2 STRANDS
16 @ 32¾" *(832)*	2 STRANDS
17 @ 34¾" *(883)*	4 STRANDS
18 @ 36¾" *(934)*	8 STRANDS

**ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT*



39" X 36" BOX BEAM
(990 X 914 BOX BEAM)
STRAND LAYOUT

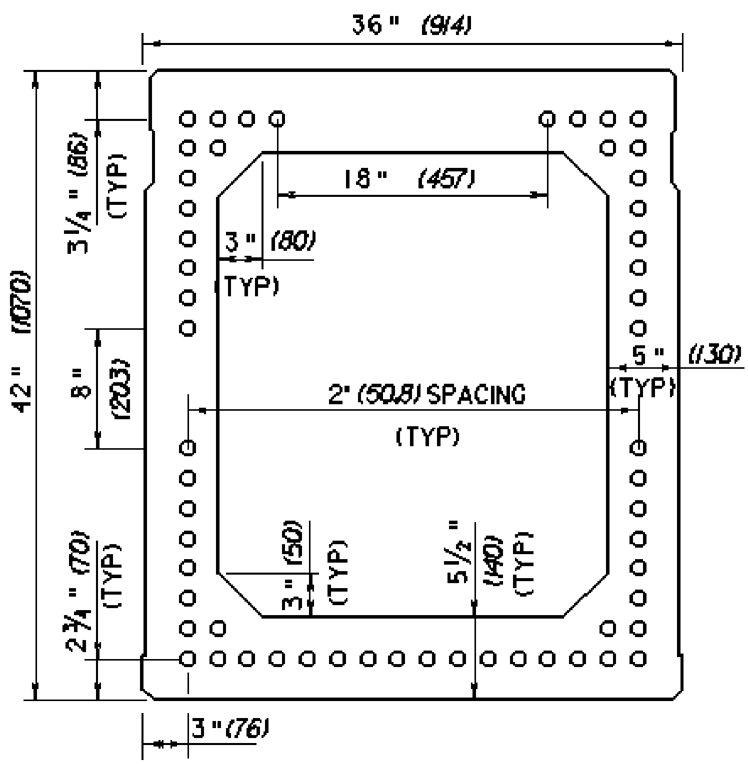


39" X 36" BOX BEAM
(990 X 914 BOX BEAM)
REINFORCING LAYOUT

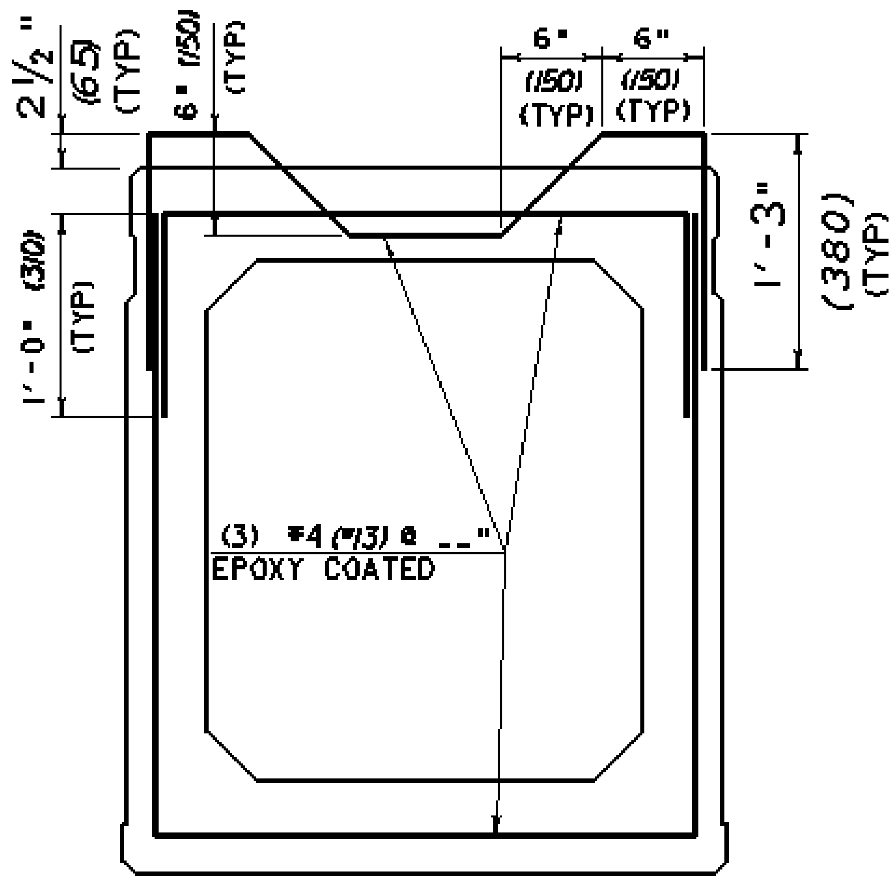
MAX NUMBER OF STRANDS FOR 42" (1070) BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" (70)	16 STRANDS
2 @ 4¾" (121)	4 STRANDS
3 @ 6¾" (172)	2 STRANDS
4 @ 8¾" (222)	2 STRANDS
5 @ 10¾" (273)	2 STRANDS
6 @ 12¾" (324)	2 STRANDS
7 @ 14¾" (375)	2 STRANDS
8 @ 16¾" (426)	2 STRANDS
12 @ 24¾" (629)	2 STRANDS
13 @ 26¾" (680)	2 STRANDS
14 @ 28¾" (730)	2 STRANDS
15 @ 30¾" (781)	2 STRANDS
16 @ 32¾" (832)	2 STRANDS
17 @ 34¾" (883)	2 STRANDS
18 @ 36¾" (934)	4 STRANDS
19 @ 38¾" (984)	8 STRANDS

*ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



42" X 36" BOX BEAM
(1070 X 914 BOX BEAM)
STRAND LAYOUT



42" X 36" BOX BEAM

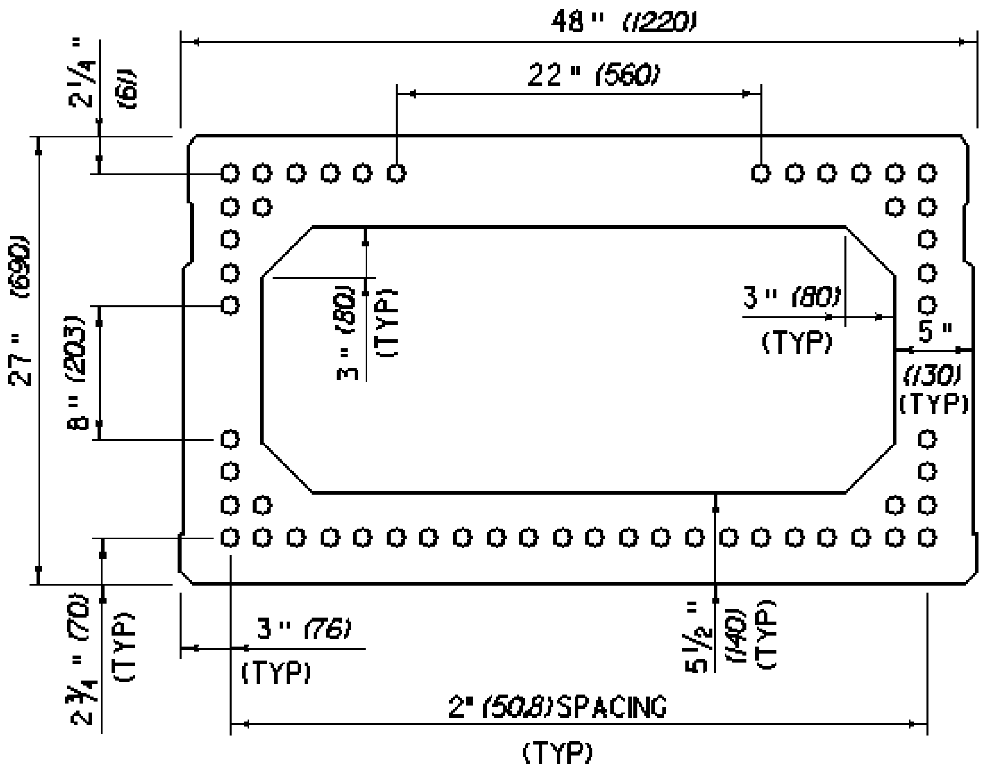
(1070 X 914 BOX BEAM)

REINFORCING LAYOUT

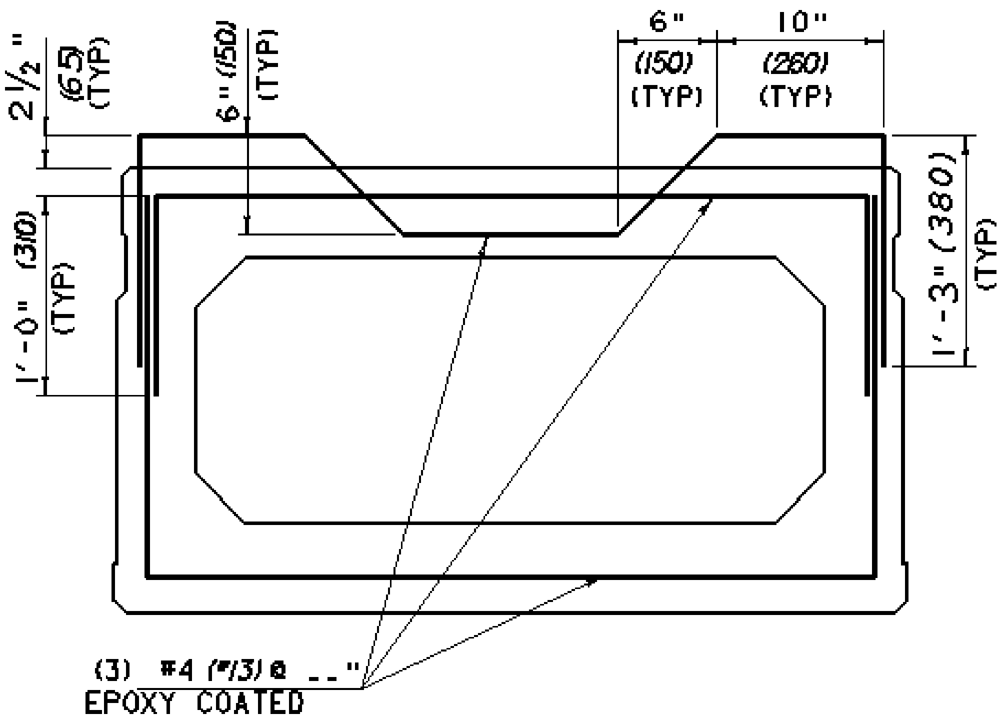
MAX NUMBER OF STRANDS FOR 27" *(690)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	22 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
8 @ 16¾" *(426)*	2 STRANDS
9 @ 18¾" *(476)*	2 STRANDS
10 @ 20¾" *(527)*	2 STRANDS
11 @ 22¾" *(578)*	4 STRANDS
12 @ 24¾" *(629)*	12 STRANDS

* ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT



27" X 48" BOX BEAM
(690 X 1220 BOX BEAM)
STRAND LAYOUT



27" X 48" BOX BEAM

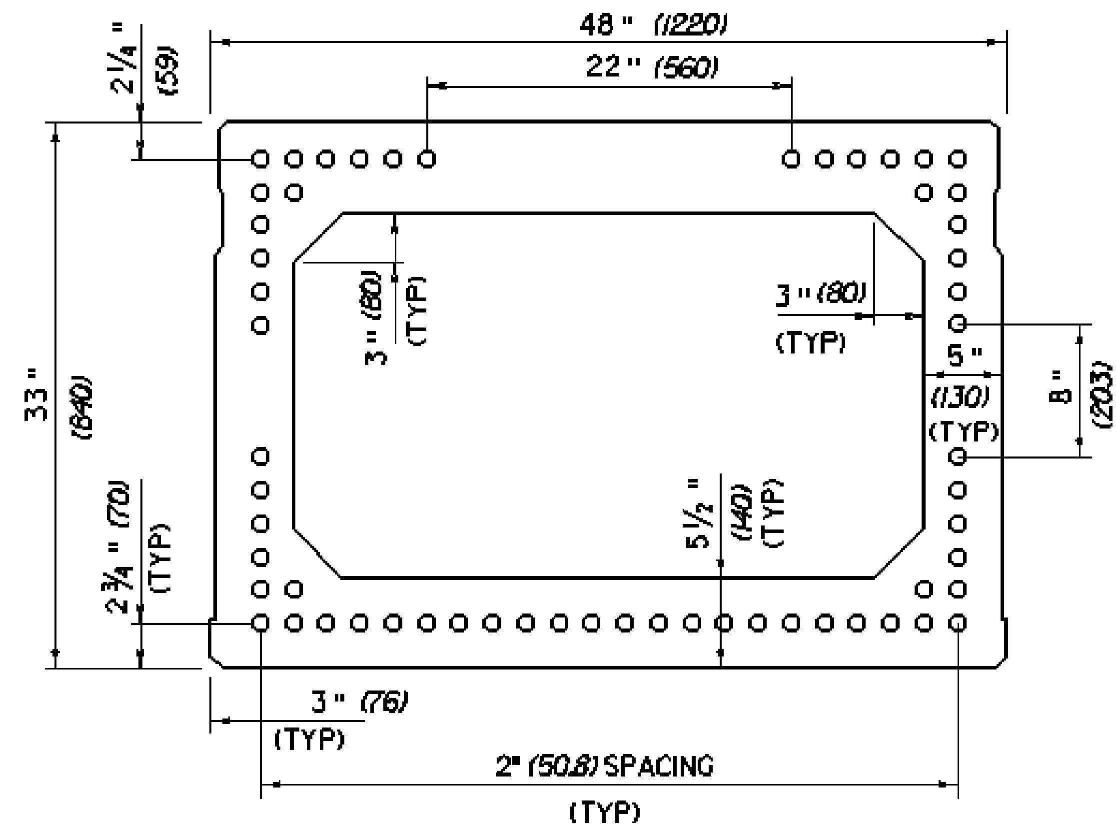
(690 X 1220 BOX BEAM)

REINFORCING LAYOUT

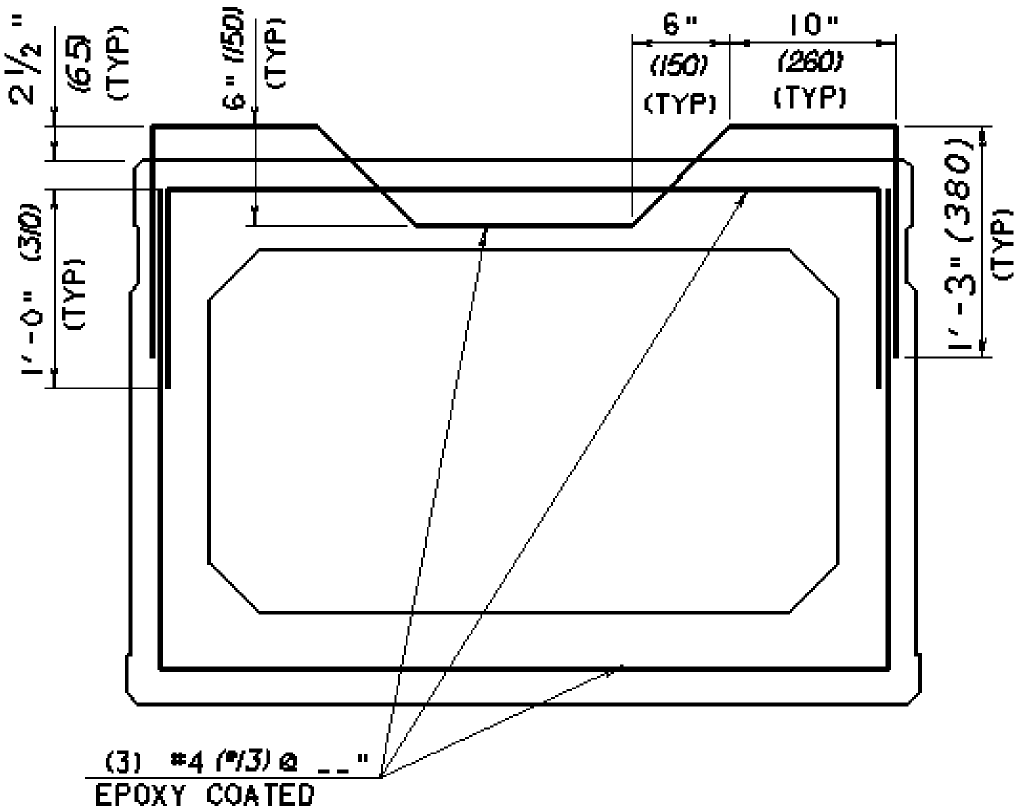
MAX NUMBER OF STRANDS FOR 33" *(840)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	22 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
5 @ 10¾" *(273)*	2 STRANDS
6 @ 12¾" *(324)*	2 STRANDS
10 @ 20¾" *(527)*	2 STRANDS
11 @ 22¾" *(578)*	2 STRANDS
12 @ 24¾" *(629)*	2 STRANDS
13 @ 26¾" *(680)*	2 STRANDS
14 @ 28¾" *(730)*	4 STRANDS
15 @ 30¾" *(781)*	12 STRANDS

* *ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT*



33" X 48" BOX BEAM
(840 X 1220 BOX BEAM)
STRAND LAYOUT

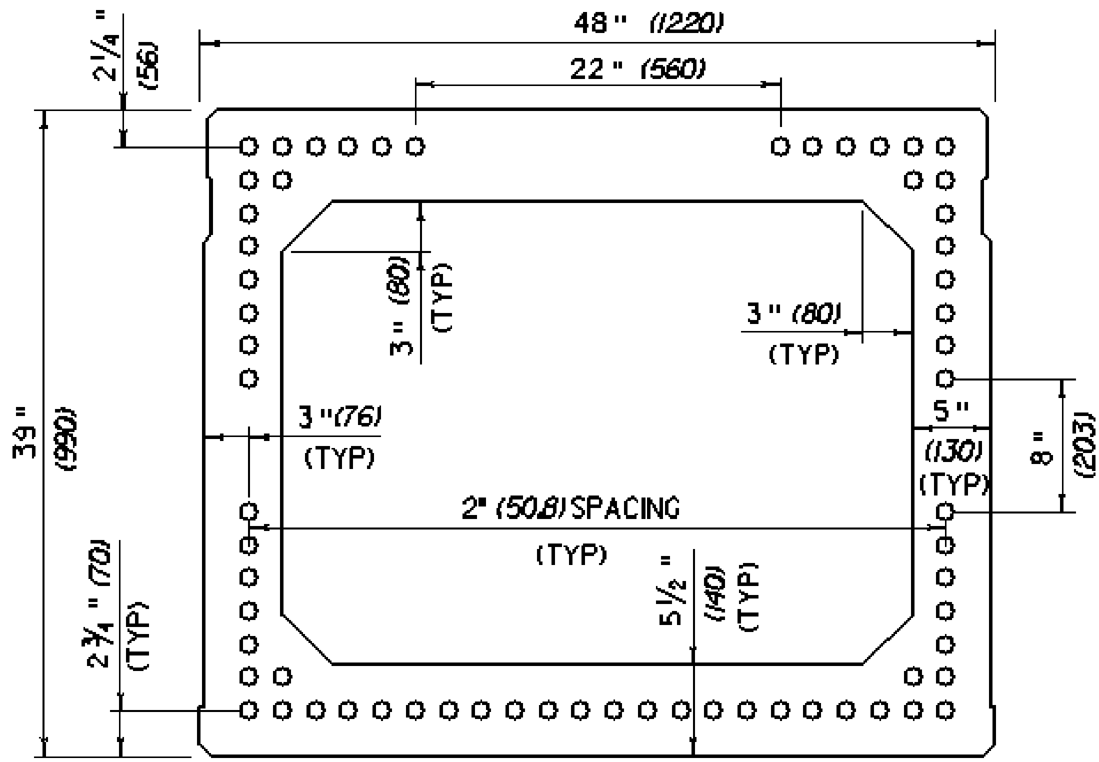


33" X 48" BOX BEAM
(840 X 1220 BOX BEAM)
REINFORCING LAYOUT

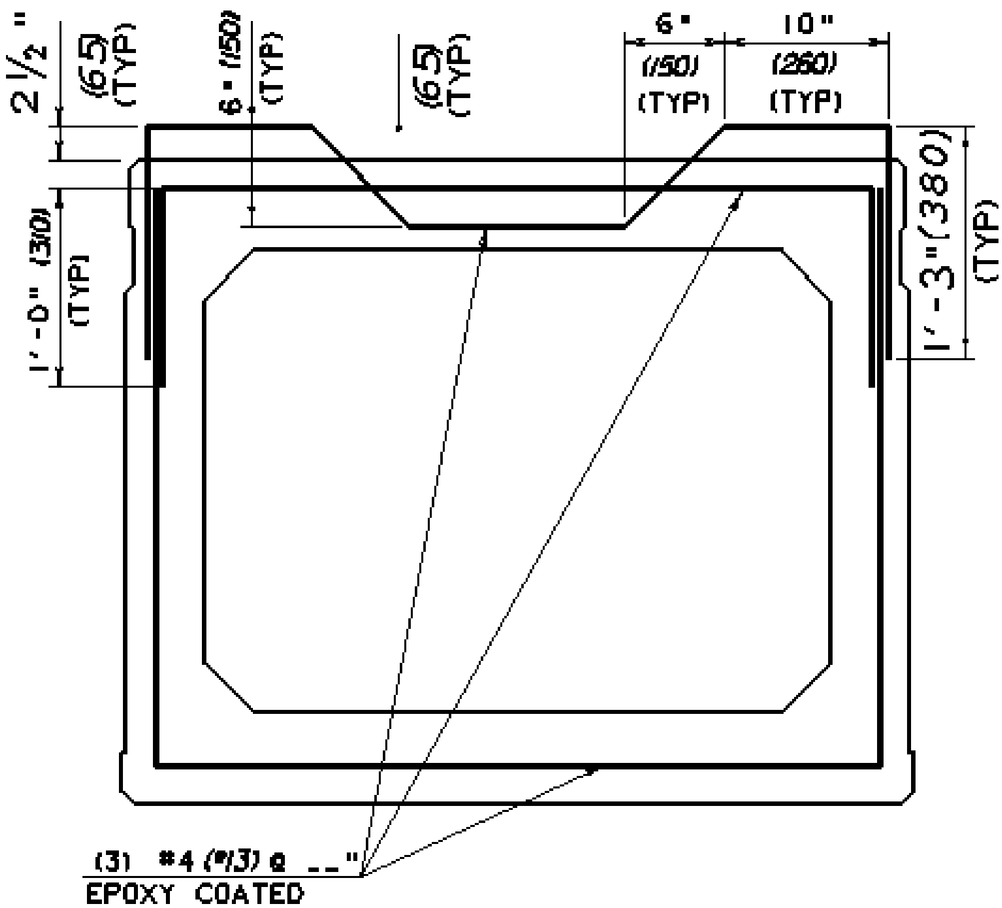
MAX NUMBER OF STRANDS FOR 39" *(990)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	22 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
5 @ 10¾" *(273)*	2 STRANDS
6 @ 12¾" *(324)*	2 STRANDS
7 @ 14¾" *(375)*	2 STRANDS
11 @ 22¾" *(578)*	2 STRANDS
12 @ 24¾" *(629)*	2 STRANDS
13 @ 26¾" *(680)*	2 STRANDS
14 @ 28¾" *(730)*	2 STRANDS
15 @ 30¾" *(781)*	2 STRANDS
16 @ 32¾" *(832)*	2 STRANDS
17 @ 34¾" *(883)*	4 STRANDS
18 @ 36¾" *(934)*	12 STRANDS

**ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT*



39" X 48" BOX BEAM
(990 X 1220 BOX BEAM)
STRAND LAYOUT

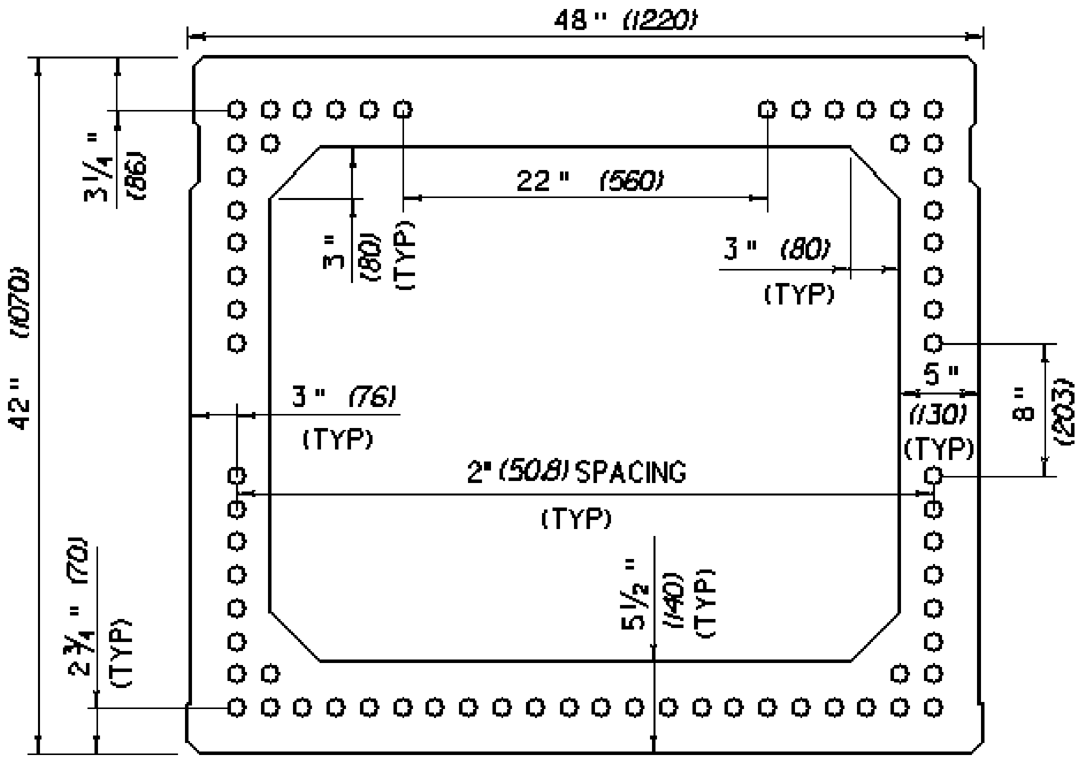


39" X 48" BOX BEAM
(840 X 1220 BOX BEAM)
REINFORCING LAYOUT

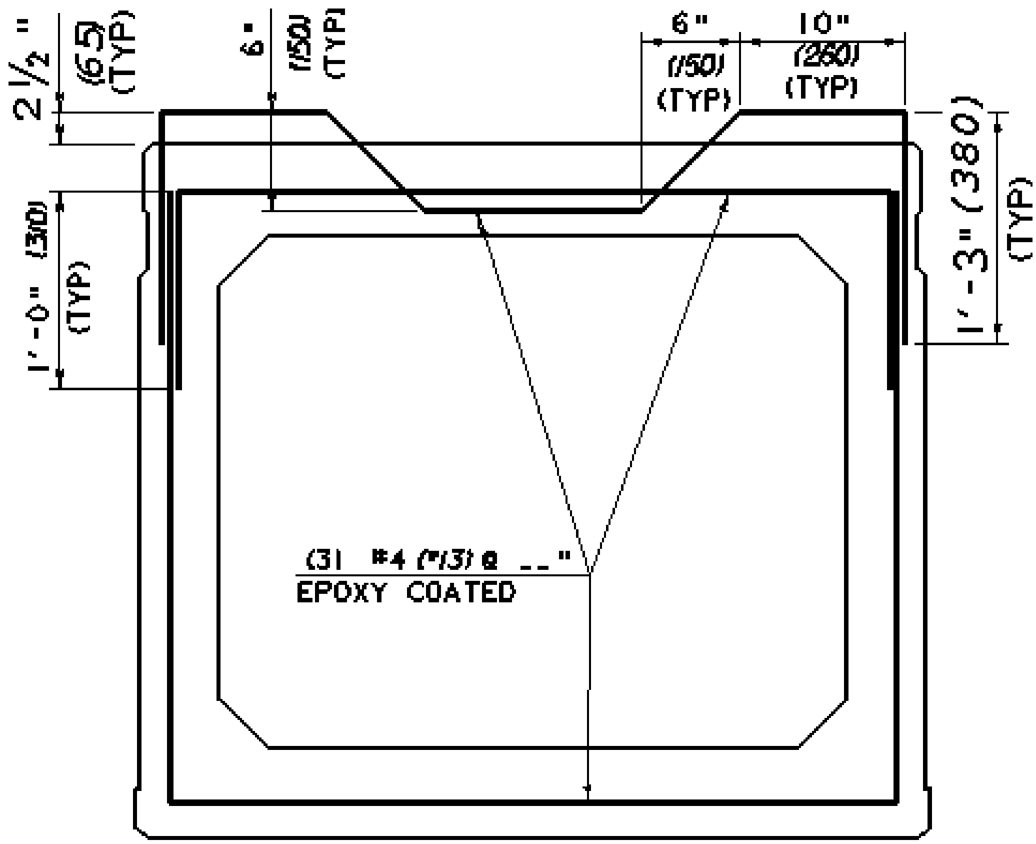
MAX NUMBER OF STRANDS FOR 42" *(1070)* BEAM

ROW *	NO. OF STRANDS
1 @ 2¾" *(70)*	22 STRANDS
2 @ 4¾" *(121)*	4 STRANDS
3 @ 6¾" *(172)*	2 STRANDS
4 @ 8¾" *(222)*	2 STRANDS
5 @ 10¾" *(273)*	2 STRANDS
6 @ 12¾" *(324)*	2 STRANDS
7 @ 14¾" *(375)*	2 STRANDS
8 @ 16¾" *(426)*	2 STRANDS
12 @ 24¾" *(629)*	2 STRANDS
13 @ 26¾" *(680)*	2 STRANDS
14 @ 28¾" *(730)*	2 STRANDS
15 @ 30¾" *(781)*	2 STRANDS
16 @ 32¾" *(832)*	2 STRANDS
17 @ 34¾" *(883)*	2 STRANDS
18 @ 36¾" *(934)*	4 STRANDS
19 @ 38¾" *(984)*	12 STRANDS

**ROWS ARE ALWAYS AT SPECIFIED DISTANCES FROM BOTTOM OF UNIT*



42" X 48" BOX BEAM
(1070 X 1220 BOX BEAM)
STRAND LAYOUT



42" X 48" BOX BEAM

(1070 X 1220 BOX BEAM)

REINFORCING LAYOUT

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