| STRUCTURAL DESIGN | Chapter: INDEXES |
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**00 INDEXES**

| STRUCTURAL DESIGN | Chapter<br>INDEXES |
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| STRUCTURAL DESIGN | Chapter<br>INTRODUCTION<br>Subject<br>Design of This Guidance Manual |
|---|---|

**ORGANIZATION & NUMBERING:**

**Chapters** – The subject matter in the manual is divided into chapters. The chapter title appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

**Sections** – Some chapters are divided into sections. Each section title, instead of chapter title, appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

**Subjects** – Chapters and sections are arranged by subjects.

**Subject Number** – Each subject is assigned a number, which appears in the upper right-hand corner of each page of the subject. For example, Chapter 500 includes subject 503, followed by subject 504, which is divided into section subjects 504-1 through 504-3.

**"SD" Prefix** – Preceding each subject number, this prefix stands for the manual title *Structural Design*.

**Subject Title** – The title of a subject appears in the upper right-hand corner of the first page of a subject and in the upper left-hand corner of any subsequent page.

**Date** – The latest issuance date of a subject appears at the bottom of each page of the subject. This date agrees with the latest issuance date shown for the subject in the Table of Contents **(SD-02)**.

**Page Numbering** – Each subject has its own page numbering, which appears at the bottom of each page.

**LOCATING**

**INFORMATION:**

**Indexes** –Each index entry includes the corresponding subject number in the manual where you will find detailed information for the entry.

- **Table of Contents (SD-01)** – This index lists the titles of the manual's chapters and sections and their subjects, as well as other information, in numerical order. It includes the latest issuance dates of all the subjects. As the manual matures, these dates change.
- **Alphabetical Index (SD-02)** – This index alphabetically lists key information in the manual. Generally, it directs you to subject titles and to margin, paragraph, and subparagraph headings within subjects. This index is your main tool for finding specific information in the manual.
- **List of Exhibits (SD-9900)** – This index lists the manual's exhibits. It includes the latest issuance date of each exhibit. As the exhibits are revised, the issuance dates change.

**QUESTIONS:**

**Who to Contact** – For answers to questions about the contents of the manual, please contact the Division of Structural Design at (502) 564-4560.

For copies of the manual, please contact:

Policy Support Branch
Transportation Cabinet Office Building
W4-26-02
200 Mero Street
Frankfort, KY 40622
(502) 564-3670

| STRUCTURAL DESIGN | Chapter<br>INTRODUCTION<br>Subject<br>Audience & Abbreviations |
|---|---|

**AUDIENCE FOR THIS MANUAL:**

This Guidance Manual is written to the bridge designer. The sentences that direct the designer to perform work are written in the active voice, imperative mood. These directions to the designer are written as commands. For example, a requirement to provide minimum concrete cover is expressed as, “Provide minimum concrete cover,” rather than, “The designer shall provide minimum concrete cover.” In the imperative mood, the subject “the designer” is understood.

Other requirements to be performed by others have been written in the active voice. Sentences written in the active voice identify the party responsible for performing the action. For example, “The Geotechnical Engineer will recommend the approximate footing elevation.” Certain requirements of the designer may also be written in active voice, rather than active voice, imperative mood.

Sentences that define terms, describe a product or desired result, or describe a condition that may exist are not written in either the active voice or the imperative mood. These types of sentences, which describe a condition, use verbs requiring no action. For example, “The characteristics of the soils actually encountered in the subgrade may affect the quality of cement and depth of treatment necessary.”

**ABBREVIATIONS:**

The following abbreviations, when used in this Manual, represent the full text shown.

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing and Materials |
| AWS | American Welding Society |

| | |
|---|---|
| CRSI | Concrete Reinforcing Steel Institute |
| DGA | Dense Graded Aggregate |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| KAZC | Kentucky Airport Zoning Administration |
| MSE | Mechanically Stabilized Earth |
| NAVFAC | Naval Facilities |
| RCBC | Reinforced Concrete Box Culvert |
| USCG | United States Coast Guard |
| USGS | United States Geologic Survey |

| STRUCTURAL DESIGN | Chapter<br>INTRODUCTION |
| --- | --- |
| | Subject<br>Function, Organization & Location |

**FUNCTION:**

The prime function of the Division of Structural Design is the design and preparation of contract plans for all highway structures, as well as any other special structures which may be necessary, that will be built as part of the Department of Highways' system of roads.

The Division of Structural Design also performs the design of and prepares repair plans for existing highway structures.

The Division of Structural Design's Geotechnical Branch performs geotechnical investigations. The Geotechnical Branch publishes its own Guidance Manual, which may be found on the Division's website.

**DESIGN FUNCTION:**

The design function of highway structures is subdivided into design performed by the Division of Structural Design personnel and design performed by private consultant engineering firms under contract to the Department of Highways.

Situation survey information gathered by the Department and/or private consultants is submitted to the Division of Structural Design.

The Structural Designer takes the survey information and develops contract plans which are architecturally pleasing, economically sound, and the best engineering solution to the structural situation presented.

The Division reviews the plans prepared by private engineering firms to assure that the plans meet the specification requirements of the Department.

**STRUCTURE MAINTENANCE**

**& REPAIR FUNCTION:** The Division of Structural Design has as an additional function: the design and preparation of repair plans for existing structures when repairs are of a major nature affecting the load-carrying capacity of the structure or when the replacement of deteriorated floor systems and other repairs are necessary for normal maintenance care and operation. The Division of Structural Design works closely with the Division of Maintenance in these regards.

**GEOTECHNICAL BRANCH:** The Geotechnical Branch is responsible for all functions relating to geotechnical engineering (with the exception of research) required for the planning, design, construction, and maintenance of roads and bridges under the jurisdiction of the Department of Highways.

**ORGANIZATION:** The Division of Structural Design is assigned to the Office of the Deputy State Highway Engineer for Project Development.

**LOCATION:** The Division of Structural Design is physically located on the Third Floor of the Transportation Cabinet Office Building at 200 Mero Street in Frankfort, Kentucky 40622. The telephone number is (502) 564-4560.

Submit presentations outlined in the following chapters to this office. Shop plan checking is also coordinated here.

| STRUCTURAL DESIGN | Chapter<br>INTRODUCTION<br>Subject<br>Services Performed by Consulting Engineers |
|---|---|

**AGREEMENT:**

The engineering agreement for the particular project governs services performed by consulting engineers.

All work under an agreement is at all times subject to the general supervision and direction of the Director, Division of Structural Design, and is subject to review and approval. The term "Director, Division of Structural Design," means the Director of the Division of Structural Design or his/her authorized representative.

Follow the procedures of structural design set forth in this manual, unless otherwise instructed by contract or written instructions signed by an authorized representative of the Division of Structural Design. Even though any particular paragraph heading may not be addressed directly to the consultant, the instructions still apply.

**CONSULTANT AGREEMENT CHANGE ORDERS:**

When changes arise in structural design procedures that are not covered in the original consulting engineering agreements, the consultant must initiate a request to the Project Manager to approve a change order involving compensation for extra work.

**PRE-DESIGN CONFERENCE WITH CONSULTANTS:**

The consultant will be provided guidance, necessary forms, etc. to submit a proposal. The scope of the project will be developed, including applicable structure design criteria, progress reporting, normal review times, required submittals, contract completion date, and any other requirements relating to the development of structure plans for the project. The number and type of alternate structures that will be studied, if any, will also be determined.

If agreeable to all parties, the pre-design conference may be held via telephone and/or email.

**Combination Roadway & Bridge Design Projects** – See the Division of Highway Design Guidance Manual regarding pre-design conference procedures on projects which contain both roadway and bridge design. On combination projects, schedule a structure pre-design conference in the Division of Structural Design to discuss applicable design criteria and procedures when deemed necessary by the Division of Structural Design or the consultant.

**Bridge Design Only Projects** – For consultant proposals involving bridge design only, conduct the proposal conference in the Central Office, Division of Structural Design. Attendance by a district representative is not required, but may be desirable in some instances.

| STRUCTURAL DESIGN | Chapter<br>INTRODUCTION<br>Subject<br>Website |
|---|---|

**ADDRESS:** The Division of Structural Design maintains a website, which may be accessed from the Transportation Cabinet's main website at www.transportation.ky.gov.

**CURRENT GUIDANCE:** The Division of Structural Design will post future transmittal memoranda and design guidance on the website. Check the web site for current guidance.

**CONTENT:** The Division's website contains links to the following useful information:

**Specifications**

- Standard Drawings
- Standard Specifications
- Special Notes and Special Provisions
- Division of Structural Design Guidance Manual
- Geotechnical Branch Guidance Manual
- Division of Structural Design Transmittal Memoranda

**File Downloads**

- Base Sheets
- MicroStation Resource Files
- Cell Libraries
- Miscellaneous Details

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| | Subject<br>Submittal Phases |

Private consultant engineering firms present plans to the Division in **five phases**:

1) Situation Survey
2) Preliminary Plans, Stage 1
3) Preliminary Plans, Stage 2 (if required)
4) Final Plans, Stage 1
5) Final Plans, Stage 2

This Chapter outlines the data required for each presentation. Modification of these phases and/or their content requires written approval from the Director, Division of Structural Design.

| STRUCTURAL DESIGN | Section<br>ADVANCE SITUATION SURVEY |
| --- | --- |
| | Subject<br>Procedure |

**GENERAL:**

Submit an Advance Situation Survey for each structure to the Division of Structural Design after all outstanding issues have been settled. The Advance Situation Survey will serve as an 'order form' for structure plans. Submit two copies if submitting a printed folder. The Project Manager will contact the Division of Structural Design prior to submitting the Advance Situation Survey if there are any questions concerning the proposed structure that would benefit from early involvement by the Division. These questions might include, but are not limited to, architectural treatments and alternate span arrangements.

**TIMING OF SUBMITTAL:**

Submit the Advance Situation Survey to the Division of Structural Design a minimum of **10 months** before a scheduled letting for a normal, straight, prestressed concrete bridge.

This provides:

- 3 months to hire a consultant or work into the in-house schedule,
- 3 months to design the structure,
- 2 months for review/comment and still meet the required plans completion date which is usually
- 2 months before the letting.

The following conditions require **additional time**:

- A curved bridge will require an additional month.

- A bridge requiring phase construction will require an additional month.

- A steel bridge will require two additional months.

- A bridge over a railroad will require 3 additional months.

- If permits or approvals are required from other agencies, i.e. Coast Guard, FHWA, or the structure is complex, then additional time will be required and the Project Manage should contact the Division of Structural Design to set the letting schedule. This is particularly true if a Coast Guard Permit is required, as this process is very time consuming.

- If the Geotechnical Report has not been completed prior to the submittal date, then additional time will need to be allocated for that task.

**ELECTRONIC SUBMITTALS:**

In conformance with future Department policy or with the permission of the Director, Division of Structural Design, the Advance Situation Survey may be a submitted electronically. The Director, Division of Structural Design, will determine if electronic submittals will be a CD, email attachment or a reference to a file(s) on a server.

**REVIEW:**

The Division of Structural Design reviews the Advance Situation Survey for bridges according to the procedure outlined on **Form TC 66-110**.

The Division of Structural Design reviews the Advance Situation Survey for culverts according to the procedure outlined on **Form TC 66-111**.

**DISPOSITION:**

Upon completion of the review of the Advance Situation Survey, the Division of Structural Design will resolve any outstanding issues with the Project Manager.

| STRUCTURAL DESIGN | Section<br>ADVANCE SITUATION SURVEY |
|---|---|
| | Subject<br>Contents |

**GENERAL:**

When possible, provide 10” from top of slab to top of beam.

When proposing a wall-type abutment, include an alternate for a spill-through structure, if feasible. A spill-through type structure is generally more economical than a short span structure with tall abutments.

Greater vertical clearance gives the most flexibility in structure design.

Measure span lengths along centerline to the face of abutment and the centerline of pier.

**ALL CROSSINGS:**

Submit the following information:

- A discussion of **critical features** governing the location
- **Design Executive Summary** Form TC 61-9
- **Typical section(s)**
- The **roadway plan and profile** of the route over, including the sheets before and after the structure. If the route over is a railroad, profile the low rail. Clearly mark utilities that are to remain in the vicinity of the structure.
- A **natural scale plan and elevation** along centerline of the proposed structure for each structure alternate. See **Exhibit 219** for examples. In dual bridge locations, include a section at the centerline of each bridge.
- Site **contours** with centerline of project and plan of proposed structure superimposed.

- **Architectural** and/or aesthetic requirements

- Lighting, signing, utility requirements

- Any non-standard **wing** details

- Copies of previous **correspondence** pertinent to the structure location and/or interchange approval.

- When applicable, show reference to the **existing structure** as it relates to the new and show if phased construction is required.

**STREAM CROSSINGS:** Submit the following additional information:

- **Drainage Inspection Report** along with other pertinent correspondence

- **Bridge and Culvert Summary** (Form TC 61-504) and a USGS Topography Sheet with alignment and drainage areas indicated (see Drainage Manual).

- **Design Summary Sheet** (Form TC 61-100)

- **Stream profile** (see Drainage Manual)

- If applicable, enclose a copy of the **Bridge Site Report** prepared by U.S. Geological Survey for some major stream crossings. The Drainage Section of the Division of Highway Design provides this report. For electronic submittals this may be a reference to a file(s) on a server.

- For **culverts**, show the stream gradient and the flowline elevation at the intersection of centerline roadway and centerline culvert. Also include culvert equation and skew of baseline with centerline. When extending an existing culvert, show the distance from the new centerline to each end of the existing culvert barrel. Measure this distance normal to the new centerline of survey. Show the new skew angle, existing culvert barrel size, date of construction, drawing number, and condition of existing culvert.

**GRADE SEPARATIONS:** Submit the following additional information:

- **Design Executive Summary** (Form TC 61-9) showing roadway design of route under

- Roadway **plan and profile of the route under**. If the route under is a railroad, profile the high rail.

- Show in calculations and on the structure profile the ditch and berm **elevations** used to compute span lengths. Indicate controlling cut slopes or fill slopes.

- On railroad grade separations, show **milepost** tie-in to centerline survey station and locate centerline of track from tangent offsets at 25-foot intervals in each direction to establish track curvature within bridge site limits.

**RAILROAD GRADE SEPARATIONS:**

The Project Manager will contact the railroad to determine required clearances and other requirements for the particular location.

**BRIDGES ON CURVED ALIGNMENT:**

Generally, curve any bridge located in a curved roadway location to properly fit the curved roadway alignment. However, where the degree of curvature is slight and the bridge length provides only a small maximum offset, **consider using a straight bridge**. Perform a complete analysis of each curved roadway location before recommending a straight bridge, taking into consideration bridge length, degree of curvature, maximum offset, approach grade profiles, etc. Position the structure to provide the minimum required horizontal clearances. The maximum allowable widening to accommodate a straight bridge in a curved roadway section is 15 inches.

Note that bridges located on curved alignments generally cost more to design and construct than straight bridges. **Roadway designers should attempt to keep bridges out of curves,** if possible. If economics prevent locating the structure outside a segment of curved roadway, locate the bridge outside of any pavement transitions.

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| | Subject<br>Subsurface Exploration |

**IMPORTANCE:** The importance of reliable subsurface exploration information to the structural engineer is paramount. Even preliminary structure plans have no value if the foundation exploration is unreliable. The importance of dependable supervision of the foundation exploration phase by responsible geotechnical personnel cannot be overemphasized.

**TIMING OF REQUEST:** After the Joint Inspection, the Project Manager will request the geotechnical engineer to prepare subsurface exploration plans for all structures on the project, following procedures outlined in the Geotechnical Manual. Include in the subsurface exploration plans any viable alternate layouts. The Project Manager will contact the Division of Structural Design concerning the viability of alternate layouts.

**SUBSURFACE DATA SHEET:** Show the drill logs and laboratory test results on the subsurface data sheet, in accordance with the Geotechnical Manual. Show the subsurface exploration plan and subsurface data on the same sheet, if practical. Use a separate subsurface data sheet for each structure.

The geotechnical engineer will submit a print of the S**ubsurface Data Sheets** to the bridge designer with recommendations for structure foundation design for his/her review. Include in the recommendations the following: type of foundation, bearing elevations, estimated pile tip elevations, pile capacity tables, negative skin friction, allowable bearing pressures for soil or rock, consolidation, rate of consolidation, slope stability, material specifications, construction specifications, and/or others where applicable. When alternate foundation types may apply, a meeting may be scheduled with the Divisions of Structural Design and

Construction to discuss alternates prior to submitting the final report.

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| | Subject<br>Federal and State Agency Approvals |

**CORRESPONDENCE:** The Department of Highways will handle all correspondence with the various federal and state agencies, unless otherwise directed. Request any information desired from these agencies through the Division of Structural Design.

**NAVIGATION PERMIT APPLICATIONS:** Navigation Permits will be required on the Green River to Mile 108.5, on the Cumberland River to mile 75, on the Big Sandy River to mile 8, and on the Ohio, Tennessee and Mississippi Rivers in their entirety. Tributaries and embayment areas which are lateral extensions of navigable waterways are considered navigable upstream to the limit of ordinary high water of the main waterway and should be considered questionable. **Exhibit 206** contains a list of waterways that should also be considered questionable. In these and any other questionable cases, request through the Division of Structural Design to the U. S. Coast Guard (USCG) for their comments regarding the need for a permit. In any questionable cases, request through the Division of Structural Design to the U. S. Coast Guard (USCG) for their comments regarding the need for a permit.

The Commander, USCG, handles all matters pertaining to navigation clearances and permit approvals. The address is Commander, Eighth Coast Guard District, 1222 Spruce Street, St. Louis, Missouri 63103.

The navigation permit application form and content follow the procedures set forth in the current USCG publication entitled, "Bridge Permit Application Guide," which may be found on the USCG website.

The construction of wharves, dolphins, boons, weirs, breakwaters, bulkheads, jetties, protective cells, or other structures infringing on navigable waters continues to require permit applications to be submitted to the Department of the Army, Corps of Engineers.

**NAVIGATION LIGHTING APPROVAL:**

With the issuance of the Instrument of Approval, the USCG prescribes permanent navigation lighting requirements regarding location and type. Incorporate the permanent navigation lighting requirements in the structure plans as a contract bid item. No USCG approval of the contract plans is required if all permit requirements are met. However, submit Stage 1 Final Plans of Permanent Navigation Lighting to the Division of Traffic Operations for review and approval. Note on the structure plans any construction contract requirements involving temporary navigation lighting.

**PERMITS FOR AIRSPACE:**

Indicate structures located in the vicinity of airports in the Preliminary Line and Grade Inspection Report and in the Final Plans-In-Hand Inspection Report.

**Federal Aviation Administration Approval** – Before completing preliminary plans for bridge superstructure or towers that might infringe on air space in the vicinity of airports, investigate the need for aviation warning lights. Forward a preliminary inquiry through the Division of Structural Design to the Federal Aviation Administration (FAA) as to requirements. The FAA will provide the necessary forms to complete for resubmittal. The FAA will then determine the requirements of aviation warning lights. Address any correspondence to Chief, Air Traffic Division, Federal Aviation Administration, Southern Region, P.O. Box 20636, Atlanta, Georgia 30320.

**Kentucky Airport Zoning Commission (KAZC) Approval** – Before completing preliminary plans for structures that may infringe on airspace in the vicinity of public use airports, forward a completed "Application for Permit to Alter or Construct a Structure," (Form TC 56-50), through the Division of Structural Design to the Administrator, Kentucky Airport Zoning Commission, Department of Aviation, 200 Mero Street, Frankfort, Kentucky 40622. Prepare the form in accordance with KAZC's Book of Regulations.

The Commission assumes jurisdiction over airspace of the Commonwealth that exceeds 200 feet in height above ground level or 50 feet in height above surface of open water of the Ohio River, the Mississippi River, Kentucky Lake, Lake Barkley, Lake Cumberland, Barren River Lake, Nolin Lake Reservoir, Rough River Lake, Dale Hollow Reservoir (KY), Green River Lake, and Taylorsville Lake.

The Commission also assumes zoning jurisdiction over that airspace over and around the public use airports within the Commonwealth that lies above the imaginary surface that extends outward and upward at one of the following slopes:

- One hundred to one for a horizontal distance of 20,000 feet from the nearest point of the nearest runway of each public-use airport or military airport with at least one runway 3,200 or more feet in length

- Fifty to one for a horizontal distance of 10,000 feet from the nearest point of the nearest runway of each public-use airport or military airport with its longest runway less than 3,200 feet in length

**AVIATION LIGHTING APPROVAL:**

If the FAA or the KAZC determines that aviation lighting is necessary, they will prescribe permanent aviation lighting requirements. Incorporate these requirements in the structure plans as a contract bid item. No FAA or KAZC approval of the contract plans is required if all prescribed requirements are met. However, submit Stage 1 Final Plans for Permanent Aviation Lighting to the Division of Traffic Operations for review and approval. Note on the structure plans any construction contract requirements involving temporary aviation lighting.

**Forms -** On structures requiring aviation lighting, the FAA and the KAZC provide the Department of Highways with forms to be completed and returned to them before construction begins and when the structure reaches its maximum height. Forward these forms to the Division of Construction as soon as the project is let to contract.

| STRUCTURAL DESIGN | Section<br>PRELIMINARY PLANS |
|---|---|
| | Subject<br>Procedure |

**GENERAL:** All bridges require preliminary plans unless exempted by the Director, Division of Structural Design. Do not begin preliminary plans until drainage has been approved and the Geotechnical Report is complete. Submit two sets of prints plus additional sets for other agencies where applicable. In addition, submit an electronic copy which meets Division of Structural Design's Graphic Files Standards.

**STAGE 1 SUBMITTAL:** Submit the required copies of the preliminary plan to the Division of Structural Design. The Division of Structural Design will return one copy noting any suggested changes. Upon completion of the review of Stage 1 Preliminary Plans, the Division of Structural Design will determine whether Stage 2 Preliminary Plans submittal is required. If not, Stage 1 Preliminary Plans will be considered also as Stage 2 Preliminary Plans.

**STAGE 2 SUBMITTAL:** If required, submit the required copies of Stage 2 Preliminary Plans to the Division of Structural Design.

**REVIEW:** The Division of Structural Design reviews preliminary plans according to the procedure outlined on **Form TC 66-112**. The Director, Division of Structural Design, approves the preliminary plan of all structures before authorizing any detailing of the final structure plans.

Before the Division of Structural Design approves Stage 2 Preliminary Plans, the following agencies require further review and tentative approval when applicable. Submit all preliminary plans for structures to the Division of Structural Design, which forwards plans to the appropriate parties for comment.

The **Federal Highway Administration** reviews and approves the preliminary plans for all interstate bridges (route over or under) and some other structures.

The **Federal Aviation Agency** reviews and approves preliminary plans for aviation warning lighting for bridge superstructures or towers, in accordance with **Section SD-204**, “Permits for Airspace”.

Each **railroad** company affected by the bridge structure reviews and approves preliminary plans for structural details or specifications and for conformance to clearance requirements declared by the railroad during the situation survey review, as outlined in **Section SD-202-2**, “Railroad Grade Separations.” Submit 3 copies of the preliminary plan for the railroad company. Submit 1 copy of the preliminary plans for the Railroad Coordinator in the Division of Highway Design.

Each **utility** company affected by the bridge structure reviews and approves preliminary plans concerning the relocation of overhead, surface or subsurface transmission lines. In particular, avoid any disruption of utility service by advance planning and scheduling. During the preparation of widening plans or maintenance repair plans for existing bridges, the Division of Structural Design will consult with the district utility agents concerning the ownership of easily observed utility lines and the possible location of utility lines not readily seen. The district utilities agent will manage all negotiations with utility companies using plan information furnished by the Division of Structural Design.

**DISPOSITION:** Upon completion of the review of Stage 2 Preliminary Plans, the Division of Structural Design will retain one marked copy for records, return another marked copy to the consultant, and forward an email copy of the return transmittal memorandum to the Project Manager (with copies to the central office location engineer, the central office construction engineer, and the district construction engineer) for their notification of completion of the review activity.

| STRUCTURAL DESIGN | Section<br>PRELIMINARY PLANS<br>Subject<br>Contents |
|---|---|

**11"x17"**
**SHEET ASSEMBLY:** Submit the following information:

- A **Title Sheet** from the roadway plans containing a vicinity map of the project and indicating the bridge location
- A **bridge layout** for the recommended structure showing all items of data listed in **Section SD-305**. Critical datum elevations may be estimated to the nearest tenth of a foot.
- **Sections** of the recommended structure (and any alternate structure if required) showing beam depths, roadway widths and sidewalks and any proposed utilities
- Bearing details, pier types, and, for steel bridges, a girder elevation showing plate sizes, stiffener locations and splice locations
- **Plan-profile sheets** for route over, and route under, if applicable
- Plan-profile sheets of the **alternate** plan or profile design study, if either varies from the recommended layout.

**8 ½" x 11"**
**SHEET ASSEMBLY:** Submit the following information:

- Preliminary **general notes** for specifications, design load, design method, foundation pressure, and materials design specifications if they are to be **non-standard**
- **Estimate of Quantities** (**Form TC 66-101**) for the

recommended structure with cost extensions and separate subtotals for the substructure and the superstructure

- **Estimate of Quantities** (**Form TC 66-101**) for the **alternate** design study next lowest in cost to the recommended structure with cost extensions and separate subtotals for the substructure and superstructure

- List of special conditions of loading and material specifications not covered in the AASHTO Design Specification for Highway Bridges.

| STRUCTURAL DESIGN | Section: FINAL PLANS |
|---|---|
| | Subject: Procedure |

**SUBMITTAL:** Submit the final structure plans for review in **two stages**.

**STAGE 1 REVIEW:** The Division of Structural Design reviews Stage 1 Final Plans according to the procedure outlined on **Form TC 66-116**.

Before the Division of Structural Design approves Stage 1 Final Plans, the Division will request review and approval, when applicable, from other agencies:

The **District Construction Engineer** and the **Division of Construction** review structure plans to avoid details which may create high maintenance costs, to avoid known construction difficulties, and to coordinate the bridge construction and inspection with either adjoining or concurrent work.

Each **railroad** company affected by the bridge structure reviews and approves final plans for structural details or specifications and for conformance to previously approved preliminary plans. Submit three sets of prints for this review. This review must be completed by the railroad and further plan changes required by them must be finished before contract agreements can be drafted for final execution by signatures of railroad and Department officials.

The **Division of Right of Way and Utilities** will contact each utility company affected by the bridge structure, using final plan sheets furnished by the Division of Structural Design. Final plans for suspending utility lines from structures must be finished before contract agreements can be drafted for final execution by signatures of utility and Department officials.

**STAGE 1 DISPOSITION:** Upon completion of the review of Stage 1 Final Plans, the

Division of Structural Design will retain one copy of all items and return one marked copy of the plans and special notes to the consultant for correction. The Division of Structural Design will forward an email copy of the return transmittal memorandum to the Project Manager (with copies to the central office location engineer, the central office construction engineer, and the district construction engineer) for their notification of completion of the review activity.

**STAGE 2 REVIEW:** The Division of Structural Design reviews Stage 2 Final Plans according to the procedure outlined on **Form TC 66-117**.

**STAGE 2 DISPOSITION:** Before the Division of Structural Design approves Stage 2 Final Plans, the Division will establish with certainty that the final plans are acceptable to other agencies without further changes. The Federal Highway Administration reviews and approves the final plans on all interstate bridges (route over or under).

| STRUCTURAL DESIGN | Section: FINAL PLANS / Subject: Contents |
|---|---|

**STAGE 1 SUBMITTAL:** Completely design, detail, check, and provide quantities for all structures submitted for Stage 1 review. Submit two sets of 11”x17” prints plus additional sets for other agencies where applicable. Also submit an electronic copy which meets the Division of Structural Design’s Graphic Files Standards.

Submit the following items:

- A **list** of all items included in the submittal noting the number of prints of each item
- One letter-size print of the structure design **calculations**, as described below
- One letter-size print of applicable **special notes**, if any, and an electronic copy in WORD format
- One print of **Bridge and/or Culvert Design Data Forms TC 66-100** and/or **TC 66-101**, completed through the final-plans estimate

**STAGE 2 SUBMITTAL:** After resolving the suggested changes from the Stage 2 review, submit the final plans.

Submit the following items:

- A **list** of all items included in the submittal, including the number of sheets for each drawing number
- All **final bridge tracings** with drawing number affixed for the entire design project. Trim the edges to 22 inches by 36 inches sheet size. Include one complete set of 11”x17” prints. Include required additional set of prints of

each railroad separation structure. Also submit an electronic copy which meets the Division of Structural Design's Graphic Files Standards.

- Typed, letter-size copies of **special notes**, if any, and an electronic copy in WORD format

- A plan size Mylar sheet of the "**Bridge and Culvert Summary**" for each project (see **Exhibit 217**), correct to this stage of submittal. In addition, submit an electronic copy which meets Division of Structural Design's Graphic Files Standards.

- One print of final **Forms TC 66-100** and **TC 66-101** showing any final estimate revision and drawing number. In addition, submit an electronic copy of the **Close-Out Form**.

- **Identification** of Department of Highway Design Sections or Consulting Engineers, the Designer, and the Checker in the proper location in the title block of each structure of separate drawing number (see **Exhibit 310**). The names should be names, not initials.

**CALCULATIONS:**

Maintain a legible record of all structure design calculations which relate to structure layout, geometrics, clearance, design, and quantities. Submit the calculations with final structure plans as a permanent record for the Division of Structural Design's files. When drawing numbers have not been assigned prior to submittal, review sections will add them to calculation folders when closing out project files.

- Use sheets measuring 8 ½ by 11 inches for all calculations or studies. Avoid using scratch pads since their size is a filing inconvenience.

- **Identify** on each calculation sheet heading the design section or consultant, the project number, the structure, the date, and the initials of the designer and checker.

- Maintain legible and organized calculations so that both method and results are self-explanatory and can be retrieved.

- Assemble calculations for each bridge or set of twin bridges in a separate folder. Voluminous calculations for a single bridge may be submitted in more than one folder with the component folders identified and numbered on the label of each folder. Begin each calculation folder with an index sheet listing titles of the component folders and listing the detailed contents of the containing folder. Include in the calculations for each structure or twin structures a print of the final Summary of Bridge Design Data, Form TC 66-101.

- Group all calculations for culverts on a project in one folder consecutive by station with a final print of the culvert data Form TC 66-100 inserted as an index in the front of the folder.

- Submit calculations in stiff-backed binders and title the outside front of each binder as follows (see **Exhibit 218**):

COUNTY, PROJECT NUMBER (State and Federal)
ROAD NAME
CROSSING NAME
STATION, DRAWING NUMBER
ITEM NUMBER
DESIGN SECTION or CONSULTANT IDENTITY

**DOCUMENTS REQUIRING P. E. SEAL:** The following documents, when prepared by consultants, require the signature and seal of a professional civil engineer registered in the Commonwealth of Kentucky by the State Board of Registration for Professional Engineers and Land Surveyors. Affix the signature and seal near the title block on plan sheets and in any appropriate space on other documents.

- The title sheet of each set of final plans assigned a separate drawing number for each individual bridge structure location

- The front sheet of each set of final plans assigned a separate drawing number for each individual culvert location

- The first sheet of each individual set of final design calculations for both bridges and culverts, preferably an index sheet

- The first sheet of final design specifications and/or special notes when prepared for projects where standard specifications and special provisions do not apply.

| | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| **STRUCTURAL DESIGN** | Subject<br>Final Situation Folders |

Requirements, if any, for Final Situation Folders will be set by the Division of Highway Design.

**Do not send** Final Folders to the Division of Structural Design for any reason at any time.

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL<br>Subject<br>Estimate of Quantities |
|---|---|

**BRIDGE AND CULVERT SUMMARY:** Submit a **Bridge and Culvert Summary** Sheet in electronic format to the Division of Structural Design's Administrative section to be placed in the Roadway Plans (see **Exhibit 217**).

**BID ITEMS:** The Department maintains a list of the exact names for bid items commonly used in structure plans. This list also contains the code number and the bid unit and can be obtained by request. These Bridge Item Codes, along with Roadway and Traffic Item Codes, are also included in the Highway Department Bid Item File maintained by the Division of Highway Design.

**TEMPORARY BID ITEM CODES:** Bid item codes numbered 7300 - 7599 are for temporary use only. These numbers are given to items which are unique to a particular structure. Temporary bid item codes are valid only through the calendar year in which they are assigned and are purged on January l of the following year.

Obtain approval from the Division of Structural Design to use items which are not listed in the Bid Item File and/or temporary bid item codes. This includes item designation, bid unit, and accuracy.

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| | Subject<br>Right-Of-Way |

**PLANS:** For a bridge-only construction project, a set of right-of-way plans may need to be included in the construction plans to let the contractor know what right-of-way is available for construction and access purposes.

**PHASING:** When a second phase of a contract or another contractor will use the same right-of-way, ensure that any staging areas for the Phase 1 contract do not interfere with Phase 2.

| STRUCTURAL DESIGN | Chapter<br>SUBMITTAL FOR REVIEW AND APPROVAL |
|---|---|
| | Subject<br>Progress Reports |

**SUBMITTAL:** Report progress in the development of structure plans **each month** to the Administrative Section of the Division of Structural Design. Submit a report for each structure **via email**.

**PROGRESS PERCENTAGES:** Apply the following progress percentages in reporting progress for structure plans and in evaluating fee invoices presented for payment:

Upon Department approval of Advance Situation............ 10%

Upon submittal of Stage 1 Preliminary Plans .................. 15%

Upon Department and other agencies' (if required) approval of Stage 2 Preliminary Plans............................. 20%

Between approval of Stage 2 Preliminary Plans and submittal of Stage 1 Final Plans, base Progress Percentages on Monthly Progress Reports. In general, a completion of 55% indicates that the design has been completed and checked but the drafting has not yet begun.

Upon submittal of Stage 1 Final Plans............................. 95%

Upon submittal and Department acceptance of Stage 2 Final Plans ...................................................... 100%

**WEIGHTED PROGRESS FOR STRUCTURES:** For projects which include multiple structure locations, submit preliminary plans for review and approval on a structure-by-structure basis at various times rather than at one time as an entire group. State which structure is the "controlling" factor for purposes of overall project development.

**REVIEW TIMES:**

When estimating completion dates and when determining claims for time extensions to design consultant's agreements, allow the following times and include them in the estimate. Note that these times are measured from the beginning of the review process. The Division of Structural Design will begin the review process in accordance with the Department's current project schedule.

USCG Permit............................................360 calendar days

Review of Advance Situation Survey...........21 calendar days

Review of Stage 1 Preliminary Plans ..........21 calendar days

Review of Stage 2 Preliminary Plans ............7 calendar days

FHWA Review of
Stage 2 Preliminary Plans ...........................21 calendar days

Railroad Review ..........................................90 calendar days

Review of Stage 1 Final Plans.....................31 calendar days

Review of Stage 2 Final Plans.......................7 calendar days

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Notes |

**PLAN NOTES:**

The Division of Structural Design maintains a MicroStation **cell library** containing various plan notes to be placed on the structure plans when necessary. Place these notes on the same plan sheet as the detail with which the note is associated. The cell library may be obtained upon request to the Director, Division of Structural Design, or on the Division's website.

**GENERAL NOTES FOR PRELIMINARY PLANS:**

Preliminary plans require only **non-standard** general notes.

**GENERAL NOTES FOR BRIDGE AND CULVERT PLANS:**

Maintain awareness of all current specifications, design specifications, supplemental specifications, special notes, special provisions, general notes, standard drawings, and transmittal memoranda that may be necessary for the design of structures.

Incorporate into the structure plans all notes used for project control or to modify, supplement, or otherwise change the specifications. Insert in the structure plans a separate sheet entitled "General Notes" immediately following the title sheet for bridges. Place general notes for culvert plans on the first plan sheet.

The Division of Structural Design maintains a **General Note cell library** which may be obtained upon request to the Director, Division of Structural Design, or on the Division's website.

Evaluate each structure as to which notes apply. Certain circumstances may require additional notes to supplement the standard notes in the computer library. Any additional notes require the approval of the Director, Division of Structural Design. Compose additional notes clearly as to meaning and avoid conflict with any article of the Department of Highways' Standard Specifications for Road and Bridge Construction, unless exception from the Standard Specifications is the intent of the note.

**ORDER OF GENERAL NOTES:**

To facilitate review of notes for accuracy and thoroughness, place notes on the General Note Sheet by category in the following sequence:

1) **Specification Notes** – These notes refer to Department of Highways' Standard Specifications and AASHTO Standard Specifications for Highway Bridges used in the design of the structure.

2) **Material Specification Notes** – These notes contain specific information pertinent to the materials used in construction of the structure.

3) **General Specifications Notes** – These notes contain general information relative to material or construction for the structure.

4) **Superstructure Notes** – These notes contain specific and/or general information relative to the superstructure elements of the structure.

5) **Substructure Notes** – These notes contain specific and/or general information relative to the substructure elements of the structure.

6) **Miscellaneous Notes** – These are notes that do not belong in any of the above categories.

7) **Culvert Notes** – These notes contain specific and/or general information relative to culverts.

Place all applicable notes of a category upon the General Notes Sheet before placing notes for the following category.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT<br>Subject<br>Geometric Design Criteria |
|---|---|

**GENERAL:** Design bridges to meet the geometric design criteria set forth for the project.

**UNDERPASS DESIGN:** Place piers and/or abutments outside the clear zone for the road class and speed. For piers and/or abutments inside the clear zone, protect the structure from traffic by appropriate means. Study each structure situation for the most economic combination of span length and abutment design.

Do not use Mechanically Stabilized Earth (MSE) walls to support structures without permission of the Director, Division of Structural Design. MSE walls may be used for wings (see **Exhibit 517**).

In full cut sections requiring ditch drainage through the structure location, place the 2:1 fill slope toe at the normal ditch line, thereby eliminating the need for the fill slope transition and drainage pipe under the fill.

Where fill slope and/or ditch drainage pipe transitions are required, fully detail the transitions on the Roadway Plans and Profile Sheets at the applicable structure locations and further reference them on the structure Layout Sheet.

Place the top of pier footing 2 feet minimum below normal median ditch elevation. Pier crashwalls are not necessary where median guardrail protection is used.

Provide vertical clearance appropriate for the road class. See AASHTO Policy on Geometric Design of Highways and Streets. Provide an additional 12 inches for interstates and parkways and 6 inches for other roads for future overlays.

**OVERPASS DESIGN:** In general, match the bridge width between gutters to the approach roadway width between faces of guardrail. For curb-and-gutter projects, match the bridge section to the approach roadway section.

**GRADES AND SUPERELEVATION:** Limit profile grades to **0.5%** minimum on bridges to prevent water ponding. In certain circumstances, grades less than 0.5% may be unavoidable.

Grades and superelevation on bridges are set by the project requirements. Highway designers may want to limit grades and superelevations on bridges due to the tendency for bridges to freeze before roadways.

**CROSS SLOPES:** Provide pavement cross slopes for roadway crown on bridges as shown on geometric design sheet (normally 0.02). See **Exhibit 308** for **parabolic crown** details.

**PEDESTRIAN ISSUES:** To accommodate persons with disabilities, limit grades on ramps to pedestrian bridges to **8.33%** maximum. The maximum allowable rise for any run is 30 inches. Provide a level landing on ramps at the bottom and top of each run and a level landing at each turn. The minimum allowable landing length is 60 inches.

Standard details for pedestrian cages are available in Micro Station (.dgn) format from the Director, Division of Structural Design, or on the Division's website.

For vehicular bridges with sidewalks that are located over another highway or over a railway, use a partial cage with details similar to the pedestrian bridge cage.

Maintain a recommended minimum vertical clearance of 17 feet when a pedestrian bridge crosses over a highway.

| STRUCTURAL DESIGN | Chapter: PLAN DEVELOPMENT |
|---|---|
| | Subject: Sign Supports, Electrical Systems, & Utilities on Bridges |

**OVERHEAD SIGN SUPPORTS ON BRIDGES:**

The Division of Highway Design will initiate any requirement that overhead signs be located on a bridge. Include any design and detail of the structural supports for the signs in the structure plans. Before approving the preliminary structure plans, the Division of Structural Design will request the Division of Highway Design to fix the location of the sign supports and the location of any conduit and/or junction boxes for lighting the signs on the bridge layout.

**ELECTRICAL SYSTEMS ON BRIDGES:**

Show on the structure plans the details of luminaire pedestals or structural attachments and the details of the conduit encasements or structural attachments. Before approving the preliminary structure plans, the Division of Structural Design will request the Division of Traffic Operations to fix the location and size of the luminaire supports, conduit and junction boxes on the bridge layout.

**Conduit Only** – If lighting or signing is not a part of the initial construction, provide on the structure plans for a conduit to accommodate future lighting on all bridges on or over interstate highways and when directed by the Director, Division of Structural Design. Provide 3-inch diameter galvanized steel conduit through both barriers. Provide pole bases and junction boxes at 250 feet maximum spacing.

**UTILITIES ON BRIDGES:**

Provide utility attachments when required. Do not attach gas lines to bridges.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Bridge Title Sheet |

**GENERAL:** All bridges require a Bridge Title Sheet. Take care on this sheet and all sheets to provide details and text size that will be legible when reducing the plan sheet to half-size. **Exhibit 301** shows a typical title sheet.

**ESTIMATE OF QUANTITIES:** Use the correct bid item name. Indicate in the table subtotals for each substructure, for each superstructure, and for each bridge. Leave blank lines and columns for the addition of bid items.

**INCIDENTAL MATERIALS:** Do not include a bill of incidental materials. Instead, use General Note #131 on the General Note Sheet.

**TITLE:** Use the following format:

TRANSPORTATION CABINET
DEPARTMENT OF HIGHWAYS
COUNTY NAME
ROAD NAME
ROUTE NUMBER OVER CROSSING
STATION NUMBER

**P.E. SEAL:** Projects prepared by **consultants** require on the title sheet the signature and seal of a Professional Engineer registered in the Commonwealth of Kentucky by the State Board of Registration for Professional Engineers and Land Surveyors.

**TITLE BLOCK:** **Exhibit 310** shows a sample of a title block. Begin all structure sheet numbers with the upper case S. Therefore, label any index of sheets S1, S2, etc. On projects with multiple structures, label the first sheet of each structure "S1". Use names for the designer and detailer, not just initials.

**REFERENCES:**

List all standard drawings, with the current postscript used in the structure plans, on the title sheet. Reference the standard drawings elsewhere in the plans as “c.e.” (current edition) without the postscript. For example, "For details of expansion assembly, see Standard Drawing BJD-001, c.e." This avoids having conflicting references on the same set of plans. List any applicable special provisions and special notes with the current number and name on the title sheet.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Bridge Layout Sheet |

**GENERAL:**

Customarily, an adequate layout of the bridge is a plan view with the deck removed. By removing the deck from the bridge plan view, the survey lines, the control lines, and the dimensions may be clearly indicated without distracting detail. Field crews may then use this plan view to lay out the substructure units. For complex survey alignment and control, provide a separate survey control sheet in addition to the layout sheet.

From the plan view, orthographically project a structure elevation at the same scale. A typical bridge roadway section completes the layout sheet. Use the same scale on the plan and elevation views. See **Exhibit 311** for an example of a typical layout sheet.

**BRIDGE PLAN:**

Show the following items on the bridge plan:

- Centerline of survey, with stations increasing from left to right, and chord to curved centerline
- Station on centerline of survey of road over at the intersection of the centerline of survey of road under
- Station on centerline of survey of road under at the intersection of the centerline of survey of road over
- Centerline of roadways
- Horizontal curve data
- Stations at substructure units
- Skew angle
- North arrow
- Berm width
- Slope protection limits
- Stream name
- Direction of flow
- Span lengths
- Toe of embankment

- Geometrics of underlying crossing in grade separations
- Location of the points of minimum vertical clearance
- Working point layout control
- Milepost tie-in for RR grade separation
- Dimensions of out-to-out length of bridge
- Stations of termini of bridge
- Horizontal clearances for RR grade separations
- Bearing of centerline of survey or chord to centerline of survey.

**BRIDGE ELEVATION:** Show the following items on the bridge elevation view:

- Sea level datum reference
- Roadway profile data
- Datum elevations for each of the following:
    - Pile group cut-off
    - Low bridge seat at each substructure
    - Bottom of footings
    - Edge of berm. Normally, place the berm 12 inches below the low bridge seat. However, place the berm 2 feet minimum below the low bridge seat in rock cuts. See **Section SD-606**.
    - Extreme high water and normal pool
    - One datum line extended across the sheet
- Existing ground line along the centerline of the roadway
- Proposed ground line along the centerline of the roadway
- Existing rock line along the centerline of the roadway
- Label the substructure units and number the spans
- Fixed and expansion bearings
- Location of various expansion joints
- Road destination arrow
- Slope of embankments
- Slope Protection limits, type and thickness - see **Section SD-306** for details
- Vertical dimensions for:
    - Substructure heights
    - Grade separation clearances, allowable and actual
- List under the title "Elevation" span lengths and framing, design live load, roadway width, skew, shoulder width at bridge, fill slopes.
- Scour lines and elevations, if applicable

**BRIDGE ELEVATION OF TWIN STRUCTURES:** When detailing twin structures with only slight dissimilarities, a single profile view of the near right hand structure may be used to represent both structures. Note datum elevations in pairs, one for each structure, such as N.B. and S.B. for Northbound and Southbound Structures, or E.B. and W.B. for Eastbound and Westbound Structures. When twin structures are dissimilar in span length, skew, or foundation type, prepare separate Layout Sheets for each structure.

**BRIDGE TYPICAL ROADWAY SECTION:** Include the following items on the roadway section:

- Slab thickness
- Barrier height
- Beam depths
- Roadway width showing lanes and side clearances
- Barrier and median width
- Beam spacing
- Cross slopes
- Centerline of bridge
- Centerline of survey
- Long Chord, if applicable

**SURVEY CONTROL FOR CURVED ALIGNMENT:** For most locations of structures on curved alignment, the control deserves a detailed layout of the working points, allowably on a separate plan sheet. Base the control on a chord intersecting the centerline of survey. Extremities of the chord may be the centerline of survey intersections with the end bearing centerlines or the end bearing centerlines extended. Show the compass bearing and end stations of the chord. Show dimensions along the chord to intersections with other bearing centerlines. Show dimensions from these intersections to working points on the substructure units. Provide only one working point on each substructure unit.

**SURVEY CONTROL FOR TWIN BRIDGES:** When the centerline of survey is not on the bridge road, the line through the working points should form a closed geometric figure with the chord to the centerline of survey and the respective centerlines of bearing.

**SCOUR DESIGN DATA:** For all bridges on wet crossings, add the scour data to the layout sheet for future reference.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT<br>Subject<br>Slope Protection |
|---|---|

**GENERAL:** Three types of slope protection are approved for general use. Two of these are for route crossings and one for stream crossings. Specify the type of slope protection used in the quantity description on the Title Sheet. Show the limits, type and thickness of the slope protection on the layout sheet.

**STREAM CROSSINGS:** Use **Dry Cyclopean Stone Riprap** underlain by Geotextile Fabric Type I. Note on the plans that the Geotextile Fabric is incidental to the slope protection. When the fill in front of the abutments is a rock fill, do not use slope protection. Where the new earth fill in front of the abutments is entirely above high water, slope protection ordinarily need not be used, but obtain approval of the Drainage Section, Division of Highway Design. The limits of slope protection are 2 feet above high water and 15 feet back along the sides of the fill from the back edge of the abutment. See **Exhibit 313** for details.

**ROUTE CROSSINGS:** The lateral limits of slope protection for route crossings are 18 inches outside the fascia lines. Special consideration to this limit is noted for the median between twin bridges.

- Use a **6-inch Reinforced Concrete Slopewall** only in urban areas with easy pedestrian access and at railroad crossings when requested by the railroad. The upper limit of this slope protection is the front edge of the berm. Reference Standard Drawing BGX-004 or BGX-005 on the title sheet.

- Use **Crushed Aggregate** underlain by Geotextile Fabric Type I at all other route crossings. Note on the plans that the Geotextile Fabric is incidental to the slope protection. The upper limit of this type of slope protection is the back edge of the berm. See **Exhibit 314** for a typical section.

**BETWEEN TWIN BRIDGES ON DIVIDED HIGHWAYS:**

To avoid excessive maintenance costs and problems, extend the slope protection to include the slope between the bridges on all projects that have a median 64 feet or less in width. For railroad grade separations, provide slope protection for all medians, unless the roadway section is bifurcated.

Consider protecting the slope between bridges where the median is greater than 64 feet; however, study costs and other maintenance problems carefully.

On interstate projects, obtain FHWA approval on a structure-by-structure basis in the preliminary stage (probably on the joint field inspection) and include the approval in the inspection report.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT<br>Subject<br>Content of Bridge Plans |
|---|---|

**SCALE:** Use scales such as may be read on 11” x 17” prints.

**REINFORCED CONCRETE DETAILS:** Include the following items on reinforced concrete structure details:

- Full dimensioning, both vertical and horizontal, of all concrete surfaces
- Location of all reinforcement by dimensions
- Identification of all reinforcement by bar marks
- Location of construction joints
- Dimensioning of construction keys. Avoid the use of raised keys - wherever possible use recessed keys.
- Clearances from concrete surfaces to reinforcement
- Datum elevations on the substructure at important levels and control points
- Bar splices and embedments
- Do not use crankshaft type reinforcement in bridge decks
- Bill of Reinforcement with bar-bending details
- Hooks on ends of reinforcement terminated in tension concrete or terminated in a distance not sufficient to develop bond
- Location of the top of cap bars so that they will not interfere with the drilling of the holes for anchor bolts
- Dimensions from working points to related details.

**STRUCTURAL STEEL DETAILS:** Include the following items on structural steel details:

- Framing plan with control dimensions
- Rolled sections, sizes, and weights
- Plate sizes
- Flange plate cut-off points
- Field splice location and details

- Joint details at connections
- Stiffener spacing
- Bolt spacing and gauge lines
- Blocking diagram and Dead Load Camber diagram
- Shear connector details and spacing
- Bolt sizes and size of open holes
- Details of welded connections
- Material specifications
- Welding notes and procedure specifications. For built-up girders, include Special Provision 4, current edition, "Welding Steel Bridges," in the special provision list on the title sheet.
- Estimate of structural steel weight
- Dimensions from working points to related details.

**ABUTMENT DETAILS:** This article describes the items to include on structure plans for abutments in addition to those described in “Reinforced Concrete Details” above. Detail each abutment separately in the structure plans. Provide a Bill of Reinforcement at each abutment. Detail and dimension breastwalls sufficiently so that calculations for foundation layout by field personnel are unnecessary.

- Plan of cap showing bearing details in position. Design the cap wide enough to accommodate a 3-inch setback for the bearing device.
- Front elevation
- Sectional views as needed. The section through the end wall shows the roadway notch, if required.
- Use a **roadway notch** only when using a rigid approach slab. Place the top of the roadway notch parallel to cross slope and 2’-5” below grade.

**PIER DETAILS:** This section describes the items to include on structure plans for piers in addition to those described in “Reinforced Concrete Details” above. Detail each pier separately in the structure plans. Provide a Bill of Reinforcement for each pier.

- Plan of cap showing the bearing details
- Front elevation
- Side elevation, if necessary
- Footing plan or piling plan
- Sections as required

**SOUNDING LAYOUT SHEET:** Show the location of all cored holes on the sounding layout. Show a sounding log with the soil materials encountered. For additional information on soundings, see **Section SD-203**.

**FOUNDATION LAYOUT SHEET:** See **Exhibit 318** and/or the Division's website for an example. Detail and dimension substructure layouts sufficiently so that calculations for foundation layout by field personnel are unnecessary. Forward the completed tables to the Division of Structural Design after construction is complete.

**Spread Footings** – Show the "Spread Footing Record". For foundation units with multiple spread footings, provide a space in the table for each footing. Provide additional lines in the table for foundations on continuous spread footings, in case the continuous footing is stepped in the field.

**Piles** – Show the "Pile Record". Indicate the test pile locations and lengths on the pile layout. See the Pile Record base sheet's "Definition of Terms" for the method of calculating Required Field Bearing.

**SPAN DETAILS:** This section describes the items to include on superstructure plans in addition to those listed in "Reinforced Concrete Details" and "Structural Steel Details" above. Include the following items on span details:

- Framing plan
- Elevation view of girder and haunch or soffit geometrics
- Girder sections
- Slab Plan – detail bridge deck slabs from end to end. Do not use "Similar by rotating symmetrical about centerline of structure" or "Similar but opposite hand."
- Slab section, crown geometrics (parabolic crown)
- Elevation view of diaphragm
- Unless otherwise directed by the Director, Division of Structural Design, provide all stream crossings with an adequate deck drainage system. See the next section for details.

**DRAINS:** Do not place floor drains on spans directly over railroad tracks or over another highway unless special conditions warrant their use. When special conditions prevail, obtain approval from the Director, Division of Structural Design.

**ELASTOMERIC BEARING PADS:** Elastomeric bearing pads are preferred for all beam types. Unless design or geometric considerations indicate otherwise, provide bearing pads under PCI-Beams as indicated on Standard Drawing BBP-001, current edition. Provide bearing pads under box beams as indicated on Standard Drawing BBP-003, current edition. Use only rectangular bearing pads and place them under the girder perpendicular to the centerline of girder. Detail and dimension non-standard elastomeric bearing pads on the plans.

**STEEL SHOE BEARINGS:** Include on the plans material specifications, surface finish specifications, and an estimate of quantities with individual estimates of the weight of each assembly. Indicate the maximum allowable reaction capacity of each shoe. Shop drawings for the steel shoes are required.

**ANCHOR BOLT PLAN:** Show the size and location of the drilled holes for the entire bridge. On structural steel bridges, place the anchor bolts far enough outside the edge of the flange to allow the drilling of the anchor bolt hole after the girder is in place.

**HANDRAIL DETAILS:** Include the following items on handrail details:

- Material specifications
- Post spacing
- Estimate of quantities
- Where expansion joints are permitted in bridge decks, use open joints in plinths.
- Shop drawings for metal handrails are required.

**BARRIER CURB DETAILS:** Where expansion joints are permitted in bridge decks, use open joints in the barrier curbs.

**SLAB ELEVATIONS:** Show the following information on the **Construction Elevation Sheet**:

1) Plan view with longitudinal lines representing:
   a) beam or girder lines

   and with transverse lines representing:

b) centerlines of substructure units
c) end wall lines
d) other lines forming a grid spacing of approximately 8 feet.

The transverse lines for (b) and (c) above are always parallel to skew. The other transverse lines are perpendicular to the longitudinal lines or long chord if bridge is on a curve.

2) List elevations in tabular form for the top of slab at the intersections.

3) List elevations for the bottom of girder on cast-in-place reinforced concrete girders.

4) Detail of parabolic crown when applicable.

**CORNER REINFORCEMENT:** On skewed bridges with concrete end diaphragms, place additional reinforcement in a radial manner to eliminate diagonal cracks which form in the acute corners. See **Exhibit 315**.

**DECK SLAB OVERHANG:** Show the bottom of bridge deck slab overhang at exterior beams as level or parallel to cross slope. If the design requires a thicker section for the overhang, show this dimension on the plans.

**INSERTS:** Show on the plans the required minimum capacity of inserts, where used or allowed.

Do not use inserts in the ends of beams that are continuous at piers or where the ends are encased by at least 6” of concrete.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Content of Culvert Plans |

**GENERAL NOTES:** Place the General Notes on the title sheet for culverts.

**LAYOUT SHEET:** The layout sheet is mandatory for culverts. This article describes the items to include on the layout sheet. See **Exhibit 312** for an example of a typical culvert layout sheet.

Include the following items on the culvert plan sheet:

- Centerline of survey and tangent to curved centerline with compass bearing and advancing stations indicated
- Inlet, outlet, and total lengths dimensioned
- Station of culvert
- Skew angle
- North arrow
- Direction of stream flow
- Sounding locations, if necessary
- Proposed structure plan
- Slope protection limits

Orthographically project a longitudinal section from the culvert plan and include the following items:

- Sea level datum
- Culvert structure in section or elevation
- Datum elevations for each of the following:
  - Inlet invert
  - Outlet invert
  - Finished grade elevation at centerline of culvert
- Finished fill section over culvert
- Location of changes in type of culvert footings, steps, etc.
- Location of selected fill for bedding when necessary
- A list under the title of this section including:
  - Barrel opening height, width, and length
  - Foundation

- Skew
- Design loading
- Shoulder width
- Fill slopes.

**CULVERT DETAILS:** This article describes the items to include on culvert plans in addition to the details described above. Use scales such as may be read on 11” x 17” prints. Detail and dimension culverts sufficiently so that calculations for foundation layout by field personnel are unnecessary.

- Plan showing reinforcement in top and bottom slab
- Longitudinal barrel sections
- Typical and special transverse barrel sections
- Wing elevations, wing plans and wing sections
- Bill of Reinforcement.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Existing Structures |

**GENERAL:** When applicable, show reference to the existing structure as it relates to the new. This helps in determining whether wings can be constructed fully or if phased construction of the wings is required to avoid hitting the existing structure.

Except for culvert extensions, do not include any bid quantity for these items on the structure plans unless there are no roadway plans. Structure plans may reference the roadway plans for these items.

**REMOVAL OF STRUCTURES OUTSIDE EXCAVATION LIMITS:** Remove existing structures of any size or description that lie outside the excavation limits for the new structure in accordance with Section 203 of the Standard Specifications. Note if an existing steel bridge requires match marking (generally not required). Reference the removal of an existing structure and the pay items for removing the existing structure in the General Summary Sheet and not on the Bridge and Culvert Summary Sheet. Notes for the removal will appear on the roadway plans.

**REMOVAL OF PIPE:** Remove concrete or metal pipe in accordance with the roadway plans.

**REMOVAL OF CULVERT:** Payment for removal of a culvert with a clear span of less than 20 feet (measured along centerline of roadway) is incidental to the contract. Payment for removal of a culvert with a clear span of 20 feet or more (measured along centerline of roadway) is Lump Sum Bid for removal of existing structure.

**CULVERT EXTENSIONS:** Payment for removal of concrete from an existing culvert to allow for an extension to tie in is included in the lump sum bid for Foundation Preparation. Include a plan note to this effect.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT<br>Subject<br>Use of Trade Names |
|---|---|

**USAGE:** Avoid the use of proprietary items or trade names, and wherever feasible, word the specifications to provide opportunity for competition among equivalent materials.

**EXCEPTIONS:** In exceptional cases where satisfactory specifications cannot be developed, the use of trade name designations is permitted, if at least three alternates are named and a provision made for other acceptable alternates.

**FHWA APPROVAL:** When proposing less than three trade-name type articles, obtain approval from the FHWA and submit this approval to the Division of Structural Design prior to submitting final plans. Submit the request for approval to FHWA as early as possible during plan development to allow ample time for FHWA review and approval.

| | | |
|---|---|---|
| **STRUCTURAL DESIGN** | Chapter | PLAN DEVELOPMENT |
| | Subject | Maintenance Inspection Manual |

Develop a Maintenance Inspection Manual for structures that have **unusual** maintenance requirements.

| STRUCTURAL DESIGN | Chapter<br>PLAN DEVELOPMENT |
|---|---|
| | Subject<br>Graphic File Standards |

**FORMAT:** Use the following procedures for any requested electronic transfer. The Transportation Cabinet's CADD format is **MicroStation** (.dgn).

**WORKING UNITS RESOLUTION:** Set the Working Units Resolution to 12000 units per foot.

**REFERENCE FILES:** Do not use reference files for the final design file.

**SHEET LOCATIONS:** Place sheets in a design file according to the sheet locations shown in **Exhibit 319**. Set the beginning coordinates for the sheet grid to 1000,1000 and space the sheets on a grid interval of 50 master units. Sheet size in design file units is 36 by 22. Organize the design file as follows:

| | |
|---|---|
| TIT | Title Sheet |
| GN1-GN3 | General Note Sheets |
| LAY | Layout Sheets |
| BC2, X1-X5 | Sounding Sheets |
| PL | Foundation Layout Sheet |
| A1A-A1C | Abutment #1 |
| P1-P4 | Piers |
| A2A-A2C | Abutment #2 |
| NJ1 | Framing Plan |
| PCI | Beam Details |
| 1SS-8SS | Superstructure Details |
| M1-M6, X6-X7 | Miscellaneous Details |
| CE | Construction Elevations |
| BC1 | Bridge and Culvert Summary |
| A1-K7 | Structural Steel Details or Additional Details |

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF<br>AASHTO SPECIFICATIONS |
|---|---|
| | Subject<br>General |

**REFERENCES:** This chapter lists Division of Structural Design policies and interpretations of Division I of the AASHTO Specifications on a paragraph-by-paragraph basis. The subjects in this chapter reference the AASHTO article by number.

**INCLUSIONS & OMMISSIONS:** The wording of the Specifications provokes many questions. These comments represent an attempt to answer some of the questions most frequently asked and to establish our preference where the wording of the Specification permits.

If an AASHTO article does not have a corresponding section in this chapter, then the Division of Structural Design does not have a specific policy relating to the article or the subject is covered elsewhere in this manual. Direct any questions regarding the interpretation of the AASHTO articles or the omission of any interpretation to the Director, Division of Structural Design.

**DIVISION I DESIGN:** These articles of the AASHTO Standard Specifications govern the design of structures for highway bridges and for highway drainage for the Department, unless the plan General Notes specifically provide exceptions.

**DIVISION II CONSTRUCTION:** With few exceptions (most notably bearings), Kentucky does not use AASHTO construction specifications.

**DESIGN ANALYSIS:** When proposing structures of such a special nature that Division I of the AASHTO Specifications is not adequate, submit an outline of AASHTO paragraph revisions and addendum to the Director, Division of Structural Design, for approval before proceeding with the design of the structure.

**2.7 RAILINGS:**

Use railings appropriate for the road class.

Use **Railing System Type I** (**Exhibit 614**) on culverts only.

Use **Railing System Type II** (Standard Drawing BDP-005) with "Railing System Type II Guardrail Treatment" (Standard Drawing BHS-007) on side-by-side box beam bridges and on short structures.

Use **Railing System Type III** (**Exhibit 601**) on all other bridges.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF<br>AASHTO SPECIFICATIONS |
| --- | --- |
| | Subject<br>Section 3 - Loads |

**3.3.3**
**FUTURE WEARING SURFACE:**

Provide a minimum of 60 psf. See **Section SD-501-1** for additional wearing surface requirements.

**3.3.5**
**WEARING SURFACE:**

Consider the top ½ inch of the slab as the wearing surface.

**3.7.4**
**MINIMUM LIVE LOAD:**

Design all new structures for HS 25* loading. Use HS 25 loading for fatigue design. Design the following road classifications for the alternate military loading specified in Article 3.7.4.

- Interstate Highways
- Roads with ADT greater than 1500
- Roads with DHV greater than 200
- Roads carrying heavy coal truck traffic

*NOTE: Calculate HS 25 loads by increasing the standard AASHTO HS 20-44 truck and lane loads by 25%.

**3.14.3**
**RAILING LOADINGS:**

For Railing System Type III, design for P = 8.5 kips.

**3.15**
**WIND LOADS:**

Use a wind velocity of 100 miles per hour for bridge design in Kentucky.

**3.15.2.1.3**
**SPAN LENGTH FOR WIND:**

Loads in this section may be used for bridges with spans up to 200 feet in length.

**3.16**
**THERMAL FORCES:** For temperature ranges, consider Kentucky a cold climate using a median temperature of 60 degrees Fahrenheit.

**3.17**
**UPLIFT:** Obtain the approval of the Director, Division of Structural Design, before recommending a structure with uplift.

**3.18**
**FORCE OF STREAM CURRENT, FLOATING ICE AND DRIFT:** Conditions must be extraordinary for these forces to control the design. Lacking a stream velocity from a geological survey report or from Design Summary Sheet TC 61-100, use approximately 10 feet per second.

**3.20**
**EARTH PRESSURE:** Determine lateral pressures by using the methods shown in NAVFAC DM-7.2, MAY 1982, Chapter 3. Figures 16 and 17, which apply to walls of less than 20 feet in height, appear in **Exhibit 413**. When using **Exhibit 413**, assume soil type 3 unless a special backfill is specified or the subsurface investigation report states differently. Apply pressure to twice the column width for open column frames when the aspect ratio of depth to width is three or more. Also double the pressure on portions of piers above natural ground line extending through man made fills which may likely shift or move.

**3.21**
**EARTHQUAKES:** Design structures to resist earthquake motions in accordance with the AASHTO Specifications for Seismic Design of Highway Bridges. See **Exhibit 401** for Acceleration Coefficients to use in Kentucky.

**3.23**
**CURVED GIRDERS:** Design curved girder bridges in accordance with the current edition of the AASHTO Guide Specification for Horizontally Curved Highway Bridges, when applicable. Design bridge members based on a rational analysis of the entire structure which takes into account the complete distribution of loads to the various members. Section 1.4 of the Commentary to the Guide Specifications lists several available methods of analysis for curved I-section girders. Other methods may be

used, but verify the applicability and suitability of the method to their particular structure.

Except for curved girder bridges, do not use methods of analysis other than the empirical method described in this article without approval from the Director, Division of Structural Design. In no case shall any beam have less load carrying capacity than if it were designed for HS20 and the empirical method.

**3.24.1**
**SPAN LENGTHS:** Apply the provisions of 8.8.2 to haunched slabs 45 degrees or steeper. For flatter slab haunches, use Article 3.24.1 neglecting the haunch, or use a more rigorous frame analysis. For RCBC, see **Section SD-505-2**. For slabs supported on prestressed concrete box beams or AASHTO Type I through Type IV PCI beams, S = Clear Span.

**3.24.5**
**CANTILEVER SLABS:** These requirements apply to slab overhang design.

**3.24.8**
**LONGITUDINAL EDGE BEAMS:** This requirement applies for slab bridges and culverts at grade.

**3.24.9**
**UNSUPPORTED TRANSVERSE EDGES:** Support the slab at transverse joints in either steel or concrete framed bridge spans when slab structural continuity is broken. The requirement for diaphragm design from wheel loads applies only where slab continuity is broken and does not apply at slab construction joints where the reinforcement is continuous through the joint.

**3.24.10**
**DISTRIBUTION REINFORCEMENT:** Use AASHTO percentages as specified in bottom of slabs. Use, additionally, half of that percentage in top of slabs. Satisfy shrinkage and temperature reinforcement provisions of 8.20 in top and bottom. If the bridge is continuous requiring negative-moment longitudinal reinforcement in the top of slab, consider using this steel as part of the temperature and distribution reinforcement required in the top of the slab.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF<br>AASHTO SPECIFICATIONS |
|---|---|
| | Subject<br>Section 4 - Foundations |

**4.1**
**METHOD:**

Check stability and bearing pressures using the Service Load Design Method. For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**4.2**
**FOUNDATION TYPE:**

The Geotechnical Branch provides a **Geotechnical Engineering Report** to assist in determining the type of foundations to study.

Competent rock for bearing is available in most areas of Kentucky. For spread footings on rock (shallow or deep), the Geotechnical Report includes the allowable bearing capacity of the rock.

When competent rock is unavailable, or the depth to competent rock is excessive, use piles or drilled shafts to transfer the bridge loads to deep rock or to the surrounding soil. Normally, use point-bearing piles to transfer the bridge loads to deep layers of competent rock. Where point-bearing piles are not appropriate, use friction piles or drilled shafts. The Geotechnical Report includes an anticipated pile tip elevation for point-bearing piles. For friction piles, the Geotechnical Report includes charts or graphs to assist in selecting the pile type and in estimating the pile length.

For simple span bridges on dry crossings only, consider using spread footings on earth foundations. When considering an earth foundation, a more detailed geotechnical investigation is necessary. The Geotechnical Branch conducts field drilling and sampling combined with laboratory testing to assist in determining the bearing capacity of the soil. Bearing capacity is a function of the unconfined compressive strength for cohesive or fine-grained soils such as silt and clay. For cohesionless or coarse-grained soils, such as sand and gravel, bearing capacity, if based on the relative density, is estimated from the "N" count as obtained from a Standard Penetration Test of the soil.

**4.4.7 GEOTECHNICAL DESIGN ON SOIL:** B/6 may be factored by the percentage of the basic unit stress given in Table 3.22.1A when checking the location of the resultant.

**4.4.8 GEOTECHNICAL DESIGN ON ROCK:** B/4 may be factored by the percentage of the basic unit stress given in Table 3.22.1A when checking the location of the resultant.

**4.5.1 DRIVEN PILES:** See **Section SD-504**.

**4.5.1.3 PENETRATION:** Note minimum allowable penetration:

Hard Material – 10 feet
Soft Material – 20 feet

Since material at stream crossings is generally saturated and soft, use a minimum allowable penetration of 20 feet. At grade separation structures, the minimum 10-foot penetration may be applied in suitable materials. Fill material is considered soft material. Use a minimum length of pile of 10 feet. Note requirement for piles to penetrate hard material a sufficient distance to rigidly fix the ends. At abutment locations where the distance from original ground line to rock is not sufficient to adequately fix the pile ends or where other strata is present which would prevent driving of piles, consider using one of the following substructure types in lieu of traditional Pile Bent Abutments: Open Column Abutments, Breastwall Abutments, or Pile Bents constructed by driving piles into a rock-socketed, pre-drilled hole filled with sand.

**4.5.1.8 TEST PILES:** Static load test value is 200% of design value. Driving formula value is 125% of design value.

**4.5.2.4**
**BATTER PILES:** See **Section SD-504-1**, “Batter”.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF AASHTO SPECIFICATIONS |
| --- | --- |
| | Subject<br>Section 5 – Retaining Walls |

**5.1**
**GENERAL:**

When a wall frames into a supporting structure, such as at a culvert headwall, and such that the overturning is resisted by the headwall, calculate the design height of the wall as the height where a 45-degree line (beginning where the wall meets the supporting structure) intersects the top of the wall. See **Exhibit 514**.

Maintain a factor of safety of 1.5 against overturning and sliding.

**5.5.6**
**STRUCTURE DESIGN:**

Design individual wall elements by the **Load Factor Design** Method. For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**5.5.6.1**
**BASE OR**
**FOOTING SLABS:**

Design the rear projection to support the vertical component of the soil pressure due to sloping backfill. This component may also be used in computing the factor of safety against overturning.

| STRUCTURAL DESIGN | Chapter: INTERPRETATION OF AASHTO SPECIFICATIONS |
|---|---|
| | Subject: Section 6 - Culverts |

**6.2.1 TRENCHED OR UNTRENCHED YIELDING:** Before designing a structure for the trench condition, obtain approval from the Director, Division of Structural Design.

**6.2.2 UNTRENCHED UNYIELDING:** When a RCBC is rigidly supported on rock and is untrenched, design according to the following parameters:

Distribute a uniform load P1 in psf, equal to 84 pcf * H, over design span L1. Supplement this uniform load P1 by two additional uniform loads P2. The value of P2 in psf is equal to [(120 pcf * K1 * K2 * K3) – 84 pcf] * H. See **Exhibit 403** for locations of load P2 and design span L1. H is equal to fill height over culvert. Interpolate the values of K1, K2, and K3 from graphs on **Exhibit 404**.

Check shear at the distance 1/12 the clear width of culvert, or "d" depth of the slab, measured from the inner face of the vertical wall, whichever is closer to the face of the wall.

The moments and shears calculated shall not be less than those calculated when using a uniform load of (120 pcf * H) distributed over design length "L1".

The loads shown above are based on Research Report UKTRP-84-22. Note that checking shears at the distance L2/12 is intended to be applied only with the loading proposed by UKTRP-84-22 and applies only to slab shear at exterior walls. Check slab shear at interior walls at distance "d".

**6.4.2 DISTRIBUTION OF WHEEL LOADS THROUGH EARTH FILLS:**

Measure the "total width" (in first sentence) at 90 degrees to centerline roadway.

See AASHTO Article 3.8.2 for impact factors for fill depths less than 3 feet. When the depth of fill exceeds both 8 feet and the distance between sidewalls, the effect of live load may be ignored.

Apply to the sidewalls a lateral live load equal to half the vertical load on the top slab.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF AASHTO SPECIFICATIONS<br>Subject<br>Section 7 - Substructures |
|---|---|

**7.3 PIERS:**

Proper pier design often involves frame analysis and complex strength computations. Of major importance in pier design, however, is the exercise of good judgment.

Use **webwalls** to eliminate drift traps from 2 feet below ground or normal pool to 2 feet above the 100-year flood.

Some rules-of-thumb for rapid pier design are as follows:

- Maintain L/b less than 12 for columns.
- Footing depth equals or exceeds column width.
- Footing overhangs column sides by approximately footing depth to 2/3 depth or less.
- Footing length for expansion piers or short span fixed piers equals 1/5 pier height.
- Footing length for most fixed piers equals 1/4 pier height.

**7.5 ABUTMENTS:**

See **Exhibit 405** for detailing practice for Open Column Abutments. Compute earth pressure on twice the area of the rear face of Open Column Abutment columns to allow for friction on the long side. In general, use solid Breastwall Abutments rather than the Open Column type.

The design of abutments except integral abutments includes, but is not limited to, the three loading conditions which follow:

1) **Surcharge, No Span:** The approach embankment complete to the top of the parapet elevation with 2 feet of surcharge to allow for construction equipment. No Superstructure component in place. Design for a factor of safety against overturning of 1.25.

2) **Surcharge, Span DL:** Completed approach embankment plus 2 feet of surcharge, and the span in place, considering dead load only. Design for a factor of safety against overturning of 1.5.

3) **No Surcharge, Span DL + LL:** Completed approach embankment with no surcharge. Span in place, considering dead load and live load. Design for a factor of safety against overturning of 1.5.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF<br>AASHTO SPECIFICATIONS |
|---|---|
| | Subject<br>Section 8 – Reinforced Concrete |

**8.2**
**CONCRETE:**

a) Class "A" f`c = 3500 psi
for culverts, bridge substructures and retaining walls.

b) Class "AA" f`c = 4000 psi
for bridge superstructures and slabs.

**8.3**
**REINFORCEMENT:**

If field bends are required, use the smallest bars practical. In some cases, specify Thermex treated bars.

**8.14.1**
**METHOD:**

Design all reinforced concrete members by the strength design method (**Load Factor**). For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**8.16.8.4**
**DISTRIBUTION OF FLEXURAL REINFORCEMENT:**

The quantity z in equation 8-61 equals 170 kips/inch in most concrete members, except in concrete bridge decks and in buried concrete structures.

The quantity z equals 130 kips/inch in concrete bridge decks.

The quantity z equals 98 kips/inch in cast-in-place RCBC. For culvert wings, use 170 kips/inch.

**8.19**
**SHEAR REINFORCEMENT:**

Consider the stems of breastwall abutments and retaining walls as slabs for determining minimum shear reinforcement.

**8.22**
**PROTECTION**
**AGAINST CORROSION:** See **Section SD-501-1** for “Bridge Deck Corrosion Protection”.

**8.23**
**HOOKS AND**
**BENDS OF**
**REINFORCEMENT:** See CRSI Manual of Standard Practice for Detailing Practices. For Kentucky Standard Details, see **Exhibit 406**.

**8.32.1**
**LAP SPLICES:** Design pier column splices as Class C splices. Add 12 inches to design length of dowel bar when pier footing is founded on rock to allow for adjustment of footing elevation during construction.

**8.32.2**
**WELDED SPLICES**
**AND MECHANICAL**
**SPLICES:** Use welded splices only with written approval from the Director, Division of Structural Design.

| STRUCTURAL DESIGN | Chapter<br>INTERPRETATION OF AASHTO SPECIFICATIONS |
| --- | --- |
| | Subject<br>Section 9 – Prestressed Concrete |

**9.2 CONCRETE:** Limit the compressive strength to 8000 psi maximum.

**9.3.1 PRESTRESSING STEEL:** Design prestressed beams using ½ inch nominal diameter, 270-grade uncoated seven-wire low-relaxation strand, AASHTO M203, with stress-relieved strand allowed as an alternate. Use other strand sizes and grades only with approval from the Director, Division of Structural Design. Minimum allowable strand spacing is 2 inches.

**9.13.1 METHOD:** For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**9.16.2.1.2 ELASTIC SHORTENING:** Calculate tendon relaxation during placing and curing of the concrete for normal ½ inch strands by the following equation:

Loss = [LOG(T)/A][(FSI/FY)-0.55][FSI]

Where

T = Time in hours between stressing and release (usually taken as 18 hours)

A = 45 for low-relaxation strands
  = 10 for stress-relieved strands

FSI = Jacking stress

FY = 0.90 (catalog ultimate) for low-relaxation strands
  = 0.85 (catalog ultimate) for stress-relieved strands

For strands other than ½ inch nominal diameter, calculate the loss from loss-time curves available from the manufacturer of the strand.

**9.17 FLEXURAL STRENGTH:** Check ultimate capacity at the tenth points. Reduce F*su if adequate development length is not available.

**9.22 PRETENSIONED ANCHORAGE ZONES:** For purposes of this article, total prestress force equals the prestress force at release (i.e. Jacking Force - Elastic Shortening - Tendon Relaxation During Placing and Curing of Concrete).

**9.23 CONCRETE STRENGTH AT STRESS TRANSFER:** Limit the concrete strength at stress transfer to 6000 psi maximum.

**9.28 EMBEDMENT OF PRESTRESSING STRAND:** Per FHWA memo dated October 26, 1988, development length for prestress strand equals 1.6 times AASHTO equation 9-42. For debonded strands use the 2.0 factor given in AASHTO 9.27.3.

**10.2.2**
**STRUCTURAL STEELS:** AASHTO designation M270 Grade 50W (unpainted weathering steel) is the basic structural steel recommended for use in Kentucky's steel bridges.

Use AASHTO M270 Grades 50, 70, 70W, 100 and 100W only with approval of the Director, Division of Structural Design.

**10.3.1**
**ALLOWABLE**
**FATIGUE STRESS:** Design the main load carrying bridge members as continuous and redundant, i.e., multi-girder (three or more girders). Use non-redundant main load carrying bridge members only with the approval of the Director, Division of Structural Design. Design all non-redundant steel bridge members in accordance with the AASHTO publication, "Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members."

Use Category E Details only with approval from the Director, Division of Structural Design.

**10.3.3**
**CHARPY**
**V-NOTCH**
**REQUIREMENTS:** Design the main load carrying members of steel bridges, subject to tensile stresses, according to the supplemental requirements for notch toughness (zone 2).

Designate these tensile members, including flanges, webs, and splice plates, on the plans by "CVN" with an explanation of these letters on the sheet.

**10.13**

**COVER PLATES:** Use welded cover plates only with approval from the Director, Division of Structural Design.

**10.14**
**CAMBER:** Rolled beams may be heat cambered only with the approval of the Director, Division of Structural Design. Camber plate girders to accommodate dead load deflections and vertical curves, when present. Show blocking diagrams on the plans when the bridge is in a vertical curve.

**10.15**
**HEAT-CURVING:** Design rolled beams and welded plate girders heat-curved to obtain horizontal curvature in accordance with AASHTO Guide Specifications for Horizontally Curved Highway Bridges. Do not heat curve normalized or quenched and tempered steels.

**10.18**
**SPLICES:** In continuous spans, locate field splices at or near points of dead load contraflexure.

**10.18.5**
**WELDED SPLICES:** Use welded field splices only with approval from the Director, Division of Structural Design.

Approximately 500 pounds to 700 pounds of flange material should be saved before specifying a welded butt splice in a flange plate. Use a minimum length of 20 feet between splices for flange plates in most cases. Avoid splicing flanges of different widths.

Transition materials of different widths and thicknesses, spliced by butt welds, according to AASHTO 10.18.5.5, except when there is more than ½ inch difference in plate thickness or 4 inches in plate width. Under these conditions, use a 4:1 plate taper to increase fatigue strength.

At butt weld splices that join material of different thickness, limit the thickness of the thicker plate to 1.75 to 2.0 times the thickness of the thinner plate. See the section below on AASHTO Article 10.23, “Welding, General.”

**10.20**
**DIAPHRAGMS AND CROSS FRAMES:** Place diaphragms or cross frames at each end support and throughout the span at 25-foot maximum centers.

Preferably, locate diaphragms adjacent to a field splice between the splice and the pier. Cross frames are not required at the piers on continuous units. See **Exhibit 409** for intermediate diaphragm details. Concrete diaphragms are preferred as end diaphragms. For concrete end diaphragms, provide a 6-inch minimum end cover and 1-inch diameter holes in the girder web to provide for continuous front-face diaphragm reinforcement.

Place all intermediate diaphragms and cross frames at right angles to the girders. Where two adjacent girders are not parallel, place the diaphragms and cross frames at right angles to one of the girders, if feasible.

To prevent development of fatigue cracking in the webs, give special consideration to the connection between the floor beams and the main girder for two-girder system bridges.

If the deck of the superstructure is superelevated at a rate greater than 0.02 ft/ft, place the end diaphragms on a constant slope across the structure. In such cases, do not step the end diaphragm, which supports the drop slab, at the end of the concrete deck. Such steps are difficult to form, and the abrupt change in section could introduce cracking in the concrete deck.

**10.21**
**LATERAL BRACING:**

Investigate the need for lateral bracing for all simple or continuous spans. On continuous spans, provide lateral bracing only in those spans that require lateral bracing. For details, see **Exhibit 411**.

**10.23**
**WELDING, GENERAL:**

Design all welds according to ANSI/AASHTO/AWS Bridge Welding Code, current edition and Department of Highways Special Provision No. 4, current edition.

Welding that uses base metal materials and processes not covered by these specifications requires approval by the Director, Division of Structural Design, prior to the design of the project.

Use General Notes or Special Provisions to specify construction-related exceptions to the ANSI/AASHTO/AWS Specifications.

Design-related exceptions to the ANSI/AASHTO/AWS Specifications are as follows, by paragraph:

(2.17.6) GIRDERS AND BEAMS

Design plate girders (built-up I-sections) with one plate in each flange, i.e., without cover plates. Vary the thickness and width of a flange by butt welding parts of different thickness or width with transitions conforming to AWS 2.17.5, except when there is more than ½ inch difference in plate thickness or 4 inches in plate width. Under these conditions, use a 4:1 plate taper to increase fatigue strength. Limit the thickness of the thicker plate to 1.75 to 2.0 times the thickness of the thinner plate.

**10.24 FASTENERS:**

Use high strength bolts of equal diameter in field connections. Use one-inch diameter bolts unless design constraints require a different diameter bolt. Use DTI's for all high strength connections.

In the design of **slip-critical joints**, consider the contact surface of a bolted part a Class "A" coating with a slip coefficient of 0.33. Use Class "B" and "C" contact surfaces only with written approval from the Director, Division of Structural Design. Indicate on the plans the joints designed as slip critical and the slip coefficient used. If a Class "B" or "C" contact surface is used in the design, note on the plans the requirement for test data on the coating system to verify that it meets the design slip coefficient.

**10.29.1 BEARINGS:**

When curved bearing plates are used, curve the top plate to avoid creating a wedge action that would allow a span to slip down grade. Preferably, use elastomeric bearing pads as expansion bearing devices on steel structures as well as on concrete structures.

**10.29.2 BRONZE OR COPPER ALLOY SLIDING PLATES:**

Use this type expansion device primarily on widening or rehabilitation projects to match existing bearing devices.

Self-lubricating plates with bronze castings (B22) are recommended.

**10.29.5**
**MASONRY BEARINGS:** Be aware that debris collecting on abutment seats holds moisture and can cause damage to bearing devices and girder flanges.

**10.29.6**
**ANCHOR BOLTS:** Design and detail bearing devices to permit pneumatic drilling into the concrete bridge seat for placing the anchor bolts after the structural steel has been erected and adjusted to position. Specify non-shrink grout to bond anchor bolts in drilled holes.

| STRUCTURAL DESIGN | Section<br>Section 10 – Structural Steel<br>Subject<br>Part C |
|---|---|

**10.31**
**METHOD:**

Use **Load Factor Design** for the design of main members wherever the AASHTO Specifications allow this option. For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**10.34**
**PLATE GIRDERS:**

Because of economics, do not consider haunched girders until span length exceeds 300 feet.

**10.34.2**
**FLANGES:**

The minimum allowable thickness for flange plates in welded plate girders is ¾ inch. Make thickness changes at field splice points when possible.

**10.34.3**
**THICKNESS OF WEB PLATES:**

The minimum allowable thickness of web plates in welded plate girders is 3/8 inch. Make thickness changes of web plates at field splice points when possible.

**10.34.4**
**TRANSVERSE INTERMEDIATE STIFFENERS:**

The minimum allowable thickness of transverse intermediate stiffeners is 5/16 inch. Use transverse intermediate stiffeners in pairs, with one stiffener fastened on each side of the web plate, or with a single stiffener fastened to one side of the web plate. Place transverse stiffeners normal to flange. See **Exhibit 410** for details.

When using transverse intermediate stiffeners as connecting plates for cross frames, weld the stiffener to both flanges and investigate the flange stress at that location for fatigue under Category C.

See **Exhibit 409** for cross frame details.

Generally, design girder webs as partially stiffened.

To determine which is more economical, assume that 12 inches of weld (one stiffener fillet welded both sides) equals the cost of 40 pounds of structural steel.

**10.34.5 LONGITUDINAL STIFFENERS:**

Use longitudinal stiffeners only with approval from the Director, Division of Structural Design. If longitudinal stiffeners are necessary, provide similar treatment as for transverse intermediate stiffeners. Do not splice longitudinal stiffeners. Terminate stiffener to web welds at a point six times the web thickness from a vertical stiffener to web weld, and clip the longitudinal stiffener.

**10.34.6 BEARING STIFFENERS:**

Do not weld bearing stiffeners to either flange on rolled beams or welded plate girders, except as indicated hereafter. Mill bearing stiffeners on the bearing end and provide a tight fit on the other end. Detail bearing stiffeners as plumb.

Weld the bearing stiffeners to both flanges when using these stiffeners as connection plates for cross frames or diaphragms.

See **Exhibit 410** for details.

**10.38 COMPOSITE GIRDERS:**

Design structural steel bridges composite. Erect beams without temporary shoring to eliminate the possibility of dead load acting on the composite section.

When the concrete slab in a simple span is poured in multiple pours, advance the pours from the middle of the span outward toward the supports.

When the concrete slab in a continuous span is poured in multiple pours, advance the pours from points of low dead load shear toward points of high dead load shear.

Achieve closer control over dead load camber by completing the slab pour for a single simple composite span or by completing the slab pour for a multi-span continuous composite unit prior to final set of the concrete in a single day's operation. (250 cubic yards is the average amount that can be placed in one day.)

If proper slab pouring sequences are observed, computed deflections will approximate actual deflections.

**10.38.1.7 CONSTRUCTION LOADING:** Add 10% of the concrete dead load to allow for weight of forms when computing steel dead load stress. Do not assume that the concrete slab supports the steel flange when computing the allowable steel compressive dead load stress. For most cases a concentrated load of 5000 pounds is sufficient to account for the effects of screed machines and live loads during the pouring operation. Note that pouring procedures can cause girder stresses due to wet concrete on portions of the structure to be significantly greater than girder stresses due to wet concrete on the entire structure.

**10.38.2 SHEAR CONNECTORS:** For the usual composite design, use ¾ inch round stud shear connectors, a minimum of 4 inches long. However, excessive fillet heights may dictate the use of a longer stud. In all cases, extend the top of the stud a minimum of 2 inches above the bottom of the deck slab. Show a detail similar to the one shown on **Exhibit 412** on the plans.

In continuous wide flange beams and plate girders, use composite design in negative moment areas.

**10.39 COMPOSITE BOX GIRDERS:** Because of fabrication costs, box girders are usually not economical. Use this type of structure only with approval from the Director, Division of Structural Design.

| STRUCTURAL DESIGN | Section: Section 10 – Structural Steel<br>Subject: Part D |
|---|---|

**10.42 METHOD:** Use **Load Factor Design** for the design of main members wherever the AASHTO Specifications allow this option. For all new designs begun after October 1, 2007, use Load and Resistance Factor Design (LRFD).

**10.48.5 TRANSVERSELY STIFFENED GIRDERS:** See **Section SD-410-2** for AASHTO Article 10.34.4.

**10.48.6 LONGITUDINALLY STIFFENED GIRDERS:** See **Section SD-410-2** for AASHTO Article 10.34.5.

**10.48.7 BEARING STIFFENERS:** See **Section SD-410-2** for AASHTO Article 10.34.6.

**10.50 COMPOSITE SECTIONS:** See **Section SD-410-2** for AASHTO Article 10.38.

**10.51 COMPOSITE BOX GIRDERS:** See **Section SD-410-2** for AASHTO Article 10.39.

**10.52 SHEAR CONNECTORS:** See **Section SD-410-2** for AASHTO Article 10.38.2.

**14.6.5.1**
**TAPERED PADS:**

In steel reinforced elastomeric bearings, a **tapered top cover layer** may be used when necessary, but preferably slope the cap of the substructure. When using tapered layers, check the bearing based on the least favorable rubber thickness coupled with the least favorable shear modulus for the durometer hardness specified in the plans, as follows:

- Allowable Compressive Stress – use the thicker rubber layer with the lowest shear modulus
- Allowable Horizontal Movement – use the thinner rubber layer
- Allowable Rotation – use the thinner rubber layer with the highest shear modulus (as with non-tapered bearings, the pretensioned girder rotation associated with camber may be considered as acting to cancel the rotations associated with the application of subsequent loads)
- Anchorage Requirements – use the thinnest rubber layer and the highest shear modulus
- Shear Forces Transferred to the Substructure – use the thinnest rubber layer and the highest shear modulus.

Limit the plan dimensions of the bearing to the plan dimensions provided for non-tapered elastomeric bearings shown in the standard drawings. Limit the number of different bearing geometries used on a project as much as possible.

For bearings tapered greater than 4.5%, provide positive restraint of the beam to prevent slippage of the beam down grade.

Dimension bearings to the nearest thousandth of a foot.

Manufacturers must fabricate bearings within tolerances allowed in the specifications.

Check beam clearances at the edge of cap at all substructure units to provide a minimum ½ inch clearance.

For steel girder bridges on grade, in lieu of tapered layers of elastomer, tapered top bearing plates may be used to provide a uniform distribution of pressure on the surface of the bearing and accommodate the bridge grade.

When calculating rotation, use a single truck load for live load rotations.

<table>
<tr><td rowspan="2">STRUCTURAL DESIGN</td><td>Section<br>BRIDGE SUPERSTRUCTURE</td></tr>
<tr><td>Subject<br>Slabs</td></tr>
</table>

The purpose of this chapter is to outline preferred structural relationships, proportions, and details. It is not intended to be a definitive guide to design, and alternates to these preferences may be considered. Approval may be granted by the Director, Division of Structural Design for an alternate demonstrated to be beneficial.

**DEPTH:** The minimum allowable Class "AA" slab depth is 8 inches for slabs with epoxy-coated reinforcement.

**REINFORCEMENT COVER:** For Class "AA" concrete slabs, provide a minimum cover of 2 ½ inches and use epoxy-coated reinforcement.

**WEARING SURFACE:** Deduct a ½ inch design wearing surface when designing slabs and girders.

**GENERAL NOTE:** Designate the type of concrete in the general notes.

**POURING SEQUENCE:** Provide on the plans a pouring sequence for the slab when the slab contains more than 250 cubic yards of concrete.

**CANTILEVER DESIGN:** Check the cantilever portion of the deck using the reinforcement from normal bridge deck design. If this reinforcement is inadequate to carry the cantilever loads, add additional reinforcement to the cantilever portion. Do not thicken the cantilever slab beyond normal deck thickness unless absolutely necessary. A research report in TRB's Transportation Research Record 950 indicates that the horizontal railing load may be reduced by 15% due to edge stiffening when the bridge deck has a continuous barrier curb. Therefore, when checking the reinforcement in the deck cantilever, reduce the horizontal load by 15%.

**BRIDGE DECK CORROSION PROTECTION:** The **standard** system of corrosion protection for new cast-in-place decks is to construct the slab with "AA" concrete, epoxy-coated reinforcement (top and bottom mats), and provide 2 ½ inches minimum cover for the top mat of reinforcement.

Consider additional levels of protection such as corrosion inhibiting admixtures, exotic overlay materials, high performance concrete, shrinkage compensating cement, etc. for use on **critical structures**. A critical structure is defined as a structure whose size, design, location or importance to the transportation network would create unusual owner and/or user costs if its use were restricted for deck repairs. Examples of critical structures include high volume facilities, major stream crossings, precast segmental concrete bridges, cast-in-place box girder bridges, etc. Determine the extent of protection on a project-by-project basis.

**DESIGN FOR BRIDGE DECK REPLACEMENT:**

Design all bridge decks to be replaced under traffic.

For post-tensioned segmental girders, cast-in-place box girders, cable stayed structures or other special considerations, design the structure for 100 psf future wearing surface. The Director, Division of Structural Design, decides this on a project-by-project basis.

**EPOXY-COATED REINFORCEMENT:**

In any case where epoxy-coated reinforcement is used in the deck, specify it in all locations in the superstructure where Class "AA" Concrete is specified. (See **Section SD-502** for "Epoxy Coating in Substructure.") Indicate epoxy-coated bars on the plans by adding the suffix (e) to the bar designation in the Bill of Reinforcement table. Use straight bars in both top and bottom reinforcing mats in bridge decks. Do not hook ends of top transverse reinforcement unless required by design. Compute the quantity of epoxy-coated reinforcement steel separately as " Steel Reinforcement Epoxy Coated." Do not specify an application of linseed oil.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
|---|---|
| | Subject<br>Expansion Joints |

**JOINTS BETWEEN SLABS AND ABUTMENTS:**

Avoid joints between abutments and slabs when possible by using integral end bents or abutments without back walls. When required, design the joint between the bridge slab and the abutment backwall to accommodate the thermal movement of the bridge plus any anticipated abutment movement. To accommodate the movement of the backwall on structures that have pile bents, or abutments that are in an environment that might cause that backwall to move, add 1 inch (or more) to the opening required for thermal movement of the bridge.

**JOINTS BETWEEN SLABS:**

When the slab cannot be designed continuous, design the joints between spans to accommodate thermal movement.

**JOINTS FOR 4 INCHES OR LESS MOVEMENT:**

When an expansion dam is required for movements of 4 inches or less, use **preformed compression joint sealers** or **neoprene expansion joints**. Obtain current details and specifications from the Division of Structural Design. **Exhibit 501** shows the preformed compression joints required for certain combinations of expansion movement and skew. Obtain base drawings from the Division of Structural Design as full size plan sheets and include them in the structure plans. When a structure falls outside the limits of the chart, use a larger expansion dam.

**JOINTS FOR MOVEMENTS GREATER THAN 4 INCHES:**

When movements greater than 4 inches are predicted for a bridge expansion joint, specify a **steel finger expansion**

**dam**. Completely design and detail the steel finger expansion dams as the fully cantilevered type with no sliding parts in the roadway portion. Sliding plates may be used on sidewalks and barrier curbs. Use a trough under the finger expansion dam and slope it down from the gutterline to the centerline of bridge. Extend the trough or carry the water from the trough to the ground by pipes. Submit preliminary details for the expansion joint to the Division of Structural Design for approval. Use **modular joints** only with written approval from the Director, Division of Structural Design.

**UNSEALED EXPANSION JOINTS:** When the skew is greater than 45 degrees, consider using **unsealed sliding plate expansion dams**. However, use them only with the approval of the Director, Division of Structural Design. When using an unsealed expansion dam, (sliding plate or finger), make provisions on the bridge seat to keep deck drainage off the bearing devices. Specify corrosion inhibitor in the concrete for the backwall and abutment cap. Use epoxy-coated bars in the backwall and the abutment cap.

**BRIDGE DECK BLOCK OUT:** Block out the concrete bridge deck 10 feet from the end of the finger dam when using a finger dam. This provides better controls for installing the expansion joint.

**LENGTH CONTRIBUTING TO EXPANSION OR CONTRACTION:** For bridges with an even number of spans and all piers fixed, measure the length of bridge contributing to expansion or contraction from the centerline of the center pier to the end of the bridge. For bridges with an odd number of spans and all piers fixed, measure the length of the bridge contributing to expansion or contraction from the centerline of the center span to the end of the bridge. For highly unsymmetrical bridges, base expansion and contraction on a more detailed analysis considering the influence of pier heights, pier geometry, bearing types (i.e. bearing stiffnesses), and span arrangement.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
| --- | --- |
| | Subject<br>Structural Steel |

**PAINTING:** On painted steel bridges, use only Organic Zinc Primer. Specify this by plan note. Apply, repair, and remove paint on structural steel in accordance with the current edition Department of Highways Standard Specifications, Supplemental Specifications, Special Provisions and Special Notes. Direct all paint questions to the Director, Division of Structural Design, who coordinates with the Division of Construction’s paint section.

**WEATHERING STEEL:** Use Weathering Steel in **all steel structures** except grade separations or in urban areas where the steel is subject to salt spray. Widen existing steel bridges in-kind.

**BOLTED CONNECTIONS:** Specify mechanically galvanized bolts, nuts and washers for all bolted connections for painted steel structures. Specify **Direct Tension Indicators (DTI's)** for all connections. For painted structures, use mechanically galvanized DTI’s. For weathering steel structures, use weathering steel DTI’s. General Notes have been developed for this and placed in the General Note Library.

**GAP BETWEEN PLATES AT FIELD SPLICES:** With the increased usage of 1-inch diameter bolts, a problem has occurred with fit up between plates. For 7/8-inch diameter bolts, the dimension from the center of the splice to the first row of bolts has been 2 inches traditionally and has served adequately. When 1-inch diameter bolts are used, this dimension needs to be increased to 2 ¼ inches to accommodate the additional required edge distance.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
|---|---|
| | Subject<br>Intermediate Diaphragms |

**MATERIAL:** When spread box beam or PCI beam spans require intermediate diaphragms, use **steel diaphragms**. Do not use concrete diaphragms. Details may be obtained upon request to the Director, Division of Structural Design, or on the Division's website.

**LOCATION:** Place diaphragms at the midpoint of the beam for PCI beams with a length of 40 feet to 80 feet. For PCI spans longer than 80 feet, place diaphragms at the quarter points of the beams. Place diaphragms at the midpoint of the beam for spread box beam spans with a length greater than 80 feet when the clear distance between the beams is greater than 4 feet. For consistent detailing practice, consider the length of the beam along centerline of beam to arrive at the midpoint and quarter points.

**INSERTS:** Check the location of inserts on small skews and narrow beam spacings. If it is obvious that inserts may be too closely placed, consider eliminating the offset of the diaphragms to avoid fabrication congestion.

| STRUCTURAL DESIGN | Section: BRIDGE SUPERSTRUCTURE |
|---|---|
| | Subject: Spread PPC Beams |

**BASE SHEETS:** Base sheets for I-beams are available in Micro Station (.dgn) format and may be obtained on the Division's website. Detail box beams as closely as possible to the composite box beams used as concrete deck units.

**DRAPED STRANDS:** When draped strands are necessary in prestressed beams, locate the hold-down points as close to the center of the span as possible. Hold-down points located 5 feet either side of the center of the span give satisfactory results in most cases. Limit the vertical component of the prestress force at the hold-down points to 4 kips per strand or less so that the capacity of the hold-down devices will not be exceeded. This requires a slope on the draped strands flatter than 1:7 in most beams. Use debonded strands only with approval from the Director, Division of Structural Design.

**HAUNCH & CAMBER:** When determining bridge seat elevations, consider the camber of the beams, the vertical alignment of the roadway, the roadway cross slope and the effect of placing straight girders on curved alignments. A minimum haunch of 2 inches at the support is recommended. Girders that are stretched to their limits may require more. This consideration prevents most occurrences where the PCI-Beam intrudes into the bridge deck.

A new column has been added to the beam information on the PCI-Beam base sheets. This column, titled "**Maximum Allowable Camber**," takes into account the haunch, deflection assumed in construction elevations, effects of vertical curve, roadway cross slope, and the beam centerline not paralleling the roadway centerline. Notes on the elevation sheet have been revised to refer to this value. The purpose of this column is to assist the Resident Engineer in determining whether the grade needs to be adjusted due to excessive beam camber.

**MILD REINFORCING STEEL:**

When designing beams, investigate the beam camber and vertical geometry to provide 2 inches minimum **embedment of the stirrup bar**.

When designing spread box beams, note that the CRSI-recommended 180-degree pin **diameters for stirrup bends** may cause fabrication problems. To accommodate fabrication, the standard box beams use stirrup bend diameters for the 180-degree bends of bars. This may be done in spread boxes also, or the webs may be thickened to eliminate this problem. The prestress manufacturers indicate that they have no problem accommodating a thicker web.

Detail the reinforcing steel for spread box beams as plain instead of epoxy-coated except the stirrup bar extending into the bridge slab, which is epoxy-coated. This matches the details for PCI beam reinforcement.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
|---|---|
| | Subject<br>Side-By-Side PPC Deck Units |

**STANDARDS:** See Standard Drawings BDP-001 through BDP-013 for 48-inch wide box beams.

**NON-COMPOSITE BOX BEAMS:** Use the Standard Drawings for non-composite box beams only on projects where the current ADT is 400 or less.

On projects where the current ADT is 400 or more and the bridge carries heavy coal trucks or when the design speed is greater than 35 miles per hour, tie the units together more positively with a composite concrete deck.

Reference the Special Note for Corrosion Inhibitors on the Title Sheet.

**COMPOSITE BOX BEAMS:** The standard box beams with a composite concrete deck may be used on all roadway classifications when they are economically competitive with other types of bridges and when the geometry is compatible. Study bridges on vertical curves to determine the amount of slab concrete required. If an excessive amount of concrete is required, redesign the box girders, since the standard box beams were designed using a 5-inch cast-in-place concrete deck and a 1-inch haunch at the ends.

Epoxy-coat all reinforcement.

Develop a construction elevation sheet with a minimum of 3 lines of construction elevations (centerline and each fascia line) to maintain the proper grade and a minimum 5-inch deck slab thickness.

Calculate the quantity of Class “AA” Concrete in the composite concrete deck and include this quantity in the

Plan Estimate of Quantities. Place the cell “5SLAB” on the superstructure sheet. Place the cell “NCEBOX” on the elevation sheet. The cell library may be obtained upon request to the Director, Division of Structural Design, or on the Division’s website.

Construct the substructure bridge seat parallel to grade to obtain even bearing on the bearing pads.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
|---|---|
| | Subject<br>Bridge Deck Drains |

**SPACING & TYPE:** Space bridge deck drains to meet hydraulic considerations. Use one of the three types of bridge deck drains outlined in this section. A different type of drain may be used with the approval of the Director, Division of Structural Design, if conditions warrant.

**THROUGH-BARRIER DECK DRAINS:** Use through-barrier deck drains for bridges with concrete girders 4.5 feet deep or less and/or when aesthetics are a design consideration. See Standard Drawing BGX-015.

To prevent excessive concrete cover in the area of the drains, follow special procedures in detailing and placing the reinforcement. Bend down the transverse reinforcement about 12 inches from the gutterline to maintain adequate cover at the drain. When tying large diameter negative moment reinforcement to the transverse reinforcement, the entire top mat is forced down in this region causing excessive cover. To alleviate this problem, place the drains away from the pier, thereby placing the drain in an area where some of the negative moment reinforcement can be reduced. If longitudinal reinforcement larger than a number 5 bar can be eliminated between the gutterline and a line 12 inches from the gutterline, use through-barrier deck drains. Otherwise, use a metal drain through the deck.

**STEEL TUBE DECK DRAINS:** If through-barrier deck drains are not used, see Standard Drawing BGX-015 for details. These drains may also be used on steel girder bridges.

**CAST IRON OR STEEL DECK DRAINS:** Cast iron or steel deck drains are available for certain specific conditions. See **Exhibit 519** for details.

| STRUCTURAL DESIGN | Section<br>BRIDGE SUPERSTRUCTURE |
| --- | --- |
| | Subject<br>Miscellaneous |

**SUPERSTRUCTURE CONCRETE:**

Use **Class “AA” Concrete** in the design of all concrete bridge decks and cast-in-place girders. See **Section SD-408** for strength of Class "AA" Concrete. Use Class “S” or other high performance concrete only with written approval from the Director, Division of Structural Design.

**LONGITUDINAL JOINTS:**

The finishing machines now in use govern the maximum slab width without a longitudinal joint. Divide the bridge deck with a longitudinal construction joint or open joint when the slab width between gutter lines is greater than 86 feet. For skewed steel bridges, the maximum allowable slab width without a longitudinal joint is reduced. For example, a bridge skewed 45 degrees has a maximum allowable slab width of 86 feet * cos(45°) or 60.8 feet without a longitudinal joint.

Locate the open joint in the center of the bridge deck and space the supporting girders accordingly. If this is not possible, locate the joint outside the through-traveled lanes. If a situation occurs that does not meet the above criteria, consult the Director, Division of Structural Design.

Locate the longitudinal construction joint, whether generated by staged construction or by the criteria shown above, over the top of a beam.

Where significant deflections due to slab loads are anticipated, consider using two construction joints and a closure pour.

**STAY-IN-PLACE DECK FORMS (SIPDF):**

Precast Prestressed Concrete SIPDF **are not allowed** as a deck forming option.

Steel SIPDF may be used, provided that the valleys of the corrugations are filled with Styrofoam.

**BEAM CLEARANCES AT EDGE OF CAPS:**

Check beam clearances at the edge of cap at all substructure units. Some sharply skewed bridges on steep grades have had beams come into contact with the edge of the cap. Provide a minimum of ½ inch clearance from the bottom of beam to edge of cap.

**ABUTMENTS:**

See **Section SD-407** and **Exhibit 405** for Open Column Abutment detailing practice. In general, use solid Breastwall Abutments rather than Open-Column Abutments.

**PILE BENT ABUTMENTS:**

Pile Bent Abutments are generally more economical than Open Column Abutments on spread footings. Therefore, if there is a choice between the two types of abutment, choose the Pile Bent Abutment even if the number of piles to be driven is small.

Preferably, use Integral Pile Bent Abutments. Obtain current details from the Division of Structural Design. Embed piles a minimum of 2 feet into the pile cap.

Reference the following on the Title Sheet: Special Provision 69, “Embankment at Bridge End Bent Structures,” and Standard Drawings RGX-100 and RGX-105, “Treatment of Embankment at Bridge End-Bent Structures.” Calculate the quantity of Structure Granular Backfill needed at each Pile Bent Abutment.

**PIERS:**

See **Sections SD-603** and **SD-407** and **Exhibits 604 through 611**. In general, limit pier dimensions to multiples of 6 inches.

Maintain the **effective slenderness ratio**, kl/r, less than or equal to 100. Request written approval from the Director, Division of Structural Design, to exceed this limit. For piers with stepped or tapered columns, maintain the ratio no less than that which would occur in a constant section design with kl/r less than 100.

When extending column reinforcement into the cap, check the intersection of column reinforcement and bottom cap reinforcement to prevent conflict.

**PILE BENT PIERS:** See **Exhibit 611**. When placing a concrete webwall around the piles in a Pile Bent Pier, provide a minimum webwall thickness of 2 feet for 12-inch piles to allow for potential misalignment on driven piles.

When calculating the concrete quantity for a Pile Bent Pier with concrete piles, subtract the concrete volume that is displaced by the piles.

**SHEAR KEYS:** Specify Styrofoam as a bond breaker and form on top of shear keys on substructure caps.

**CAST-IN-PLACE RETAINING WALLS:** Provide **expansion joints** in continuous cast-in-place walls at about 100-foot intervals. Provide **contraction joints** at about 30-foot intervals. See **Exhibit 516** for typical details.

**MSE WALLS:** Do not use Mechanically Stabilized Earth (MSE) walls to support structures without permission of the Director, Division of Structural Design. MSE walls may be used for wings (see **Exhibit 517**).

**PEDESTALS:** Pedestals as detailed in **Exhibit 602** may be used on any pier type. When using shop-fabricated structural steel spans, use raised pedestal-type concrete bearing areas on piers and abutments. Raised pedestals permit grinding, without pocketing, in the bearing areas as an adjustment for errors made during substructure construction.

The minimum allowable height of the pedestal is 4 inches. If pedestal height exceeds 15 inches, consider sloping the pier caps. Where this is not practical, detail a joint in the pedestal 4 inches above the cap.

**EPOXY COATING IN SUBSTRUCTURE:** Use epoxy coating in the following cases:

- The dowel bars which extend from abutment or pier caps into the abutment or pier diaphragms and which fix the superstructure

- Pile Bent Abutment with backwall and expansion joint: all reinforcement, including reinforcement in wings

- Integral Pile Bent Abutments:  all reinforcement above bridge seat including any reinforcement that extends from cap into diaphragm

- Open Column Abutments with or without backwalls:  all reinforcement in the cap, wings and backwall (if used), except column reinforcement extending into cap

- Breastwall Abutments with a backwall:  all backwall reinforcement

- Pier caps under expansion joints:  all cap reinforcement above bottom of cap except column reinforcement extending into cap.

| STRUCTURAL DESIGN | Chapter<br>STRUCTURE DESIGN CRITERIA |
|---|---|
| | Subject<br>Drilled Shafts |

**POLICIES & DETAILS:** Contact the Director, Division of Structural Design, for the most current policies on design and detailing of drilled shafts. See **Exhibit 518** for general details. Do not utilize side friction when calculating drilled shaft capacity without the approval of the Director, Division of Structural Design.

**CLEARANCES & TOLERANCES:** Detail the Drilled Shaft to accommodate a construction tolerance on the location of the shaft of 3 inches. Maintain a constant diameter of the drilled shaft core steel from the bottom of the rock socket to just below the top of the cap or footing. Detail the longitudinal steel 6 inches clear to the sides of the rock socket.

For non-seismic design, detail the shaft spiral with a 6-inch pitch and design the shaft as a tied column (• =0.70). For seismic design, design and detail in accordance with AASHTO. Carefully consider the difficulties encountered on construction with a small spiral pitch and small bar spacings that result from too numerous longitudinal bars.

**THROUGH SOIL:** Where drilled shafts pass through soil, use permanent casing. Detail the inside diameter of the casing 6” greater than the rock socket diameter. When a column is continuous with the drilled shaft (as opposed to using a footing), detail the column diameter 6” less than the rock socket diameter and place a note on the plans requiring that the rebar cage be held centered in the rock socket and shifted such that it is at plan location at the bottom of the column.

**ROCK ONLY:** Where rock is close to the ground surface, columns may sit directly above drilled shaft rock sockets. In that case, detail the rock socket diameter 18 inches greater that the core steel diameter. Detail the column diameter 12 inches less than the rock socket diameter and place a note on the plans requiring that the rebar cage be placed at plan location.

| STRUCTURAL DESIGN | Section: PILE DESIGN |
|---|---|
| | Subject: General |

**SPACING:** Regardless of pile spacing dictated by the criteria outlined in the following paragraphs, space adjacent piles no closer than 3 times the pile size, center-to-center of piles.

**PILE POINTS:** Use pile points on all point-bearing piles and include General Note #162 on the plans. Indicate the required type of pile point on the foundation layout sheet.

**BATTER:** Use only vertical piles in integral abutments.

In abutments with two rows of piles, batter the front row 1 to 3. In abutments with only one row of piles (except integral abutments), batter every other pile 1 to 3. In abutments with three rows of piles, batter the front row 1 to 3 and the second row at a lesser batter. Batter piles in piers (maximum 1 to 3) to provide as stable a pier design as possible.

**DESIGN PILE LOAD:** Show the actual computed design pile load on the plans. This value equals the highest value obtained when all load combinations are factored to 100 percent.

**POINT-BEARING PILES:** When the subsurface exploration indicates that point-bearing piles are appropriate, use **steel HP 12x53, HP 14x73, or HP 14x89**. Base the pile size and arrangement on economics. When necessary to preclude overstressing the piles during driving, perform a Pile Driving Resistance Analysis as described below.

**FRICTION PILES:** Typically, use **Steel H-Piles**, although certain conditions may warrant consideration of **Precast Concrete Piles**. When using friction piles, base their design on two static analyses. The first analysis determines the design pile length required for permanent support of the structure. The second analysis determines the soil resistance to be overcome during driving to achieve the estimated length.

The results of these analyses may be provided by the Geotechnical Branch or by a geotechnical consultant, or the designer may perform the analyses based on the results of an adequate geotechnical investigation of the site.

**PILE LENGTH ANALYSIS:**

The predicted ultimate capacity (Safe Bearing Value) of all driven piles equals the sum of the skin resistance and point resistance of the pile. When determining the pile length, ignore the skin resistance in all soil layers not considered suitable for permanent pile support. To minimize settlement, ignore skin resistance in soft to medium stiff clay layers. Ignore skin resistance above and including any compressible soil layers. In all cases, drive friction piles to bearing in layers unaffected by negative skin friction.

**PILE DRIVING RESISTANCE ANALYSIS:**

The predicted driving resistance equals the sum of the resistances associated with all soil layers penetrated by the pile. This value does not contain a factor of safety and does not disregard soil resistance in any soil layer.

| STRUCTURAL DESIGN | Section<br>PILE DESIGN |
|---|---|
| | Subject<br>Allowable Design Pile Loads |

**GENERAL:** Allowable Design Pile Loads are based on past experience, and their values should maintain the relationships outlined in this article.

Limit the Allowable Design Pile Loads for all piles to less than the minimum allowable value determined by:

- the capacity of the pile as a structural member,
- the capacity of the pile to transfer load to the soil or rock, and
- the capacity of the soil or rock to support the load delivered by the pile.

**STATIC LOAD TESTING:** When the Geotechnical Engineering Report recommends Static Load Testing of piles, limit the Design Axial Load to less than one-half the test load. This, in effect, requires a factor of safety greater than 2.0.

**BASIC UNIT STRESS:** Limit the Design Pile Loads for steel H-Piles bearing on rock, as specified in AASHTO, to less than an allowable basic unit stress of 0.25*fy, or as provided in the Geotechnical Report, over the end area of the pile not including the area of any tip reinforcement.

**ALLOWABLE BEARING CAPACITY:** Limit the Design Axial Loads to less than the Allowable Bearing Capacities computed from the driving formulas specified in Section 604.03.07, Part B of the Standard Specifications, when applying these formulas to the driving log. Specify the Required Field Bearing on construction to be higher than the Design Axial Load. A factor of 1.25 is recommended for determining the Required Field Bearing when ENR formulae control the pile driving.

**EXAMPLE:** With a Design Axial Load of 40 tons per pile, specify the Required Field Bearing per pile on the Foundation Layout Sheet as the maximum of:

- 50 tons,
- the predicted driving resistance necessary to achieve the desired minimum pile tip elevation if that resistance exceeds 50 tons, or
- 50 tons plus any additional driving resistance to be overcome in penetrating soil strata that may potentially be removed by a 100-year scour event.

**LOAD COMBINATIONS:** Factor the Design Pile Loads for the various combinations of loading as specified in AASHTO. For the load combination with downdrag, see the next section.

**NEGATIVE SKIN RESISTANCE:** For point-bearing steel H-Piles designed for 0.25*fy, negative skin friction can generally be ignored. Evaluate other piles for overload due to soil **downdrag**. Downdrag typically occurs when piles are driven through approach fills to bearing below soft compressible clay layers. The downdrag load equals the sum of loads from all soil layers above the "neutral point." The neutral point is the point below which there is insufficient downward movement of the soil in relation to the pile to produce drag. For excessive downdrag loads, increase the number of piles or increase the pile size. Do not batter piles when excessive downdrag is predicted. If pile driving can be delayed until 90 percent of the predicted settlement has occurred, additional piles or larger piles may not be necessary and battered piles may be used.

Design piles for downdrag loads as follows:

**Step 1** – Ignore the downdrag load and design in accordance with standard practice.

**Step 2** – Check the design by adding the downdrag load to the axial pile load calculated for the condition of substructure and superstructure dead load plus live load without impact. Limit the allowable stress at the tip for this case to 0.47*fy.

If satisfying Step 2 increases the number of piles required by 20% or more or increases the size of pile by two increments or more, obtain approval of the Director, Division of

Structural Design.

The values reported in the "Foundation Pressure" note for Design Pile Loads equal the actual computed values, factored to 100 percent, from Step 1 design calculations.

**LUGS, SCABS, & CORE-STOPPERS:** Do not use these to increase the bearing capacity of steel piles used for friction piles.

**GROUP EFFECT:** Normally, group effects need not be considered when the pile spacing exceeds 3*B.

| STRUCTURAL DESIGN | Section<br>PILE DESIGN<br>Subject<br>Pile Resistance to Horizontal Thrust |
|---|---|

**GENERAL:**

In non-integral abutments, design piles to resist horizontal thrust by battering the front row of piles 1 to 3. Use vertical piles in the back row. For abutments requiring a backwall separate from the span endwall, the minimum allowable horizontal dimension between the front row and back row of piling at the level of the bottom of the pile cap is 3 feet. This article includes a method of design.

**DESIGN METHOD:**

1) Compute vertical and horizontal loads, thrusts, and moments about some point in the plane of the bottom of footing or bottom of cap. Neglect the passive earth pressure of any earth mass
   a) that slopes sharply away from the pile group,
   b) in front of each pile,
   c) which may possibly slide or crack away, or
   d) that is above the scour line.

   Do not neglect the vertical weight of such an earth mass.

2) From the preliminary pile grouping, compute the center of gravity, moment of inertia, and other physical constants necessary to compute vertical components of pile stresses.

3) Find vertical component of pile stresses and translate component into axial stress in the battered piles to check against overstress.

4) From computed vertical and axial stresses in the battered piles, compute the horizontal component as a function of the batter slope. Fully balance the sum of the horizontal components of the computed stress in the battered piling with the total horizontal earth pressure for the dead load condition of loading. For lateral loads of short duration, any available passive earth pressure may be considered part of the resistance.

5) The passive shear resistance of the earth in front of each pile may be considered in the design. See **Exhibit 502** for the allowable Horizontal Resistance per pile. The soil strength value used to enter the graph equals the weighted average of those values for the in-situ soils in relation to the strength value and layer thickness as presented in the Geotechnical Engineering Report. When N-Counts and cohesion are presented, use the weighted average of the Horizontal Resistance values separately obtained for the two strength values. With the soil strength value for Cohesion, C (psf) or standard penetration, N-Count, the Horizontal Resistance per pile is given in kips. (The Geotechnical Branch provides the "C" or N-Count values.)

6) Read directly from the graph the allowable Horizontal Resistance per pile for construction loading conditions.

7) For all other loading conditions, the value of Horizontal Resistance, as given in the graph, may be increased by fifty percent, except that in no case may the maximum allowable Horizontal Resistance allowed per pile exceed 10 kips. The minimum allowable Horizontal Resistance per pile may be raised to 4 kips.

**SPECIAL CONDITIONS:** Since piling longer than 75 feet in abutments may be extremely vulnerable to lateral translation, use more conservative design criteria on the capacity of each pile to resist horizontal loads by means other than the thrust of battered piles.

Additionally, where sounding data, soil reports, or construction conditions indicate an extremely poor quality of earth material surrounding the pile group, use more conservative criteria.

| STRUCTURAL DESIGN | Section<br>REINFORCED CONCRETE BOX CULVERTS<br>Subject<br>General |
|---|---|

**CULVERT LENGTH:** Calculate the culvert length such that the roadway fill hits 6 inches below the top of the parapet. Round the total length of culvert to the next highest 6 inches, unless designing a culvert extension.

**MINIMUM FILL:** Provide a minimum fill of 12 inches, or design the culvert top slab as the riding surface.

**MINIMUM LENGTH:** For culverts with driven guardrail posts or culverts with guardrail posts attached to the top slab, establish a minimum length to provide 4 feet clearance from the front face of the guardrail to the face of the parapet. On projects where safety criteria are being applied, avoid locating any culvert headwall within the 30-foot clear zone. Measure this 30-foot clear zone from the edge of pavement. In cases where a combination of fill height and culvert size would normally locate the headwall within this clear zone, extend the culvert by transitioning the fill slope to a flatter slope at the culvert or change the size or type of drainage structure. If no solution can be found by the aforementioned methods, request exception from the FHWA on an individual structure basis. Exceptions will only be considered where the headwall is adequately protected with guardrail or other protection designed to ensure the safety of the motorist. The Preliminary Line and Grade Inspection Report, Geometric Design Sheet, and Roadway Typical Section will indicate whether to apply the 30-foot clear zone criteria.

**GUARDRAIL ATTACHMENT TO TOP SLAB:** When fill over culvert is less than required to develop guardrail post stability, attach the post to the top slab.

**END CONDITIONS:** Detail the ends of RCBC as specified in the drainage folder on Design Summary Sheet, Form TC 61-100, sheet 1. The use of a different end condition requires approval from the Drainage Section.

**WING LENGTH:** Calculate culvert wing length and associated dimensions as shown in **Exhibits 504 through 506**. Assume the slope of channel equals 0.5 ft/ft unless otherwise specified in the drainage folder.

**PAVED INLETS & OUTLETS:** Provide paved inlets and/or outlets when specified in the drainage folder. See **Exhibit 507**. High velocities may require an "energy dissipater" on the outlet end of a culvert. Special outlet designs require recommendation or approval by the Drainage Section of the Division of Highway Design Special.

**IMPROVED INLETS:** Avoid using improved inlets.

**ACID WATER AND/OR HIGHLY ABRASIVE SITUATIONS:** When the Design Summary Sheet (Form TC 61-100 in the drainage folder) identifies either of these conditions, provide an additional 2 inches of cover on the bottom slab and the toe of the wing footings. Increase the thickness of the sidewalls, interior walls, and wing walls 2 inches for a height of 12 inches above the flow line. For this design, place the construction joint between the walls and the bottom slab 12 inches above the flow line. See **Exhibit 508**.

**GENERAL NOTES:** See **Section SD-301**.

**CULVERTS WITHOUT WINGS:** When a culvert is located where the foundation material is too unstable to support wings, extend the culvert barrel sufficiently through the fill so that wings and wing footings are not required.

**DESIGN METHOD:** Design culverts as simple frames without shear reinforcement. Culverts may be designed with shear reinforcement as a simple frame, as a rigid frame box, or as an arch if this would result in a more economical design, with the permission of the Director, Division of Structural Design. See **Exhibit 509** for additional reinforcement needed in a rigid frame box culvert.

**DESIGN STRESSES:** f`c = 3,500 psi
fy = 60,000 psi

**DEAD LOADS:** See AASHTO Article 6.2 and **Section SD-406**.

**LIVE LOADS:** See AASHTO Articles 6.4, 3.24.2, and 3.24.3.

**HORIZONTAL LOADS:** Design wings and sidewalls using earth pressure loads as outlined in **Section SD-403**, “3.20, Earth Pressure”.

**CULVERT TOP SLABS WHICH ACT AS RIDING SURFACES:** For the parapet treatment, use the curb and guardrail system shown in Standard Drawing BDP-005 where a crash-tested rail is required. Railing System Type 2 may be used in other cases. Epoxy-coated steel reinforcement is not required, except for the top of top slab reinforcement in multiple boxes, sidewalks, and other applications which have covers less than 2 ½ inches. Bottom of top slab reinforcement with hooks into the top of top slab does not require epoxy-coating.

**REINFORCEMENT IN PAVED FLOW LINES, INLETS & OUTLETS:** Use #4 bars at 18 inches in each direction with an option for WWF 6x6 - D7xD7.

| **STRUCTURAL DESIGN** | Section<br>REINFORCED CONCRETE<br>BOX CULVERTS |
|---|---|
| | Subject<br>Barrel Design |

**APPLICATION:** This article applies to RCBC other than ones of rigid frame design. See **Exhibit 510** for details of single span barrels and **Exhibit 511** for details of multiple span barrels.

**GENERAL:** All main reinforcement, any part of which lies in the bottom part of the slab, requires hooks on each end.

Detail keyed construction joints between the top slab and vertical walls. Turn the keys down.

Culverts under fills greater than 65 feet may be stepped with the approval of the Director, Division of Structural Design. If approval is given, step the culvert slab in increments of 2 inches to reduce the slab thickness as the fill height decreases toward the end. Do not step culvert slabs under fills 65 feet high or less.

Design the longitudinal reinforcement in culvert barrels (E Bars) to transfer the full axial tension from the wings to the barrel. This tension is caused by earth pressure against the inlet and outlet wings.

**TOP SLAB FOR SINGLE SPAN CULVERTS:** Unless the culvert is designed as a rigid frame, design the slab as a simply supported beam, with the span length equal to the distance center-to-center of sidewalls but not to exceed the clear span length plus the depth of the slab. The minimum allowable slab depth is 7 inches.

Assume the maximum shear to occur at a distance d equal to the effective depth of the slab from the inner face of the vertical wall, unless the culvert is rigidly supported on rock and is untrenched. In the latter case, assume the maximum shear to occur at a distance of 1/12 x clear span from the inner face of the vertical wall. If shear reinforcement is used, bend up alternate bars at an angle of 45 degrees, beginning at a distance 1.5d from the face of the wall.

**TOP SLAB FOR MULTIPLE SPAN CULVERTS:**

Design the slab as a simply supported beam continuous over the interior supports, with a span length equal to the distance center to center of sidewalls but not to exceed the clear span plus the depth of the slab.

**Details of Reinforcement** – Bend down the truss bar in the slab at the fifth point of the clear span. When the depth of fill is 3 feet or less, extend bars N to the centerline of the clear span. When the depth of fill exceeds 3 feet, extend bars N 12 inches beyond the quarter point of the clear span. Do not hook ends of bars N.

Assume the maximum shear to occur at a distance d equal to the effective depth of the slab from the inner face of the vertical wall, unless the culvert is rigidly supported on rock and is untrenched. In the latter case, assume the maximum shear to occur at a distance of 1/12 x clear span from the inner face of the vertical wall. If shear reinforcement is used, add bent bars spaced with bars N. Bend up the stirrups at an angle of 45 degrees beginning at a distance 1.5 d from the faces of the interior wall. Treat the slab over the exterior walls as in the second paragraph of the above section, “Top Slab for Single-Span Culverts.”

**BOTTOM SLABS:**

Provide the same reinforcement and effective depth in the bottom slab as the top slab. However, increase the total depth of the bottom slab by 1 inch for single span culverts and 2 inches for multiple span culverts.

Detail roughened construction joints between the bottom slab and vertical walls.

**SIDEWALLS:**

Design the wall as a simply supported beam with the span length equal to the clear wall height. Check as a column with no end restraint, with the height equal to the clear wall height and with bending and axial stresses. Design the sidewall thicknesses no less than 1/12 of the clear height of the culvert or 10 inches.

Reinforcement – Provide minimum reinforcement of #4 bars at 12-inch spacing. When the clear wall height is less than 7 feet, extend wall reinforcement into both top and bottom slabs with no hooks required. When clear wall height is 7 feet or more, use dowels from the bottom slab into the vertical wall with hooks in bottom slab end of the dowels.

**INTERIOR WALLS:** Limit the thickness of interior walls of multiple span culverts to 10 inches minimum with minimum vertical reinforcement of #4 bars at 12-inch spacing. Design interior walls as short columns. The second paragraph of the above section, "Top Slab for Single-Span Culverts," applies to interior walls. Unless otherwise specified, detail the inlet ends of the interior walls rounded to a half circle and set back to clear the rounded treatment of the parapet.

**WALL DRAINS:** Place 4-inch diameter weep hole drains in the sidewalls of all culverts 6 feet in height and greater, or culverts over 125 feet in length regardless of height. Place the same drains in all wings 10 feet in length or greater. Place the center of the drain 6 inches above the flow line and at 8 feet on center.

**HEADWALLS (PARAPETS):** Unless special conditions warrant otherwise, set the thickness of the headwall to 12 inches and the height above the bottom of the top slab to 2 feet 6 inches. Provide vertical bars, usually designated by an R, as stirrups at not less than #5 at 12 inches. Locate two bars in the top of the headwall: #6 bars in single span culverts and the same size as bars N in multiple span culverts. See **Exhibit 512**.

**APRONS:** Aprons are normally 12 inches thick. Extend aprons 4 feet below the flow line on culverts with 6 feet high openings or greater and 3 feet below the flow line on culverts with openings less than 6 feet in height. In multiple span culverts, detail two bars the same size as bottom slab bars N at 6 inches above the bottom of the apron to reinforce the negative moment. See **Exhibit 513** for apron details.

| STRUCTURAL DESIGN | Section<br>REINFORCED CONCRETE BOX CULVERTS<br>Subject<br>Wing Design |
|---|---|

**WING TYPE:** Use one of two wing types on culvert ends. One type is the traditional wing, defined as wings flared by varying angles from headwalls that are parallel to the centerline of roadway. The second type is the 30-degree flared wing, flared 30 degrees from the centerline of the barrel with the headwall perpendicular to the centerline of the barrel. This type of end condition has been designated to orient the culvert to the hydraulic flow.

**WING WALLS:** Design the thickness of wall 1/12 height of wall with a minimum thickness of 10 inches. Design the wall as a retaining wall with a sloping surcharge, reducing the pressure as a function of the skew.

Provide two #6 bars T in the top of all wing walls of culverts with openings 7 feet high or higher and all wings 10 feet long or longer. Begin spacing of horizontal bars M 9 inches above footing.

Provide vertical bars in both faces of wing walls of culverts with openings 7 feet high or higher. Use dowels in the back face with hooks in the wing footing. In the front face use no dowels, but use vertical and horizontal bars for the entire length of the wing.

See **Exhibits 514** for typical wing details.

**WING FOOTINGS:** When the wing length is 30 feet or greater, taper the footings from the width required at the high point to that required at the low end. The minimum allowable width is 3 feet.

Calculate the culvert foundation pressures for full dead load with no percentage reduction.

**HAUNCHES:** Do not use haunches.

**EXPANSION OR CONTRACTION JOINTS:** Use these joints in culverts only with approval from the Director, Division of Structural Design.

| STRUCTURAL DESIGN | Section<br>REINFORCED CONCRETE BOX CULVERTS<br>Subject<br>Excavation |
|---|---|

**CLASSIFICATION:** Specify structure excavation for culverts as one or both of two classes: Foundation Preparation (see **Section SD-605**) and Structure Excavation Solid Rock.

**STRUCTURE EXCAVATION:** Excavate according to Section 603 of the Standard Specifications. Terminate aprons for earth bearing culverts at the rock line rather than excavating rock.

**ROADWAY EXCAVATION, CHANNEL CHANGE:** Do not specify this type of excavation on the structure plans unless there are no roadway plans. If channel change excavation is required, then reference this type of excavation to the roadway plans.

| STRUCTURAL DESIGN | Section<br>REINFORCED CONCRETE BOX CULVERTS |
|---|---|
| | Subject<br>Foundations |

**YIELDING FOUNDATIONS:** Use a full bottom slab for the full length of the barrel.

**UNYIELDING FOUNDATIONS:** In accordance with Article 6.2 of the AASHTO Specifications, two construction procedures are available - trenched and untrenched. Include a comparative cost estimate of the two methods (trenched or untrenched) with the calculations.

- **Trenched** –Obtain approval from the Director, Division of Structural Design, before using this method, as special construction conditions apply.
- **Untrenched** - See **Section SD-406** for AASHTO Article 6.2.2 for vertical unit loads.

When culvert sidewalls bear on separate footings embedded in rock, use a 6-inch paved bottom slab. Check for the possibility of side pressure on the footings buckling or cracking the bottom paving. This possibility is especially dangerous for culverts under high fills and for rock situations where having a vertical rock face to pour the footings against is doubtful. If there is risk of future cracking of the bottom paving, then design struts between footings or use a full bottom slab. Use a full bottom slab on all culverts with less than a 6-foot span.

**IMPERFECT TRENCH METHODS:** For culverts rigidly supported on rock, with fills greater than 60 feet, consider using the imperfect trench method of construction. Use the same loads as for a culvert on a yielding foundation.

**VARYING FOUNDATIONS:**

The following two alternative methods are available. Include a comparative cost estimate of the alternatives with the calculations.

- **Make Total Foundation Yielding** – To make the total foundation yielding throughout, remove rock and replace with selected earth backfill of sufficient depth and width. See **Exhibit 515** for dimensions and construction sequence. Provide a uniform foundation over a width to include the exterior prisms, i.e. for a distance equal to the width of the structure on each side. Classify the excavation as Structure Excavation Solid Rock. Design the culvert according to Article 6.2.1 of the AASHTO Specifications.

- **Make Total Foundation Unyielding Untrenched** – If conditions warrant, e.g. the distance from the flow line to the rock line is not too far, excavate the earth between the rock line and the flow line and fill with selected uncompressible backfill. Classify the excavation as Structure Excavation, Common and place the backfill at the approval and direction of the engineer. Design the culvert in accordance with **Section SD-406** for AASHTO Article 6.2.2.

| STRUCTURAL DESIGN | Chapter<br>STRUCTURE DESIGN CRITERIA |
|---|---|
| | Subject<br>Material Specifications |

**LIST:** The Division of Structural Design maintains the approved list of material specifications and designations for steel, aluminum, and miscellaneous metals. This list is updated as the AASHTO and ASTM material specification books are revised.

**LIST DISTRIBUTION:** The Division of Structural Design will distribute the updated list to Division staff and approved consulting engineering firms. The list may also be obtained by request to the Director, Division of Structural Design.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS |
|---|---|
| | Subject<br>Rustication |

**GENERAL:** A rustication groove provides a location for cracks that occur in concrete walls at or near changes in wall alignment and also obscures the cracks. Detail the rustication on the plans where necessary.

**CULVERTS:** Do not use rustication grooves on culverts.

**WALLS:** Use rustication at the expansion, construction, and contraction joints of cast-in-place walls. See **Exhibit 516** for details.

**PIERS:** Use horizontal bands of V-joint rustication grooves at construction joints in exposed portions of pier columns and pier web walls.

**BARRIER WALLS:** Use rustication grooves in the outside face of barrier walls at all horizontal construction joints. Detail rustication grooves as continuous throughout the bridge, including wings. See **Exhibit 601** for details.

**PEDESTALS:** Use rustication grooves at the top of cap where using pedestals.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS |
| --- | --- |
| | Subject<br>Aesthetics |

**PLAN NOTE:** When including aesthetics as part of the structure, place a note on the plans documenting the aesthetic items and note that these items are not subject to value engineering proposals.

**USAGE:** Provide aesthetic treatments for projects in scenic, historic or recreational areas or other special considerations within reasonable fiscal restraints. Consider aesthetic treatment early in the environmental and/or design process. Project engineers should provide the bridge designer as much information as possible relative to the goals of the aesthetic treatment.

**SURFACE TREATMENT:** In urban areas, where retaining walls or large breastwall abutments are adjacent to ramps and heavily traveled routes, consider the surface treatment of the walls. Consider various treatments that are inexpensive to implement, such as shadow boxes or corrugation patterns. Submit the proposed treatment with Preliminary Plans, Stage 1, for approval.

Treatments to consider include but are not limited to form liners for exposed concrete surfaces, structure type and shape, material color and texture, and proportion of the elements. On rehabilitation projects, design for compatibility between the existing and proposed portions of the structure.

**STONE FACED BARRIERS:** When using stone faced barriers for aesthetics, note the following on the plans: attach the guardrail prior to stone placement and place the crush tube after stone placement.

**DRY STONE**

**MASONRY:** For projects containing work on existing dry stone masonry walls, specify that work done on these walls be performed by a certified Dry Stone Mason.

**MASONRY COATING:** Calculate quantities in square yards for Masonry Coating according to Standard Specifications Section 601.03.18 (B). In the Estimate of Quantities on the Title Sheet, show quantities for the superstructure and for each substructure as needed.

**MEDIAN BARRIERS:** Match the geometry of the Bridge Median Barrier System to the median barrier on the road. See **Exhibit 603** for one method of attaching median barrier to bridge deck.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS<br>Subject<br>Bridge Pier Types |
|---|---|

**TYPES:** Bridge pier details appear as **Exhibits 605 through 611**. In general, piers of these types are approved for use in bridges in Kentucky. Other pier types may be approved or recommended by the Director, Division of Structural Design.

**CODING:** **Exhibit 604** shows the standard coding for bridge piers. Use this coding when listing piers on Form TC 66-101.

**TALL PIERS:** All of the architectural pier types do not lend themselves for use as tall piers, i.e., piers 50 feet or greater in height. Consider this before designing a tall pier. Make preliminary sketches or architectural studies for all piers 50 feet or greater in height.

**PIER CRASHWALL, HIGHWAY:** When locating a bridge pier less than 4 feet from the normal guardrail location, use a crashwall for the pier. For details of highway crashwall, see **Exhibit 612**. For details of guardrail attachment, see Standard Drawing RBI-005, “Guardrail Installation At Bridge Columns.”

**PIER CRASHWALL, RAILROAD:** When locating a bridge pier less than 25 feet from the centerline of a railroad, use a crashwall for the pier. For details of railroad crashwall, see **Exhibit 613**.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS<br>Subject<br>Bridge Approach Slabs |
|---|---|

**USE:**

Use approach slabs as directed by the Project Manager. Bury the approach slab with the top of the approach slab even with the top of the DGA.

**DESIGN CRITERIA:**

Determine the length of approach slab as a function of the depth of fill adjacent to the bridge and the type of soil under fill. The minimum allowable length of bridge approach slab is 20 feet. Obtain current details for approach slabs from the Division of Structural Design.

Live load surcharge at the abutment may be disregarded when providing an adequately designed reinforced concrete approach slab, supported at one end by the bridge. See AASHTO 3.20.4.

To coordinate the preconstruction activities required to develop contract plans for the bridge approach slabs, use the following parameters and procedures:

- Include approach slabs in the structure plans. Payment is per square yard of approach slab.
- Include the provisions for the embankment required under the approach slab in the structure plans.
- For skewed bridges, skew the roadway end of the approach slab to match the bridge skew.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS |
|---|---|
| | Subject<br>Foundation Preparation |

**BID ITEMS:** Foundation Preparation is a bid item in Section 603 of the Standard Specification. All sheeting, shoring, dewatering, common excavation, partial removal of structure for culvert extension, and backfill are incidental to this lump sum item. Set up one lump sum item per structure. Provide separate bid items for solid rock excavation and any undercut of unsatisfactory material and refill.

**STRUCTURE EXCAVATION COMMON:** Some plans may continue to show structure excavation common in lieu of Foundation Preparation. This is still allowed by the specification. Eighteen-inch excavation limits now apply to all structures regardless of classification.

**END BENT BACKFILL:** Although not covered in Section 603, it is intended that End Bent Backfill (Structure Granular Backfill) remain a bid item and that any excavation at end bents remain incidental to this item.

**COFFERDAMS:** On stream crossings where it cannot be definitely determined that a cofferdam is required, use General Note #315, “Cofferdams,” in the General Note Library, which states that cofferdams may be necessary and specifies that the cost of any cofferdam required is **incidental** to the cost of Foundation Preparation. See the General Note Library.

When a project includes a large stream crossing which requires a deep excavation at the substructure units, and when it is determined that a cofferdam is definitely required, specify a **separate lump sum bid item** for each cofferdam required. Use General Note #300, “Cofferdams for Piers,” in the General Note Library. If the note does not fit a particular project location, adapt the note to fit.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS<br>Subject<br>Berms |
|---|---|

**ISSUES:**

To reduce the length of bridges without compromising the integrity of the structure, use the following procedures for determining berm widths.

Develop the type of wing and berm width individually to satisfy economics, aesthetics and site conditions such as:

- the length of wings for a bridge with a large skew angle,
- the depth of the superstructure, and
- the complexity of the bridge cone geometrics.

**MINIMUM WIDTH:**

Use a minimum berm width of 3 feet perpendicular to the abutment cap on stream crossings. This provides a factor of safety against stream action and provides space for placement of slope protection.

Use a minimum berm width of 12 inches perpendicular to the abutment cap on grade separation structures not subject to stream actions.

**EXHIBIT:**

See **Exhibit 615 Sheet 1** for Pile Bent Abutments with wings parallel to centerline.

See **Exhibit 615 Sheet 2** for Pile Bent Abutments with wings parallel to skew.

See **Exhibit 615 Sheet 3** for Breastwall Abutments.

| STRUCTURAL DESIGN | Chapter<br>MISCELLANEOUS |
|---|---|
| | Subject<br>Shop Plans |

**GENERAL NOTE:** Place the "Shop Drawing" General Note on plans requiring shop drawings.

**STRUCTURES DESIGNED BY THE DEPARTMENT OR BY CONSULTANTS:** The design engineer will review any shop plans required for structures or structure components. This review ensures conformance with the design plans.

**Procedure** – The fabricators will send three sets of shop plans to the designer. The designer will review the submittal and send a set with comments back to the fabricator. If the designer is satisfied that the construction can proceed, the designer will request the fabricator to send the required number of sets for distribution. The designer will stamp the plans:

Authorized to Proceed
Firm name
Date

and distribute as shown on the Division's website.

In addition, place the following note on all structure plans

> Disclaimer: Acceptance of any contractor's submission required on this project does not constitute endorsement or approval. The acceptance is acknowledgement of the work performed and authorization for the contractor to proceed. The Department is not bound by acceptance of any submissions required. Final acceptance or approval will be contingent on the satisfactory completion of the project.

**PROPRIETARY STRUCTURES OR STRUCTURE COMPONENTS:**

The Department currently uses many structures or structure components that are proprietary products of various companies. The Department may provide a review of the design and details of these various products prior to approving them for use on projects. Once approved for use, the Department normally does not provide a detailed review of the product on each project in which they may be used. Any review generally consists of ensuring general conformance with project requirements such as wall height and length, culvert barrel size, expansion joint movement capacity, bearing load capacity, etc. The supplier or manufacturer is responsible for the design of the product.

Examples of these products include, but are not limited to, the following: proprietary precast concrete culverts; steel or aluminum long span structural plate structures; wood or concrete sound barriers; concrete retaining walls (such as MSE walls); aluminum or steel structural plate box culverts; pot, disc or spherical bearings; modular expansion joints or other expansion joints with structural supports carrying wheel loads; metal deck forms; and various signing or lighting structural components.

The supplier of these products will stamp the shop plans indicating that they meet all design requirements. The Department may review the shop plans for conformance with general project requirements. All shop plans will contain the stamp of the supplier and the stamp of the designer, when applicable.

**PPC BEAM SHOP DRAWING CHECK LIST:**

In reviewing shop plans for Precast Prestressed Concrete Beams, check for the following information:

- AASHTO load design specification used
- Type of prestressed beam
- Detailed drawing for each different mark number including the total number of stirrups
- Dimensions of each beam
- Quantity, size, and location of strand
- Class of concrete

- Detensioning and design concrete strength for each mark number
- Drawing of each fabricated bar
- Type of prestressing strand, preload, and initial force for each mark number
- Drawing showing location and amount of debonding for all debonded strands
- Bed layout drawing when draped strands are used
- Drawings for voids in box beams showing location and dimensions
- Drawing of leveling device for side-by-side box beams
- Detail showing location of proposed tack welding
- List of separate or loose items shipped with beams
- Types of hold-down devices
- Type and location of inserts
- Indicate whether deck will be formed conventionally or with stay-in-place (SIP) forms - detail of weld tabs or concrete inserts if SIP forms are used
- Clearances from steel reinforcement to face of concrete
- Location of name or trademark of beam fabricator
- Diagram of detensioning procedure including order of strand release
- Procedure for detensioning draped strands in relation to time of release of hold-down devices (critical unless weight of beam is twice the total of the forces to hold the strand in the low position in the beam)
- Type of end treatment
- Bridge bearing pad type, and dimensions for non-standard pads
- Treatments for shipping (e.g. holes through web) and final treatments (e.g. patching of holes through web).

| STRUCTURAL DESIGN | Chapter: EXHIBITS |
|---|---|
| | Subject: List of Exhibits |