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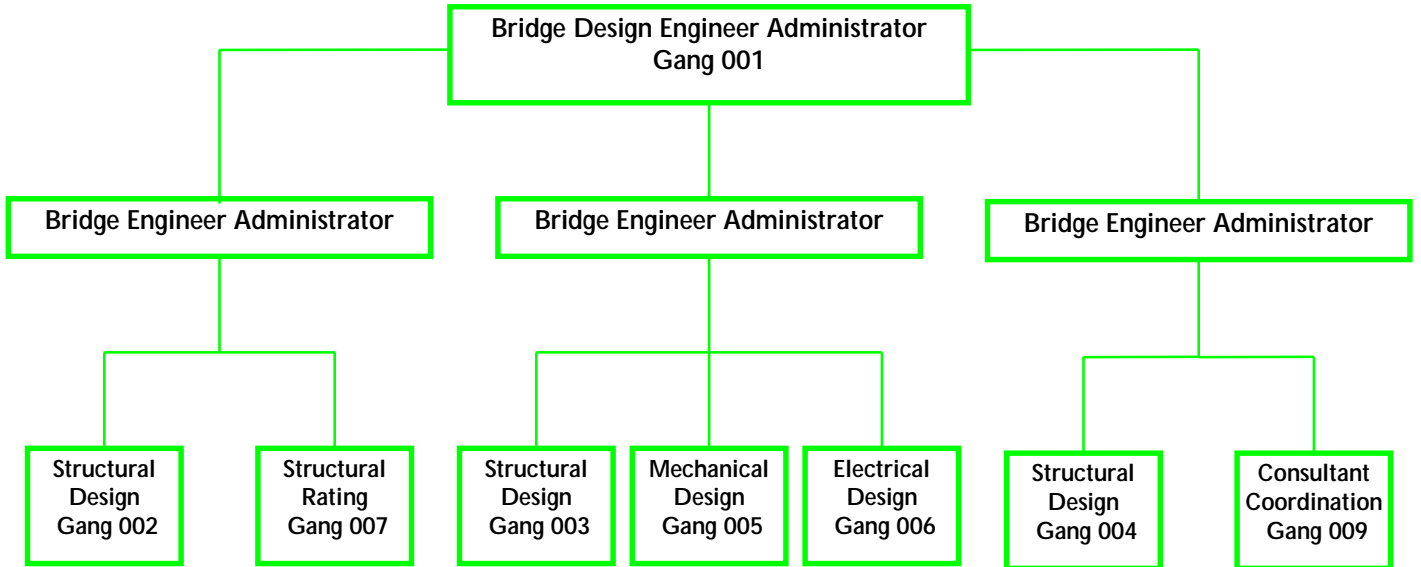
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## **FUNCTIONS OF THE BRIDGE DESIGN SECTION**

The primary function of the Bridge Design Section is to provide the necessary design and plan preparation expertise for various types of fixed and movable bridges. This may include either new bridge construction, bridge replacement or bridge rehabilitation projects. Some of the other functions of the Bridge Design Section are as follows:

1. To provide the design and plan preparation for bridge repairs and other bridge maintenance projects.
2. To provide the electrical, mechanical and architectural design and plan preparation for movable bridges, roadway lighting, communication systems, microwave towers, rest areas, weigh stations and buildings.
3. To maintain standard plans and details for bridges, guardrail, and permanent signing.
4. To provide structural ratings for existing bridges, evaluate weight limits and effect of overlays on deficient bridges, and review bridges for overweight vehicle permits.
5. To coordinate, review, and administer funding for bridge projects prepared by consulting engineering firms under contract with the Department.
6. To provide technical engineering assistance, coordination and general information to other Department sections, state and federal agencies, legislative bodies and the general public.
7. To participate in various Department and National technical committees. To periodically review the AASHTO Standard Specifications for Highway Bridges and make recommendations for its update.
8. To coordinate construction permits with the various agencies involved with the projects.
9. To provide technical engineering assistance for research projects conducted by the Department.
10. To provide assistance to Construction Section for any field problems, which may occur, and to review and approve fabrication shop drawings.

## BRIDGE DESIGN ORGANIZATION CHART





## **PROJECT DEVELOPMENT COORDINATION**

Each Department design project (consultant or in-house) is normally assigned a two coordinators, coordinator 1 and a coordinator 2. These coordinators are normally from the roadway design or bridge design sections.

The coordinator 1 is responsible for supervising the development of the road and bridge plans and to meet all project time deadlines. The Department maintains a computer database known as LETS on the mainframe computer system (CICSPROD), for all design projects. The LETS, Letting Schedule System, provides information regarding projects in the pre-letting stages of development. The Coordinator 1 is responsible for maintaining certain project information in LETS in an accurate and timely manner.

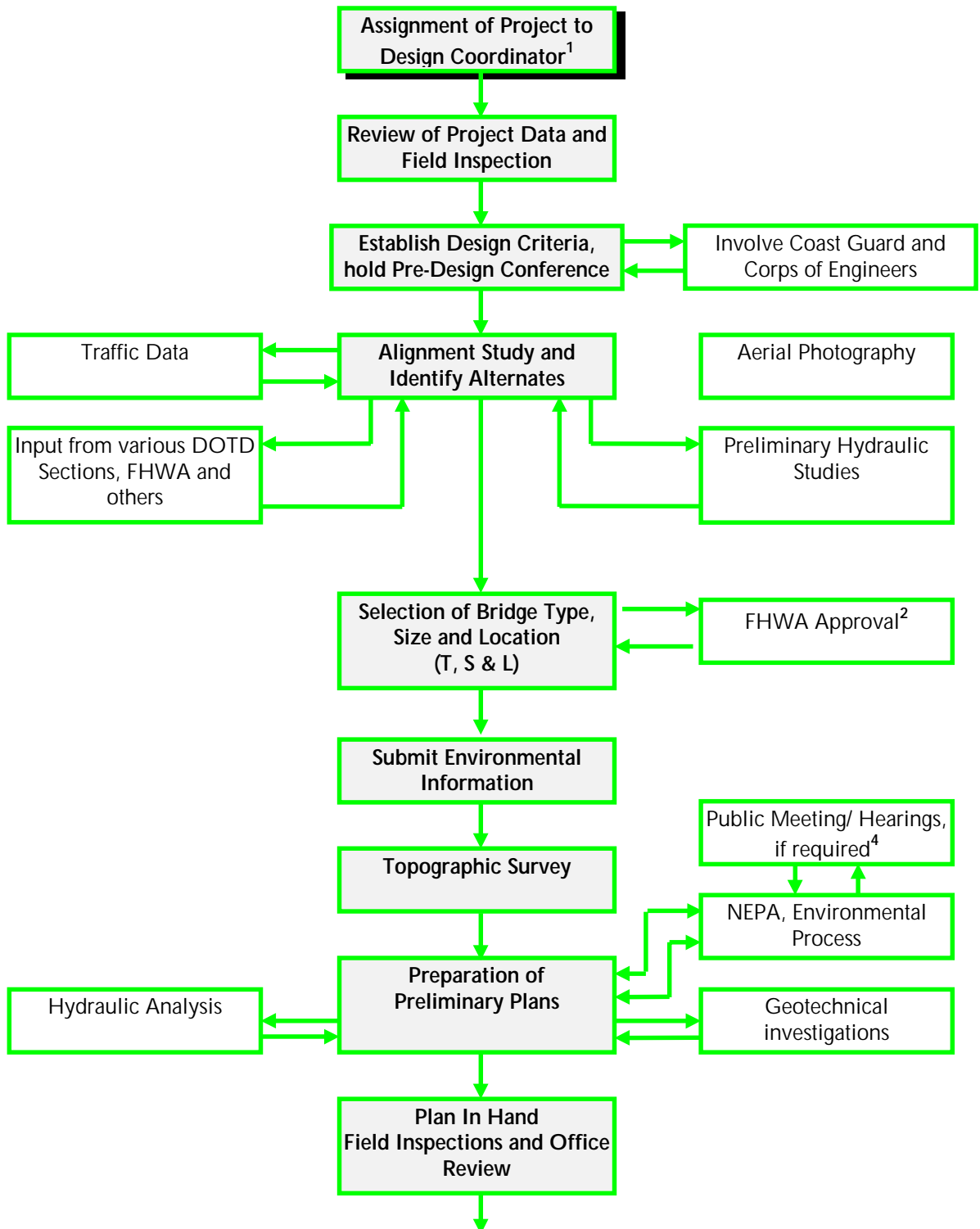
For specific information concerning the LETS System, contact the Department's Highway Needs Section.

A typical plan preparation flow chart is shown on page 4. Most projects will follow these steps although certain projects may require slightly different or additional steps. A typical plan development sequence is shown on pages 7 and 8. These sheets may be used as a worksheet for in-house projects.

Sample of data fields contained on LETS SYSTEM for each project:

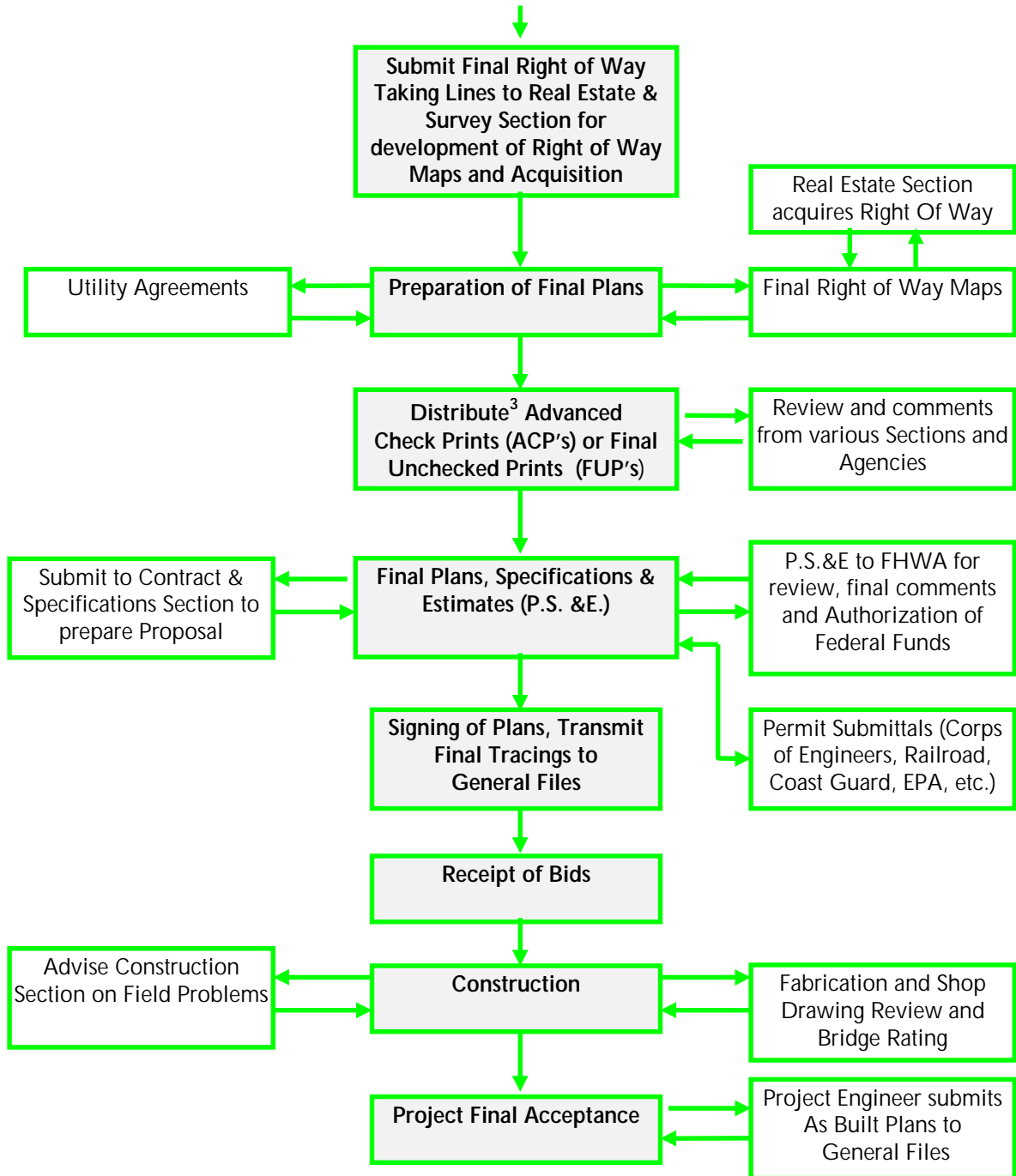
1. Project Numbers.
2. Project Description.
3. Coordinators.
4. Project time deadlines for environmental, survey, preliminary plans, advance check prints, P.S. & E, right-of-way, utilities, and letting.
5. Construction, engineering, right-of-way and utility costs.
6. Type of project funding.
7. Permit information.
8. Structure numbers and sufficiency ratings for bridges on a given project.

## TYPICAL PLAN PREPARATION FLOW CHART



Continued on the next page

Continued from previous page



<sup>1</sup> Project Coordinator (Bridge or Road Design) will be required to coordinate all meetings and plan submittals.

<sup>2</sup> FHWA approval is required on all NHS and IM projects.

<sup>3</sup> ACP's consultant projects, FUP's in-house projects

<sup>4</sup> Public Meetings / Hearings may sometimes be held prior to the survey. this will depend on the complexity of the project.

**TYPICAL PROJECT DEVELOPMENT SEQUENCE (IN-HOUSE PROJECTS)**

**PROJECT DATA WORKSHEET**

Bridge Coordinator: \_\_\_\_\_

Consultant: \_\_\_\_\_

Roadway Coordinator: \_\_\_\_\_

Project Name: \_\_\_\_\_

Route: \_\_\_\_\_

S.P. No.(Construction.): \_\_\_\_\_ S.P. No.(Engineering): \_\_\_\_\_

F.A.P. No.: \_\_\_\_\_ Parish: \_\_\_\_\_

Miscellaneous comments: \_\_\_\_\_

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## PROJECT TASK WORKSHEET (IN HOUSE PROJECTS)

<sup>1</sup> Project Task For Preliminary Plan Phase	COMPLETED DATE
1. PROJECT ASSIGNED TO COORDINATOR AND PROJECT NUMBER REQUESTED.	
2. REQUEST ADT & AERIAL PHOTOGRAPHY.	
3. MAKE INITIAL PROJECT SITE VISIT.	
4. ORDER EXISTING RIGHT-OF-WAY MAPS.	
5. SENT OUT PRELIMINARY PROJECT QUESTIONNAIRE TO DISTRICT FOR INPUT.	
6. DEVELOP ALIGNMENT AND DETOUR ALTERNATES AS NEEDED.	
7. HOLD PRE-DESIGN CONFERENCE.	
8. DEVELOP PRELIMINARY PERMIT INFORMATION FOR COAST GUARD, CORPS OF ENGINEERS, RAILROAD, ETC.	
9. SEND ALIGNMENT AND DETOUR TO DISTRICT, TRAFFIC AND PLANNING AND GEOMETRICS FOR REVIEW.	
10. SEND T, S, AND L(TYPE, SIZE AND LOCATION) TO FHWA FOR REVIEW.	
11. SEND PROJECT INFORMATION TO ENVIRONMENTAL TO START CLEARANCE PROCESS.	
12. HOLD PUBLIC MEETING OR PUBLIC HEARING IF NEEDED.	
13. ORDER TOPOGRAPHIC SURVEY.	
14. ORDER HYDRAULIC ANALYSIS.	
15. ORDER GEOTECHNICAL ANALYSIS. (BORINGS, CONSOLIDATION, SLOPE STABILITY)	
16. DEVELOP PRELIMINARY PLANS.	
17. HOLD PLAN-IN-HAND FIELD INSPECTION AND/OR OFFICE REVIEW.	
18. INCORPORATED PLAN-IN-HAND COMMENTS AND SEND FINAL RIGHT-OF WAY TAKING LINES TO REAL ESTATE TO DEVELOP R/W MAPS.	
19. PREPARE APPLICABLE PERMIT SKETCHES.	
20. OBTAIN ENVIRONMENTAL CLEARANCE BEFORE PROCEEDING TO FINAL PLANS.	

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<sup>1</sup> Notes: FHWA is normally involved in plan review and approval on NHS and IM projects. The sequence as shown may vary depending upon project type and scope.

1Project Task For Final Plans Phase	COMPLETED DATE
1. PREPARE FINAL PLANS.	
2. SEND OUT ACP'S (ADVANCED CHECK PRINTS FOR COMMENTS).	
3. SUBMIT INFORMATION TO BRIDGE RATING ENGINEER TO DETERMINE IF RATING IS TO BE DONE IN-HOUSE OR BY CONSULTANT.	
4. SEND FINAL MATTE FILMS TO CONTRACTS SECTION TO PREPARE PROPOSAL.	
5. FINAL PROPOSAL SENT OUT FOR REVIEW.	
6. CHIEF ENGINEER SIGNS TITLE SHEET AND FINAL COST ESTIMATE.	
7. PLAN REVISIONS MADE IF NECESSARY.	
8. PROJECT IS LET AND BID REVIEW COMMITTEE MAKES REVIEW OF BIDS.	
9. CONTRACT IS SIGNED AND A WORK ORDER IS ISSUED.	
10. REVIEW ERECTION AND/OR FABRICATION SHOP DRAWINGS.	
11. ASSIST CONSTRUCTION SECTION ON ANY FIELD PROBLEMS. ASSIST IN PLAN CHANGES IF NECESSARY.	
12. PROJECT FINAL ACCEPTANCE AND PROJECT ENGINEER SUBMITS FINAL AS- BUILT PLANS TO GENERAL FILES SECTION.	

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<sup>1</sup> Notes: FHWA is normally involved in plan review and approval on NHS and IM projects. The sequence as shown may vary depending upon project type and scope.



## DISTRIBUTION OF PRINTS BY BRIDGE DESIGN SECTION (CON'T.)

PURPOSE (DIRECT LETTER TO:)	NO. OF SETS	FOR	SHEETS NEEDED	REMARKS	
(16)  FINAL UNCHECKED PLANS (IN-HOUSE DESIGN)  ADVANCE CHECK PRINTS (CONSULTANT DESIGN)  (CONTRACTS AND SPECIFICATIONS)	1	CONTRACTS & SPECIFICATIONS	FULL SET & CROSS-SECTIONS	ONLY IF FEDERAL NHS PLANS	
	1	PROJECT ENGINEER			
	1	CONSTRUCTION SECTION (HEADQTRS)			
	1	FHWA			
	1	CONTRACTS MANAGEMENT	TITLE SHEET ONLY		
	1	DISTRICT UTILITY REPRESENTATIVE	FULL SET	ONLY IF ROAD WORK REQUIRED	
	1	GEOTECHNICAL ENGINEER			
	1	TRAFFIC SERVICES			
	1	ROAD DESIGN SECTION			
	1	GEOMETRICS SECTION			
	1	MAINTENANCE SECTION (HEADQTRS)			
	1	UTILITY UNIT			
	1	PUBLIC HEARING & ENVIRONMENTAL IMPACT SECTION			
	1	REAL ESTATE			
1	CONSULTANT				IF ROAD AND/OR BRIDGE PLANS PREPARED BY CONSULTANT
1	DISTRICT CONSTRUCTION ENGINEER				
P. S. & E. (1) (CONTRACTS AND SPECIFICATIONS)	1	CONTRACTS AND SPECIFICATIONS SECTION	FINAL MATTED PLANS SPECIFICATIONS AND ESTIMATE		
(1)  GENERAL FILES	1	GENERAL FILES	FINAL SIGNED MATTED PLANS	COPY OF LETTER TO:  REAL ESTATE, LOCATION & SURVEY, UTILITY, DISTRICT ADMINISTRATOR, DISTRICT CONSTRUCTION ENGINEER, ROAD DESIGN ENGINEER, PARISH OR CITY GOVERNMENT AGENCY. PRINTS ARE FURNISHED ON REQUEST BY GENERAL FILES.	
(32)  PLAN CHANGE  (CONSTRUCTION)	1	PROJECT ENGINEER	TITLE SHEET & REVISED SHEETS	NHS FUNDING ONLY ONLY IF R/W CHANGED IF APPLICABLE IF APPLICABLE	
18	CONSTRUCTION SECTION				
1	FHWA				
10	REAL ESTATE				
1	UTILITY				
1	DISTRICT UTILITY				

☒ ALL SETS SHALL BE HALF-SIZED, EXCEPT FOR THOSE WHICH ARE SENT TO REAL ESTATE & UTILITY, WHICH WILL BE FULL-SIZED.



## **BRIDGE DESIGN AND PLAN PREPARATION**

The documents on the following pages, the "General Guide for Bridge Plan Preparation" and the "Design Policy Guide for Bridges and Structures" were prepared for the engineer and staff designated by the Department as responsible for the preparation of bridge plans. Projects may be performed by an in-house engineer or by a consultant engineer under contract with the Department. These documents are included in this manual strictly as a guide in preparing bridge plans. Variations are highly probable for individual projects, and it is the responsibility of the Engineer to recognize these variations. However, any departure from the normal procedures outlined herein, or elsewhere in the manual, should be only with prior approval of the Bridge Design Section.

In cases where the AASHTO Specifications allow more than one method of analysis, the method to be used requires the approval of the Bridge Design Engineer before proceeding with the project. This is also true in cases where the specifications may be unclear. Additionally, the Bridge Design Section has certain preferences for detailing. The engineer should check with the project coordinator to assure proper format, particularly on complex projects.

It will be the responsibility of the Engineer to keep their copy of the bridge design manual properly updated. This includes all bridge design manual revisions issued by the Bridge Design Engineer, which affect design, policies and procedures.

Each project will have a DOTD design coordinator for each in-house or consultant design project. For in-house design projects, the project coordinator shall be responsible to meet all applicable project completion deadlines. This includes the coordination of road and bridge plan development with various DOTD sections (Road, Environmental, Location and Survey, Hydraulics, Real Estate, Contracts, Construction, Utilities, DOTD Districts, Geotechnical, etc.), local and state agencies, Metropolitan Planning Organizations, Wildlife and Fisheries, D.E.Q., and federal agencies such as FHWA, Coast Guard, Corps of Engineers, FAA, etc. For consultant contracts, the coordinator will monitor the consultant's design and rating contracts which include review of the plans at various stages during preliminary design, final design, construction (fabrication drawing review), bridge rating and processing of invoices.

## **GENERAL GUIDE FOR BRIDGE PLAN PREPARATION**

The information contained herein has been compiled by the Department's Bridge Design Section setting forth requirements the Engineer is to follow and what services the Department will furnish in the preparation of bridge plans for given projects.

The Engineer is hereby forewarned that the Department has a preference for certain type of details and design philosophy for the bridge structures. The Department will furnish, as when available, and if requested, miscellaneous standard details and/or standard plans for a given project. The Engineer shall be responsible for obtaining a copy of the "Bridge Design Manual", which has been prepared by the Bridge Design Section of the Louisiana Department of Transportation and Development. The "Bridge Design Manual" makes policy statements and can be used as a policy guide for structural analysis and will aid the Engineer in developing bridge plans. However, the "Bridge Design Manual" covers only a small portion of the work that the Engineer may be required to perform. In addition, it is important that the Engineer become familiar with the Design Memorandums or revisions to the "Bridge Design Manual" issued as Memorandum to all Contractors prior to beginning any work.

### **PRELIMINARY PLANS**

#### General

1. For Consultant projects, it will be the responsibility to meet the requirements stated in the contract and the project schedule. Submittals should be in accordance with the Department's Bridge Design Section Policy or as requested by the coordinator. In general, for consultant contracts preliminary plans should be submitted at the 30, 60, 90, and 100 percent completion stage. These submittals shall include completed and partially completed plans, and calculations including hydraulics. Where applicable, a separate copy of hydraulic studies described elsewhere herein for bridge sites should be submitted to the Bridge Design Coordinator at the 60% completion point for review. At 100% preliminaries, final right-of-way taking lines should be completed. For guidelines for preliminary plan payment milestones for consultant projects, see page 20. For in-house projects the engineer may follow the plan development sequence guidelines as stated on pages 4 through 8 as a general guideline.
1. It is the Engineer's responsibility to submit a request as outlined herein for deep borings and fill height analysis as soon as possible in order to avoid delays. Additionally, the Engineer shall prepare the necessary permit sketches, drawings, etc., for the Corps of Engineers, Coast Guard, railroad company, Federal Aviation Administration, etc. A list of permits can be found in Chapter 7.
2. For each consultant project, regardless of prior approval, the Engineer shall prepare and submit a synopsis of the electronic data processing software which may be used in the design or the analysis of the bridges, retaining walls or other structural

elements. This information should be submitted to the Bridge Design Engineer for his review and approval prior to their use. The Bridge Design Engineer may require that sample problems be run and the results reviewed in order to assure acceptability of the proposed software.

### Preliminary Bridge Plans In Plan-In-Hand Form

Plans for the plan-in-hand field inspection shall be prepared in accordance with the following procedures and recommendations and shall contain at least the following applicable data:

1. Design criteria, specifications, loading, materials, traffic data, navigational aspects if applicable for the structural design, and the design criteria and proposed systems to be used in the mechanical, electrical or architectural portions of the project.
2. Prior to beginning work, the engineer shall obtain approval in writing, of any details or design features which vary from the Bridge Design Manual and Bridge Design Engineer's memoranda.
3. The Engineer shall obtain approval from the Department for the scale to be used in the plan and profile drawings and general bridge plans.
4. Plan and profile of each bridge structure showing, roadway alignment (both vertical and horizontal). Show profile elevations at centerline joint, each bent, the abutments, and beginning and end of the approach slab. Indicate location of the profile grade line (P.G.L.) on the general bridge plans. No station equations are to be used from beginning to end of any bridge structure unless approved by the Bridge Design Engineer. It is also the responsibility of the Engineer to determine from the survey level books which referenced datum was used to establish the project's vertical elevations.
5. Span lengths, location of expansion and fixed ends of spans, size and type of joints to be used, all horizontal and vertical dimensions and clearances, lane and shoulder width of the bridge and approaches, type and location of bridge drainage. Approach slab type and length revetment type and length at bridge ends.
6. Length and location of test piles including test pile length and tip elevations, size, number and length of piles for pile bents, and size, type, approximate number and length of piles for column bents and location of core borings.
7. Hydraulic data, (if applicable).
8. Right-of-way is shown on bridge plans if roadway plan and profile sheets are not part of the plan set.

9. Typical sections through bridge structure showing dimensions and details of proposed superstructure and substructure, such as slab thickness, beam spacing and depth, handrail and barrier details, type footings proposed, drilled shafts, pile footings, etc. The maximum foundation pressures and maximum pile loads are to be shown, where applicable, along with the size, length, and type of piles or drilled shafts. Framing plans, if applicable.
10. Detour layout
11. Additional miscellaneous information and details include, vertical and horizontal clearances, permanent signing, construction signing, lighting and utilities if available, superelevation diagrams, guardrail layout details, attenuators location, and stopping sight distance.
12. Preliminary design of structural components are required in order to determine beam spacing, column spacing, number of piles and any special features. Preliminary design computations may be requested for the Department's review and approval. A preliminary cost estimate should also be prepared for the project.
13. Sufficient economic studies will be made available if requested with regard to recommended bridge layout, span lengths, and structural types prior to pre-plan-in-hand submittal.
14. A plan-in-hand conference may be held after the plan-in-hand field inspection at which time special features will be discussed and determinations made, all of which shall be shown on the Preliminary Bridge Plans In Final Form.

#### Preliminary Bridge Plans In Final Form

After the plan-in-hand has been completed, the engineer shall submit the preliminary bridge plans in final form to the project design coordinator for approval. These plans shall reflect all agreements reached at the plan-in-hand stage and shall contain all applicable data described in items 1 through 6 on page 13. Required Permit sketches if applicable should be included. The Department is to obtain approval of the preliminary bridge plans from others involved such as the Federal Highway Administration, Railroad Companies, Corps of Engineers, Coast Guard, Federal Aviation Agency, etc., prior to beginning final bridge plans when it is required. The engineer will be required to prepare and modify any sketches, permit drawings, calculations, or provide any information in order for the Department to secure approval of the preliminary plans.

For consultant projects the Engineer will be authorized in writing by the Department's project design coordinator to commence with final design for the project.

## Hydraulic Studies

Hydraulic studies for the bridge site in general should include: determination of flood plain discharge for the design event; determination of normal water surface elevations and the stage-discharge relationship; design selection based upon computed backwater; determination of special requirements (scour protection, spur dikes, abutment protection); predicted scour depths; and documentation of design. The predicted scour elevation should always be shown on the general bridge plans and in the hydraulic data table. An example hydraulic data table is shown on the following page. The computed table should be included in the plan-in-hand prints, as well as in final plans

Formal documentation of all design considerations and the general design process will be made in the Hydraulic Report. The Hydraulic Report will include: a general discussion of the watershed and the scope of and the reasons for the proposed improvement; documentation of any coordination with other agencies or governments; brief discussion of any local or regional ordinances influencing design; general site data used in hydraulic design; general discussion of design analysis; final design recommendations; a general "Flood Hazard Summary". As with the hydraulic calculations, the complexity of the Hydraulic Report should be commensurate with the significance of the site from a flood hazard standpoint.

Hydraulics design, unless otherwise specified, shall be in accordance with the DOTD Hydraulic Manual; guidelines, procedures and examples are there in. Further questions pertaining to bridge hydraulic design should be directed to the DOTD Hydraulics Section. For general rules regarding setting bridge finish grade elevations, refer to Chapter 3 of this manual.

**EXAMPLE BRIDGE HYDRAULIC DATA FORM**

**STATE PROJECT:** 029-02-0018

**STREAM NAME:** Forker Creek

**ROUTE:** LA 8

**BEGINNING STATION:** 16 + 35.000

**PARISH:** Vernon

**BRIDGE LENGTH:** 55 m

**STRUCTURE NO.:** 029-02-01561

**BASIN SLOPE:** 1.26 m/km

**PREPARED BY:** Joe Smith

**DESIGN STORM:** 25 years

**DATE:** May 14, 1996

**HYDRAULIC DATA TABLE FORM**

Drainage Area (km <sup>2</sup> ): 19.6				
Flood Frequency (years)	25	100	Overtopping > 500	Scour Analysis 500
Discharge (m <sup>3</sup> /s)	86.00	135.00	NA	210.00
Design Water Surface Elev. (m/ N.A.V.D- 88)	37.87	38.39	NA	39.25
Average Velocity (m/s)	0.52	0.71	NA	0.98
Area of Opening (m <sup>2</sup> )	166.0	190.0	NA	213.0
Backwater (m)	0.005	0.190	NA	0.580
Bridge Scour Elevation (m)				29.30

**REMARKS:** Recommended finish grade elevation for a 25-year design flood is 38.78 m/N.A.V.D- 88. Use 1:3 abutment slopes with flexible revetment extending 1.5 m outside the fascia of the structure on upstream and downstream side.

**BRIDGE SCOUR:** Scour depth = 2.3 m scour depth elev. = 29.3 m/ N.A.V.D- 88

**EXISTING BRIDGE:** Length = 40 m

**DETOUR BRIDGE:** Design Frequency = 5 years. The 5 year Design Water Surface Elevation is 36.30 m/ N.A.V.D- 88. A 42 m (or as required to span channel) precast concrete slab bridge at F.G. elevation of 37.50 m/ N.A.V.D- 88 is recommended.

## Geotechnical Analysis

### GENERAL:

Normally, the location, number, and depth of soil borings will be recommended by the Geotechnical Design Section. The boring request form on the page 19 shall be used to order borings, and consolidation tests through our Pavement and Geotechnical Design Section. If slope stability analysis is needed this should also be discussed and requested at this time.

For borings done in-house, three (3) sets of plans with the information described in items "1 through 6" listed below should be transmitted to our Pavement and Geotechnical Design Section. Upon receipt of this information, the Pavement and Geotechnical Design Section will order the boring logs & any additional soil information as deemed necessary for the project, including a fill height recommendation.

Some Consultant contracts require the Engineer to furnish the boring logs and test reports. For those contracts, items "1 through 6" listed below are to be submitted to the Department for approval prior to obtaining borings.

There will be some projects in which sufficient existing foundation information is available, thus eliminating the need for additional borings and foundation studies. It will be the responsibility of the Project Coordinator to request this information in writing.

Boring logs shall be included in the plan-in-hand drawings. However, in some cases, when they are not available, plan-in-hand field inspections may be made without boring logs. The boring logs shall be required as a part of the preliminary bridge plans in final form. Correlation of boring logs to actual elevation will be required and will be the responsibility of the Engineer.

The Engineer is to obtain approval from the Department for all foundation (roadway and bridge) design criteria to be used on any project, prior to submittal of preliminary plans. This will include foundation types and lengths (footings, piers, piles, drilled shafts, etc.), pile supported approach slabs, fill heights, retaining wall and sheet pile wall types and consolidation criteria (surcharge, wick drains, etc.)

Foundation studies can change structures from culverts to bridges or vice-versa. Also, the type of substructure and superstructure can be changed by these foundation studies.

Preliminary plans will show controlling fill heights as determined by or approved by the Department.

A foundation report may be required in special cases. The extent of bridge foundation studies, embankment studies, and format for the soil report is to be approved by the

Department. This work should be completed and approved prior to submittal of preliminary bridge plans in plan-in-hand form.

The following listed information shall be furnished when requesting borings to be done through the DOTD Pavement & Geotechnical Design Section:

1. Title sheet or vicinity map to locate projects.
2. Typical section of proposed embankment showing crown width and proposed side slopes.
3. Plan and profile of surveyed alignments and preliminary structure layout in plan and profile.
4. Plans to show approximate boring locations and recommended depths.
5. Type of structure being considered.
6. Fill heights and/or depth of cuts at bridge ends.



Boring Request Form

(one boring request form per site)

**PROJECT INFORMATION**

Construction No. \_\_\_\_\_ Engineering No. \_\_\_\_\_  
 Project Name \_\_\_\_\_  
 FAP No. \_\_\_\_\_ Structure No. \_\_\_\_\_  
 Route No. \_\_\_\_\_ Parish \_\_\_\_\_  
 Letting Date \_\_\_\_\_ Project Alignment  New  Old  
 Prelim. Plans Date \_\_\_\_\_ Project Units  English  Metric

**STRUCTURAL INFORMATION**

- Bridge Length \_\_\_\_\_ Pile Type & Size \_\_\_\_\_ Pile load \_\_\_\_\_  
 Abut. max. Fill Ht. (Beg. Bridge) \_\_\_\_\_ (End Bridge) \_\_\_\_\_ Crown Width \_\_\_\_\_  
 Projected Scour Elevation \_\_\_\_\_  
**Are Old Borings From This Site or Adjacent Sites Available?**  Yes  No  
**If Yes, Please Provide Copies and The Project Number.**  
 - Any Roadway Embankment?  Yes  No **If yes, complete the following information.**  
 New Embankment or  Widening Height Range \_\_\_\_\_  
 Beg. Station \_\_\_\_\_ End Station \_\_\_\_\_  
 - Are there any walls?  Yes  No **If yes, complete the following information.**  
**Type Wall** \_\_\_\_\_ Beg. Station \_\_\_\_\_ End Station \_\_\_\_\_  
 Wall Height Range: \_\_\_\_\_  
 Are Cross-Sections Available?  Yes  No **If Yes, please provide copies.**  
 Comments: \_\_\_\_\_

**Structural Info. Completed by** \_\_\_\_\_ **Date** \_\_\_\_\_

**FIELD & LABORATORY REQUEST**

(to be completed by the Pavement and Geotechnical Design Section)

Total No. Borings Requested

Sampling Frequency **Boring No.(s)**  
 Standard \_\_\_\_\_  
 Continuous \_\_\_\_\_

Boring Depth(s)  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Water Table

Consolidation Testing

	<u>Boring No.(s)</u>	<u>Sieve</u>	<u>Hydrometer</u>	<u>Depth</u>
<input type="checkbox"/> Grain Size	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____
	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____
	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____

**COMMENTS:** \_\_\_\_\_

**Field & Lab. Request Completed by** \_\_\_\_\_ **Date** \_\_\_\_\_

**NOTES:** Required Attachments

➔ 4 copies of general plan(s) (or field roll) & location map(s)

Rev. 08-12-98

Preliminary Plan Payment Milestones Table

PAYMENT MILESTONE	TASKS	BRIDGE	COMMON	ROAD
30 % Distribution	Completed	<ol style="list-style-type: none"> <li>1. Bridge hydraulic study and scour analysis</li> <li>2. Type, Size &amp; Location of Structure set</li> <li>3. Deep Borings</li> </ol>	<ol style="list-style-type: none"> <li>1. Pre-design criteria established</li> <li>2. Horizontal &amp; vertical alignment set</li> </ol>	<ol style="list-style-type: none"> <li>1. Plan/profile sheets with existing topo</li> <li>2. Preliminary typical sections submitted for review</li> <li>3. Title Sheet</li> <li>4. Typical Section questionnaire distributed</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Superelevation diagram</li> <li>2. Economic study (if appropriate)</li> </ol>		<ol style="list-style-type: none"> <li>1. Preliminary typical sections being reviewed</li> <li>2. Pavement Design</li> <li>3. Soil borings and pH/resistivity data</li> <li>4. Capacity analysis</li> </ol>
60% Distribution	Completed	<ol style="list-style-type: none"> <li>1. Preliminary design of substructure &amp; superstructure</li> <li>2. Foundation analysis</li> <li>3. General Plan</li> <li>4. Typical bridge sections</li> </ol>		<ol style="list-style-type: none"> <li>1. Horizontal/vertical alignment on plan/profile sheets</li> <li>2. Geometric details submitted for review</li> <li>3. Hydraulic design submitted for review</li> <li>4. Cross sections and required right of way</li> <li>5. Final typical section</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Span and bent details</li> <li>2. Foundation layout</li> <li>3. Framing plan</li> </ol>	<ol style="list-style-type: none"> <li>1. Sequence of construction &amp; and construction signing</li> </ol>	<ol style="list-style-type: none"> <li>1. Earthwork computations</li> <li>2. Construction notes &amp; details</li> </ol>
90 % Distribution	Completed	<ol style="list-style-type: none"> <li>1. Bridge quantities and general notes</li> </ol>	<ol style="list-style-type: none"> <li>1. Assemble plans</li> <li>2. Cost estimate</li> </ol>	<ol style="list-style-type: none"> <li>1. Geometric and hydraulic comments incorporated</li> <li>2. Pre-plan in hand review</li> </ol>
	In Progress		<ol style="list-style-type: none"> <li>1. Pre-plan-in-hand review</li> </ol>	
95 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Plan-in-hand prints distributed</li> </ol>	
100 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Plan-in-hand inspection and comments addressed</li> <li>2. Right of way taking lines set and transmitted to Location and Survey</li> <li>3. Permit sketches</li> <li>4. Revise cost estimate</li> </ol>	

## FINAL PLANS

### General

1. For consultant projects the engineer shall become familiar with the requirements stated in the contract and the schedule for completion specified. It will be the Engineer's responsibility to meet the requirements stipulated. Submittals should be in accordance with the consultant's contract or in accordance with the coordinator's request. The plans are considered final only after the plans have been reviewed and commented on the advanced check prints (95%) and all corrections have been satisfactorily completed. In general, plans should be submitted at the 30%, 45%, 60%, 95% (ACP), 98%, 100%, and shall include completed and partially completed plans. For guidelines for final plan payment milestones for consultant projects, see page 28. Design computations are to be kept by the engineer until completion of the project. These computations are to be made available to the Department upon request. These computations should be subdivided into parts, such as substructure, superstructure, quantities, cost estimate, etc. Any changes required in the computations through the Department's review or otherwise shall be resubmitted with the final plans.
2. For in-house projects, the engineer may follow the plan development sequence guideline as stated on pages 4 through 8.
3. For consultant contracts the engineer shall prepare and submit a synopsis of the electronic data processing software which may be used in the design or the analysis of the bridges, retaining walls or other structural elements which have not been previously approved in the preliminary phase to the Bridge Design Engineer for his review and approval prior to its use. The Bridge Design Engineer may require that sample problems are run and the results reviewed in order to assure acceptability of the proposed software.

### Typical Bridge Details For Final Plans

Final Plans submitted to the Department for approval shall contain the following applicable data.

### INDEX TO BRIDGE PLANS

1. Index to include sheet numbers, and descriptive title of each drawing locating bent numbers, span numbers, special detail drawings, standard details, etc.
2. The Bridge Index may be combined with the General Index, which includes all plan drawings.

3. The General Index to all plans may be placed on the title sheet provided the index is not complex.
4. The index should be complete for ease of plan use.

#### GENERAL NOTES

1. General notes for the design and construction of all structures shall be combined into one sheet. There is usually a need for additional notes to be placed on structural detail drawings. A standard general note sheet is available through the Bridge Design Section, however modifications may be required to suit the particular project.
2. The General Notes should include the following: AASHTO design specifications under which the bridge structures are designed; the construction specifications under which the bridge structures are to be constructed; highway design speed, live load design vehicles, concrete instructions, reinforcing steel, welding structural metalwork, pile instructions, erection and construction procedures, etc.; all design criteria not specifically covered by the AASHTO design specifications, and any instructions considered necessary for the proper construction of the bridge structure.

#### SUMMARY OF BRIDGE QUANTITIES

1. The "Summary of Bridge Quantities" is a master summary for all bridge quantities. It shall include item numbers, item descriptions, units of measure, quantities for each item, sub-total quantities for each bridge and grand total for all bridge structures.
2. The grand total for each item from the "Summary of Bridge Quantities" must be included in the Master Summary of Estimated Quantities for the contract plans.

## BRIDGE PLAN AND PROFILE (GENERAL PLAN)

1. The plans shall include a plan and profile view of all bridge structures. The profile view should be detailed directly under the plan view, when practical.
2. The plan and profile drawings should include the following detail information when applicable. If any details on the general plan must be expanded upon because of complexity, a more specific detail sheet should be provided.
  - a) All bridge structures shall include finish grade (FG) elevations along the Profile Grade Line (P.G.L.) at all bent stations. Provide additional finish grade elevations at other locations, such as the gutterlines, if necessary for ease of construction.
  - b) Bridge profile to include stations along profile grade lines (or other control lines) at centerline of joint. The type, size, number and length of piles shall be shown. This information may be placed in tables, provided the tables and profile drawings are properly cross-referenced, and the bent information is properly correlated. The tables should be placed close to the plan and profile drawings. Blank spaces in the tables should be provided for the order length of piles.
  - c) Span length of each span along P.G.L.
  - d) Describe the type of spans to be used (prestressed concrete, welded composite girders, curved steel spans, etc.).
  - e) Spans and bents to be identified by number or some other method acceptable to the Department.
  - f) Location and description of permanent signing and lighting stations.
  - g) Location of expansion and fixed ends of spans.
  - h) Stopping sight distance and horizontal and vertical curve data if applicable.
  - i) The actual horizontal and vertical dimension clearances to the bridge structures for railroad, waterways or highway applications.
  - j) Show details identifying the type and limits of erosion control material such as riprap and flexible revetment including underground toes of slope.

- k) Plan view showing the location and width of traffic lanes and shoulders, both on and off the bridge. The fore and side slopes of the embankment, if applicable.
- l) Deck drainage, subsurface drainage, and existing utilities. Provide special drawings for complex bridge structures.
- m) Hydraulic data table, if required. Also the name of the waterway, direction of flow, high water and low water elevations and spur dike details if required.
- n) Guardrail details and layout data at bridge ends. May be placed on separate detail sheet if needed for more complex details.
- o) Location of test piles, core borings and cone penetrometer probing. This information is to be shown on the foundation plans when required.
- p) Location and description of temporary and permanent attenuators and backup walls for attenuators.
- q) Location of any required permanent or temporary sheet pile walls.

#### TEMPORARY CONSTRUCTION SIGNING, DETOUR LAYOUT AND SEQUENCE OF CONSTRUCTION

1. Temporary construction signing and sequence of construction detail sheets should be provided to direct existing traffic through the construction sites.
2. If a bridge or roadway detour is required for the project, plan and profile detail sheets of the detour, shall be included.

These sheets may either be provided in the roadway or bridge plans depending on the type of project.

#### FOUNDATION PLAN

1. A foundation plan shall be provided for all bridge structures (except as noted below) and shall include the following:
  - a) All necessary details, dimensions, angles, and controls for ease in locating the foundations for bridge structures.
  - b) Overlay of existing foundations to identify any potential conflicts with new foundations.
  - c) Footings for column bents shall include the type of footings (typical footings may be detailed on special drawings and tabulated as to Type A, B, C, etc.) the elevation of the bottom of footings, schematic location of piles, direction of

battered piles, bent numbers, station of centerline of each bent along profile grade line.

- d) Foundation plans are usually not required for trestle bent or drilled shaft type construction. However, complex bridgework may require foundation plans for these type foundations.
- e) Foundation plans are usually required for pier type construction and should include information described in items "a - c" above.
- f) Details and information required to construct the bridge foundations may be placed in tables. However, the information furnished in the tables should be properly correlated to the foundation drawings. Also, the tables should be located close to the foundation drawings.
- g) Actual maximum pile or shaft loads should be shown in the plans for each pier or bent. Maximum soil pressure (dead load, live load) should be shown in the plans for other foundation types such as spread footings and retaining walls.

SPECIAL DETAILS, (spans, girders, bents, piers, footings, approach slabs, joints, bearings, retaining walls, etc.)

1. The design drawings shall include full details showing type of construction details of all structural members, connections, and splices and summary of quantities for each structural item.
2. All the structural drawings shall be to scale.
3. Tables may be utilized for similar structural items and details - provided the information in the tables and the detail drawings are properly correlated.
4. A deformed reinforcing steel summary of quantities is to be provided in the plans (including bar bending details) for each part of the bridge structure (spans, including precast concrete girders<sup>5</sup>, bents, piers, footings, columns, etc.). Dimensions relating to reinforcing steel fabrication are out-to-out of bar. Dimensions relating to reinforcing steel spacing are center-to-center of bar.
5. Listed below is some general information, which should be included in the plans when applicable.
  - a) Camber diagrams for proper fabrication of bridge members and construction of superstructure. Camber diagrams to include separate ordinates for beam dead load and any dead load to be placed upon the member (such as bridge barrier,

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<sup>5</sup> The reinforcing estimated quantities provided for such structure parts as precast-prestressed concrete members paid for per linear meter are for information purposes only. In such case as this, estimated quantities should be provided for a example (or nominal) members of each type.

curb, handrail, wearing surface) after the deck concrete is poured. Final camber ordinates must include correction for vertical curves.

- b) End and intermediate superstructure diaphragms to be located relative to centerline of joint.
- c) Bearing assemblies are to be fully detailed and the finished bearing elevation of each bearing are to be shown (in tables or special details).
- d) Beam dead load reactions for all bridge structures.
- e) Live load and dead load moments and shears for all steel spans. For curved steel spans show LL + DL moments and shears at 20th points.

#### DEEP BRIDGE BORINGS

- 1. The core boring sheets should include a list of all piles showing type of pile, design pile loads, pile number, sheet pile cut-off elevations, pile tip elevations and pile length. Large projects may require a table listing all pile information.
- 2. A soil profile shall be provided for major bridge structures.

#### STANDARD BRIDGE PLANS AND DETAILS

The Bridge Design Section maintains standard plans and details for various structural bridge members, permanent signing and guardrail. These standard bridge plans and details may be obtained upon written request to the Bridge Design Engineer for incorporation into any DOTD project. These standard plans and details should be included in the final plans when they can be used. For more information, refer to chapter 8.

#### MOVABLE BRIDGES

The final plans for mechanical drawings shall show complete layouts of the mechanical systems. All parts to be completely detailed and all commercial equipment shall be completely specified. A complete "bill of materials" shall be included in the mechanical plans. Since the Department has its own method of presenting mechanical drawings, the Engineer should become familiar with the detail practice of the Bridge Design Section prior to beginning any work. Details for the mechanical system should be similar to details usually presented in mechanical shop drawings.

#### ELECTRICAL PLANS

- 1. The final plans shall include complete electrical plans, including conduit and equipment layout; control schematics; and complete details of all fabricated, assembled, or otherwise made-up parts; and complete specifications of all



commercial equipment and apparatus. Furnish complete design of electrical and illumination systems and of all components. Since the Department has its own method of presenting the wiring diagrams, the Engineer should become familiar with the detail practice of the Bridge Design Section prior to beginning any work.

2. The plan shall include complete power and control elementary wiring diagrams with all conductors and equipment and apparatus identified; complete conduit and wire layout; detail drawings and equipment list.
3. When necessary, written special provisions shall be supplied.
4. The Engineer shall be responsible for obtaining written confirmation from the utility company as to their ability to supply proposed load.

#### PERMANENT SIGNING PLANS

1. For projects requiring permanent signing, separate detail sheets showing the signing layout, signing quantities and specific signing details are required. The permanent signing is normally coordinated through our Geometric Design Section.
2. Permanent signing standard details are maintained by the Bridge Design Section. These details include small ground signs (breakaway) and large overhead signs. Structure mounted special support details (bridge, median barrier, retaining wall, etc.) for large overhead signs are not shown on the standard sign details; these must be designed and detailed on an individual basis for each specific sign when required.

#### Bridge Plans In Final Form (A.C.P.'s submittal procedure)

1. The Engineer shall submit "reproducibles" of the "Advance Check Prints" (95% Final Plans) along with any required special provisions and a construction cost estimate for review and comments. Each sheet must be stamped by a Civil Engineer registered by the State of Louisiana.
2. The plans, specifications, and estimates are to be reviewed by the Department of Transportation and Development and others that may be involved such as the Federal Highway Administration, etc. The Department will advise the Engineer of all comments, errors and omissions relative to the plans, specifications, and estimate; which shall be revised and/or corrected by the Engineer. Please be advised that this is only a cursory check and the Engineer is responsible for the accuracy and completeness of the plans.
3. The Engineers are to work closely with the Department in order that the final plans, specifications and estimates may be completed and ready for the proposed contract letting date.

Final Plan Payment Milestones Table

PAYMENT MILESTONE	TASKS	BRIDGE	COMMON	ROAD
30 % Distribution	Completed	<ol style="list-style-type: none"> <li>General plan</li> <li>Framing plan</li> <li>Superstructure design</li> </ol>		<ol style="list-style-type: none"> <li>Submit final typical sections for review &amp; approval</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>Foundation layout</li> <li>Lighting and signing design</li> <li>Superstructure details</li> <li>Substructure design</li> </ol>		<ol style="list-style-type: none"> <li>Review R/W maps</li> <li>Finalizing hydraulic design</li> <li>Finalizing vertical &amp; horizontal geometry</li> <li>Finalizing construction notes</li> </ol>
60% Distribution	Completed	<ol style="list-style-type: none"> <li>Superstructure details</li> <li>Substructure design</li> <li>Foundation layout</li> <li>Lighting and signing design</li> </ol>	<ol style="list-style-type: none"> <li>Submit for sequence of construction and construction signing review</li> </ol>	<ol style="list-style-type: none"> <li>Submit for final drainage</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>Substructure details</li> <li>General notes</li> <li>Summary of quantities</li> </ol>		<ol style="list-style-type: none"> <li>Summary sheets</li> <li>Joint Layouts</li> <li>Graphical grades</li> </ol>
90 % Distribution	Completed		<ol style="list-style-type: none"> <li>Pre-ACP submitted for review prior to distribution</li> </ol>	
95 % Distribution	Completed		<ol style="list-style-type: none"> <li>Advance Check Print distribution</li> <li>Cost estimate</li> </ol>	
	In Progress		<ol style="list-style-type: none"> <li>Special Provisions</li> </ol>	
98 % Distribution	Completed		<ol style="list-style-type: none"> <li>ACP comments addressed</li> <li>Final cost estimate</li> <li>Entire set of original plan sheets transmitted to Contracts Unit</li> <li>Special provisions</li> </ol>	
100 %	Completed		<ol style="list-style-type: none"> <li>Plans, Specifications &amp; Estimate</li> <li>Plans &amp; Estimate transmitted to General Files</li> </ol>	

## **CONSTRUCTION ENGINEERING SERVICES**

For those engineering contracts in which the Engineer is to provide services pertaining to review and approval of construction contractor's shop drawings and/or working drawings; listed below are comments relative to these services:

Once the Department authorizes the construction contractor to begin work on the project, the Engineer shall provide such services as are required to check and approve shop bills, shop drawings, and other working drawings. Final Checked Prints shall be stamped "Approved" and dated, and one (1) print of each shall be retained by the Engineer; and the remaining 8 prints of each drawing shall be distributed by the Engineer.

The distribution by the Engineer will be to the following:

Number of plan sets	Department/organization
2	DOTD Construction Engineer (headquarters.) Attn: DOTD Fabrication Engineer
1	DOTD Materials Engineer
1	DOTD District Administrator
2	DOTD Project Engineer
1	Fabricator
1	Contractor

A note will be shown on the transmittal letter for distribution of the drawings stating that the DOTD Structural Fabrication Engineer shall be given notice (10) working days before work is to begin. The engineer will also be required to examine all erection drawings submitted.

# **DESIGN POLICY GUIDE FOR BRIDGES AND STRUCTURES**

## **GENERAL**

The information contained herein is to set forth a design policy guide for the Engineer to follow in preparation of bridge plans, specifications, and estimates. These criteria are supplemental to the latest Department design standards, (freeways, arterials, collectors, and local roads and streets); any project memorandums written to the engineer by the project coordinator or the Bridge Design Engineer; and the AASHTO Standard Specifications for Highway Bridges, latest edition, along with current Interim Specifications.

Final design and preparation of contract plans will be based on the applicable part of these design criteria and preliminary plans as approved by the Louisiana Department of Transportation and Development, the Federal Highway Administration, and others.

Refer to other chapters in the Bridge Manual for specific design criteria not covered in this section.

## **DESIGN**

### **SPECIFICATIONS:**

#### Design Specifications

- a) AASHTO "Standard Specifications for Highway Bridges", latest edition, with current interim specifications and all other pertinent specifications referenced in Chapter 3 of this manual.
- b) "Bridge Design Manual" prepared by the Bridge Design Section of the Louisiana Department of Transportation and Development.
- c) Memorandums and any revisions to the "Bridge Design Manual" issued by the Bridge Design Engineer periodically.
- d) Project structural design criteria shall govern over the above specifications.

### Construction Specifications

- a) Latest approved Louisiana DOTD Standard Specifications for Roads and Bridges.
- b) Special provisions and supplemental specifications.

### Welding Specifications

Welding of structural steel, steel pipe and tubular members, reinforcing steel and aluminum alloys shall conform to Section 815 of the latest edition of the DOTD Standard Specifications for Roads and Bridges.

### Loading

- a) Dead Load - Calculated weight of structure plus  $60 \text{ N/m}^3$  future wearing surface. Dry weight of earth  $20 \text{ kN/m}^3$ ; equivalent fluid pressure  $9.8 \text{ kN/m}^3$ .
- b) Live Load - Design Live Load shall be AASHTO designation MS-18 Truck or Lane Load or HST-18(M) Truck Load, whichever governs except that HST-18(M) shall generally not be used for local roads and streets except where heavy truck traffic exists. Alternate Military Load shall be applied on the Interstate System. Only MS-18 Truck or Lane Loading shall be used for fatigue design when applicable. For two design traffic lanes, the load lanes may be adjacent to and touching one another, causing the wheel loads to be 1.2 meters apart.
- c) Wind Loads - Wind forces are to be applied in accordance with the AASHTO Specifications.
- d) Seismic Loading must be investigated in accordance with the AASHTO Specifications (Guide Specifications for Seismic Design of Highway Bridges).
- e) Other loads such as temperature and stream forces shall be in accordance with the latest AASHTO specifications.

### Materials and Required Strengths

- a) Reinforcing Steel - Reinforcing steel bars shall be Grade 420.

- b) Prestressing Strand - Prestressing strand for precast prestressed AASHTO girders shall be 13 mm nominal diameter uncoated seven (7) wire low relaxation strands of ultimate strength 1860 MPa.
- c) Concrete
  - 1) Concrete for frame bent footings, columns and caps, pile bent caps, and abutments shall be Class "A" as defined by the Standard Specifications. With a design strength of 22 MPa.
  - 2) Concrete for deck slab, approach slabs, diaphragms, and barrier railing shall be Class "AA" as defined by the Standard Specifications with a design strength 24 MPa.
  - 3) Concrete for prestressed concrete AASHTO girders shall be Class "P" with a  $f'_{ci}$  (initial) of 30 MPa and a 28 day  $f'_{c}$  of 40 MPa . Class "P(M)" with a  $f'_{ci}$  (initial) of 35 MPa and a 28 day  $f'_{c}$  of 45 MPa . Girder designs requiring higher concrete strengths shall have Department approval prior to inclusion into final design plans.
  - 4) Concrete for prestressed concrete piles shall be Class "P" with a  $f'_{ci}$  (initial) of 28 MPa and a 28 day  $f'_{c}$  of 35 MPa .
  - 5) Drilled Shafts shall be class "S" concrete.

Superstructure Design: Refer to Chapter 5 for further information.

Substructure Design: Refer to Chapter 6 for further information.

Bridge Embankments and Retenments: Refer to Chapter 6 for further information.

Environmental/permit information: Refer to Chapter 7 for further information.

### Utilities

Provisions will be made for any utilities on or within any structure when deemed necessary. Existing utilities will be relocated when required.

### Lighting and Permanent Signing

Supports for signs and luminaries, including anchor bolts, nuts, and washers, shall be detailed in the plans. See Chapter 10 for permanent signing information.

## DETAILS

### Detailing Practices

1. The plans shall be prepared in conformance with the General Guide for Bridge Plan Preparation and Chapter 9 of this manual.
2. Reinforcing
  - a) All reinforcing shall be detailed in accordance with the Code of Standard Practice of the Concrete Reinforcing Steel Institute.
  - b) All bending dimensions shall be "out-to-out".
  - c) No allowance shall be made in bar lengths for bends, except for hooks. Maximum bar lengths shall be 13 m for No. 10 bars, and 19.5 m for No. 15 bars through No. 35 bars. Bar sizes greater than No. 35 bars will not be permitted. Lap splices shall be as specified by AASHTO.
  - d) The minimum concrete cover from the surface of the concrete to the face of any deformed reinforcing bar shall not be less than the following:  
  
Top of deck slab = 50 mm  
Bottom of deck slab = 25 mm  
All other reinforcing bar cover shall be 50 mm unless otherwise noted in plans.
  - e) Complete bar lists shall be placed with each unit of the structure on the final plans.

## MISCELLANEOUS

1. Summary of Quantities - When preparing contract plans with test piles, it is mandatory that certain items be included in the bridge summary of quantities. Refer to Chapter 6 for test pile information.
2. Design computations shall be maintained by the Engineer and shall be neatly arranged, clearly identified and bound. This information will be available upon request by the Department. Quantity computations and cost estimates will be prepared similar to design computations and submitted with the final plans. All computations should be stamped by a licensed Louisiana Professional Engineer.
3. When plans are submitted to the Department of Transportation and Development by a Consultant Engineer for review, such plans shall be accompanied by a written certification from the Engineer that a detailed check has been made prior to submission.



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## **METRICATION UPDATE**

Metric update of this chapter has been postponed until the National/State Policy and Guideline Criteria is established and approved by the AASHTO Bridge Committee. AASHTO and other national manuals (MUTCD, Recording and Coding Guide, Manual for Condition Evaluation of Bridges, NBI/NBIS/FHWA transmittals and directives, truck size and weight issues) are not completed and not expected to be published or available to the States. In the near future the Department's policy will be developed after we receive the National/State policy. Until such time, this chapter will remain in English system although all other chapters in the manual have been converted to metric.

## **BRIDGE REPLACEMENT PROGRAM**

### **METHOD FOR SELECTING AND PROGRAMMING BRIDGES FOR REPLACEMENT AND REHABILITATION**

The priority for the selection of bridges for replacement or rehabilitation with federal bridge replacement funds is established by the following three (3) parameters:

1. Structural adequacy
2. Functional adequacy and serviceability
3. Essential for public use

More specifically, the following information is compiled to make up the above referenced parameters: structural deficiency, posted bridges (weight limits below statutory limits), traffic count (ADT), class of highway, available detour routes, bridge geometry (particular bridges < 20' wide), bridge inspection reports, and district recommendations for replacement (submitted annually).

The Federal Highway Administration has developed a formula for prioritizing bridges that evaluates the above parameters, and provides an overall rating for the bridge called the "sufficiency rating". The sufficiency rating assigns a numerical value ranging from 0 to 100 to a given bridge with the following percentage points applied to each parameter:

Structural adequacy	55
Functional adequacy and serviceability	30
Essential for public use	<u>15</u>
	100

A bridge must be at least 20' in length to qualify for replacement or rehabilitation funds. For the purpose of applying the National Bridge Inspection Standards (Code of Federal Regulations 23 Hwy. Part 650) and the Federal Highway Bridge Replacement and Rehabilitation Program (HBRRP) and in accordance with the AASHTO Highway Definitions Manual. A "bridge" is defined as a structure including supports erected over a depression or an obstruction such as water, highway or railway and having a track on passageway for carrying traffic or other moving loads, and have an opening measured along the controls of the roadway of more than 20 feet between undercopings of abutments, or string lines of arches or extreme ends of openings for multiple boxes. It may also include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening. See sketch on page 2 (6) for defining length L.

A sufficiency rating of less than 50 and classification as structural deficient or functionally obsolete is required to qualify a bridge for replacement, whereas, a sufficiency rating of less than 80 will qualify a bridge for rehabilitation. Although the sufficiency rating accounts, in large degree, for the factors mentioned above, a subjective review of all pertinent data is followed in the selection process. Most of the information mentioned above is available on the computer (CICS - STRM mainframe database file), and can be obtained from the Department's Bridge Maintenance Section. This information can be grouped and sorted as required to aid in the bridge selection process. The following is a discussion of the three major parameters:

#### Structural Adequacy

This is determined from a list of posted bridges, bridge inspection reports, district recommendations, and is part of the sufficiency rating. This is the most important factor in the evaluation process as a bridge failure could be catastrophic. The actual field conditions of the bridge are determined by reviewing the bridge inspection reports. The recommendations from the districts, which reflect first hand knowledge of the relative condition of the various bridges in their jurisdiction, are also very helpful in determining structural adequacy.

#### Functional Adequacy and Serviceability

This is determined from the bridge inspection reports, district recommendations, and is part of the sufficiency rating. The geometry of the bridge is evaluated in the bridge inspection report. Generally, the most important factor of the bridges' geometry is the clear roadway width. Narrow bridges, if they are structurally adequate, can be widened rather than replaced. Serviceability is related to factors like stream scour, maintenance of movable bridges, and deck deterioration, etc. The frequency and severity of marine, railroad and automotive traffic accidents are also important factors. They are reflected in the bridge inspection reports and district recommendations.

#### Essential for Public Use

This is determined by the traffic count, class of highway, available detour routes, and is part of the sufficiency rating. The structural and functional adequacy of the bridge is evaluated in conjunction with the traffic count in order to minimize the exposure of motorists to unsafe conditions. If two bridges exist with the same degree of inadequacy, the one with the higher volume of traffic would receive the greatest priority. Additionally, if the bridge is on a truck or school bus route or crosses a major river or stream, it would, similarly, receive extra attention. Non-redundant routes (those without available detours) would have a higher priority than redundant routes.

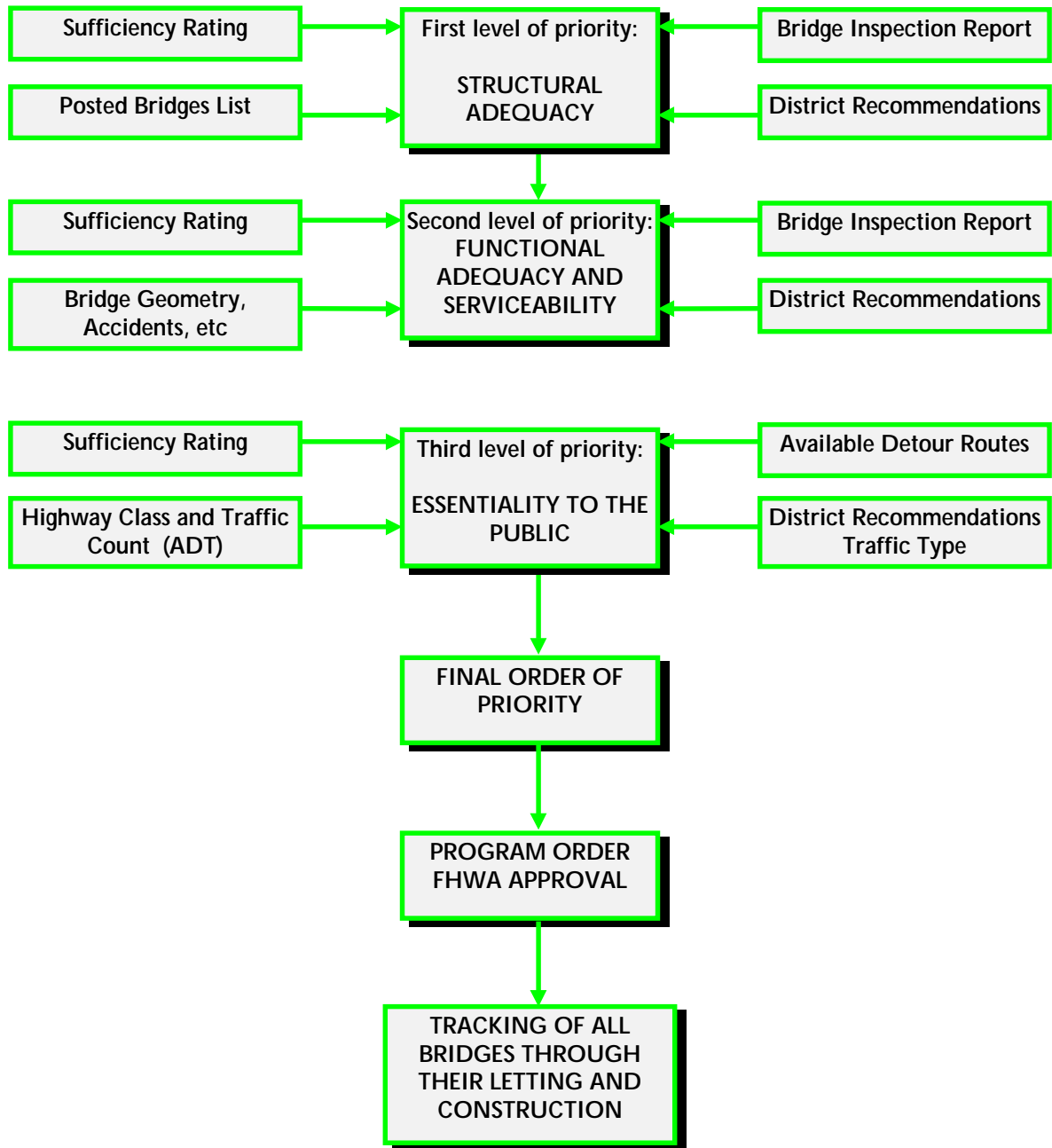
Although there are numerous ways that the referenced data can be used in the selection process, one recommended procedure involves the compilation of three lists:

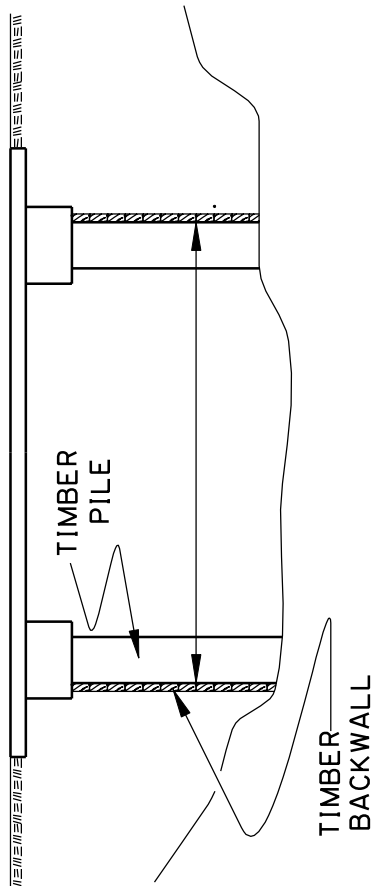
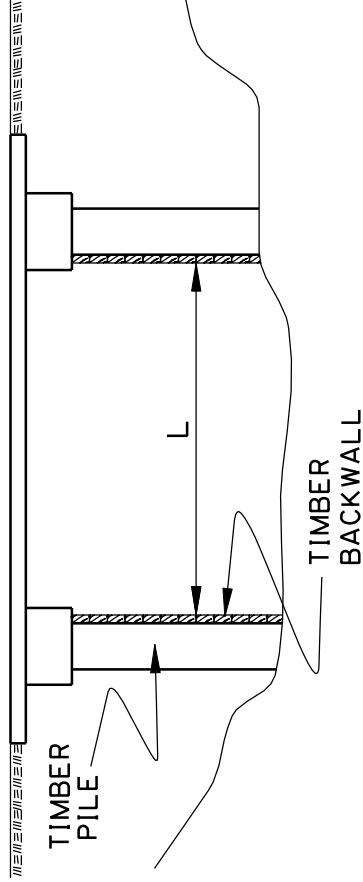
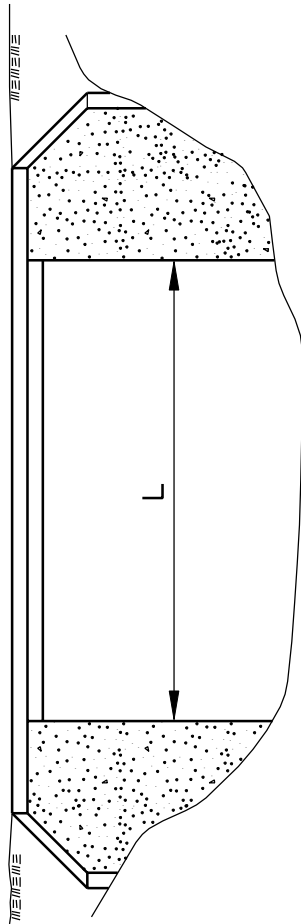
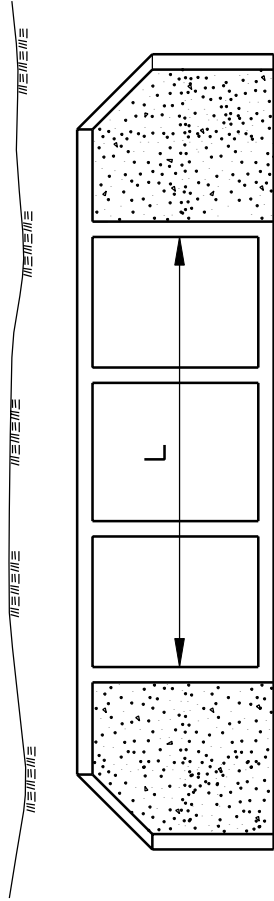
1. Bridges with the lowest sufficiency rating.
2. Bridges with the highest priority district recommendations.
3. The most severely posted bridges.

Generally, if a bridge appears on all three of these lists, it will have a high priority for replacement. All of the information previously mentioned should be considered when compiling these lists. It is important to achieve some degree of balance between the number of bridges replaced or rehabilitated in each district. Grouping of bridges into projects is another consideration. For example, if a bridge on a section of highway has a lower priority for replacement than other structures on either side of it, serious consideration should be given to including it with the other bridge replacements. If the structure does not qualify for bridge replacement (sufficiency rating of  $> 50$ ) but is deemed in need of replacement by the bridge engineer, optional funding (NHS, STP or State) will be necessary

In some instances, it may be desirable to schedule field trips to inspect various bridge sites to obtain a more adequate understanding of their relative priority. Close communication with the districts is desirable.

Selection of Bridges In Need of Replacement and Rehabilitation Flow Chart

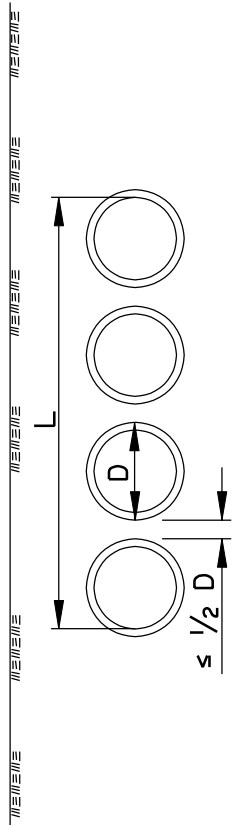




NOTE: IF  $L \geq 6.1\text{m}$ , THE STRUCTURE IS CONSIDERED A BRIDGE AND THEREFORE ELIGIBLE FOR FEDERAL BRIDGE REPLACEMENT FUNDS.

### NBIS DEFINITION

STRUCTURE "BRIDGE" LENGTH MEASUREMENT CRITERIA



## **RATING AND INSPECTION OF BRIDGES DEFINED**

Louisiana is in compliance with FHWA/AASHTO requirements. The Bridge Design Section is responsible for rating all structures on the State Maintained System. All bridge structures are rated at two stress levels (inventory and operating). Any structure that has an operating stress rating of less than 3.0 tons will be recommended for closure to any vehicular traffic. The Bridge Maintenance Section is responsible for establishing the bridge inspection policy. All Louisiana bridges are inspected at two-year maximum intervals. It is the responsibility of the city or parish authority to rate off-system structures within its jurisdiction. Presently all timber span structures are rated by our Bridge Maintenance Section. If a bridge is not capable of carrying statutory loads, it is posted for a lesser weight limit in accordance with EDSM 1.1.1.8. Most structures in poor condition are re-rated in accordance with EDSM 1.1.1.15.



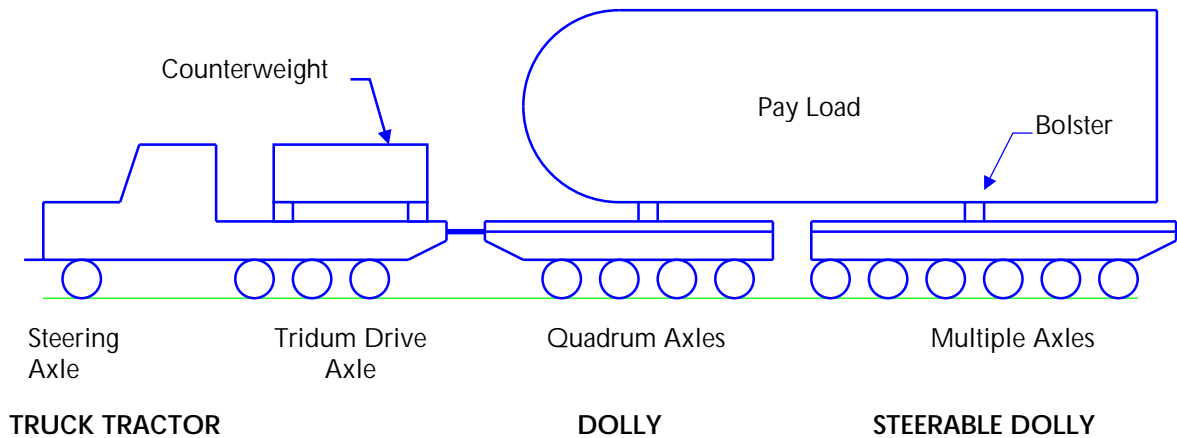
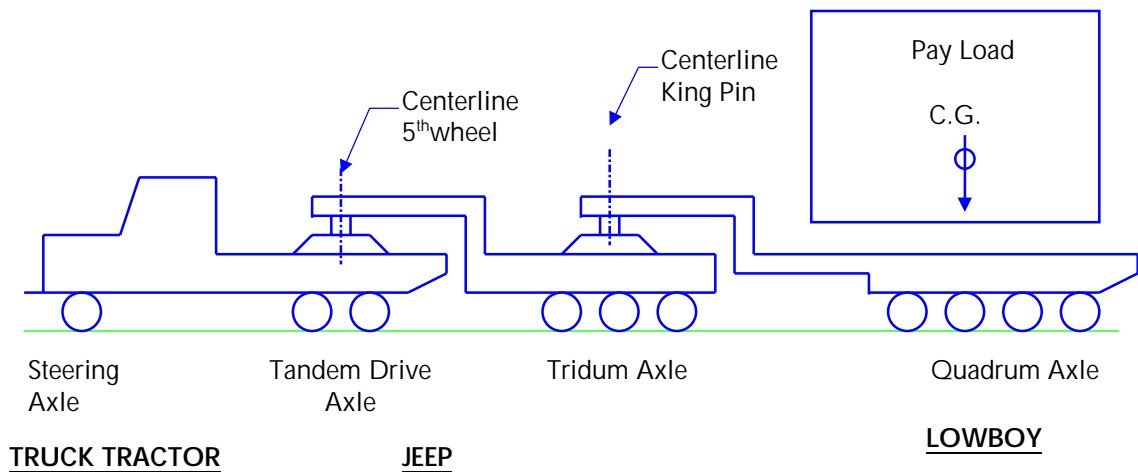
# INVESTIGATION OF OVERWEIGHT VEHICLES

## INTRODUCTION

The Truck Permits Office requests an investigation by the Bridge Design Section for a proposed passage of an overweight vehicle. They grant a permit based on the recommendation of Bridge Design that will specify the use or conditional use of any bridge involved. Presently, bridge design only reviews vehicles that weighs in excess of 254,000 pounds and/or that have an axle weighing in excess of the legal maximum allowable amount as given in the latest "Louisiana Regulations for Trucks, Vehicles, and Loads" published by the Louisiana Department of Transportation and Development. The proposed vehicle combination is reviewed, and then the bridge or bridges involved are structurally analyzed for the resulting capacity with according to the AASHTO Design Specifications and the AASHTO "Manual for Condition Evaluation of Bridges".

Review of the Proposed Overweight Vehicle:

## TWO TYPICAL OVERWEIGHT VEHICLE COMBINATIONS



## TERMINOLOGY

General definitions are given in the previously mentioned references and AASHTO's "Recommended Policy on Maximum Dimension and Weights of Motor Vehicles to be Operated Over the Highways of the United States". Some specific definitions are as follows:

- a) A vehicle is a device in, upon, or by which any person or property may be transported or drawn upon a highway except devices powered by humans or used exclusively on stationary rails or tracks.
- b) A hauling unit is a combination of vehicles connected together in a series.
- c) A tractor is a motorized vehicle, which steers and propels the vehicle combination.
- d) A lowboy is a low, usually flat platform upon which the payload is placed.
- e) A jeep is a vehicle connected between the tractor and the lowboy when necessary to distribute one reaction from the lowboy to more axles than provided by the tractor.
- f) A dolly is a low, flat platform upon which one end of the payload is placed.
- g) A booster unit is one or more axles mechanically attached to the rear of a vehicle as a unit to provide a lifting effect to the rear and increase the number of effective axles. It can be a temporary or permanent addition.
- h) A connection is a load transfer point which consists of a kingpin and a fifth wheel and which allows rotation and easy assembly.
- i) A kingpin is usually a steel pin located in the gooseneck of a lowboy or jeep, which is inserted into the center of the fifth wheel. Its location is often adjustable.
- j) A fifth wheel is a disc located over or forward of the rear tractor axles and forward of the jeep unit's axles, is usually attached through a hinge mechanism to the frame of its unit, and is designed to accept loads transferred from the gooseneck. It allows the trailing unit to swivel about the kingpin and its location is often adjustable.
- k) The tare weight is the weight of the vehicle.
- l) The pay weight is the weight of the load to be carried and is often referred to as the payload.
- m) The gross weight is the sum of the tare weight and the pay weight.

## INFORMATION TO BE FURNISHED BY THE PERMIT REQUESTER

Trucking companies that apply for overweight permits are not always able to properly determine the vehicle combination and load configuration. Thus it is necessary that the permit requester submit the following information for the reviewer to verify the weight distribution to the axles. The tare weight, the pay weight, and the gross weight have to be given separately.

- a) The location of the centerline of each axle
- b) The location of the connections to the jeep and tractor
- c) The location of the bolsters and other load points
- d) The spacing and size of wheels on each axle
- e) The length and width of flat beds
- f) The maximum height of the loaded vehicle
- g) The location and orientation of the payload on the vehicle
- h) The overall dimensions of the payload to be hauled on the plan, side and end elevation views
- i) The location of the center of gravity of the payload
- j) The pay weight in pounds
- k) The tare weight of each axle in pounds
- l) Maximum tire load for each axle and
- m) Centerline transverse spacing of each group of wheels

Tare weights can best be obtained by weighing the empty vehicle combination assembled. Occasionally this is not practical or convenient, and the weights of the individual components are used. For the purposes of checking, an estimated weight of axles can be used by assuming that each four-tire line axle weighs 2,000 pounds, increasing this weight by 500 pounds per each additional tire and then distributing the remainder of the weight equally between the kingpin and the axle group.

If there is confusion over the vehicle combination, there are three possibilities that may help: photographs of the various suspension systems and components, a manufacturer's drawing or a field trip may be necessary.

## INFORMATION TO BE FURNISHED BY PERMIT OFFICE

A good quality copy of the state, parish, and/or city map marking the proposed route to ensure that the route to be reviewed is the correct one.

## SUSPENSION SYSTEMS

- a) A conventional mechanical system is a combination of levers and pins, which distribute loads evenly to the axles. The levers are referred to as "walking beams" and the pins are referred to as trunnions. This system is being replaced more and more by pneumatic and hydraulic systems, which are considered equal or superior to the conventional mechanical ones.
- b) A pneumatic system distributes the load evenly to the axles by maintaining constant gas pressure. It becomes totally inoperative if it malfunctions, but otherwise it is considered fully capable of distributing the load as specified in the analysis section given below. The system reacts and adjusts quickly to pressure changes due to variations in the pavement elevation and, therefore, is used in vehicles that are driven at high speeds.
- c) A hydraulic system operates similarly to a pneumatic system except it maintains constant fluid rather than gas pressure and does not react and adjust quickly to pressure changes due to variations in the pavement elevation. It is, therefore, used in vehicles that are driven at slow speeds that allow time for changes.
- d) The suspension system for a booster unit can be independent from the vehicle to which it is attached and may be mechanical or pneumatic. Hydraulically suspended booster units are not allowed because of their inability to quickly adjust to variations in the pavement elevations.

The vehicles comprising the hauling unit may have the same or different types of suspension systems. A specific vehicle may have a hydraulically suspended booster unit while the rest of its system is a conventional mechanical one. Vehicle units are available. However, they are entirely suspended by pneumatic or hydraulic systems.

## ANALYSIS

1. Locate the path across the bridge for the overweight vehicle that would create the least overall stress on the components of the bridge.
  - a) For concrete decks, the location might be where the wheels are close to the longitudinal members and not centered between them.
  - b) For longitudinal members, the location might be where the wheels are over the maximum number of the members.
  - c) For roadways cantilevered from a central support, the location might be as near to the support as practical.
  - d) Generally, the location is where the centerline of the overweight vehicle coincides with the centerline of the bridge.
2. Distribute the wheel loads according to engineering judgment.
  - a) AASHTO wheel distribution factors are not applicable to the widely spaced four tire line axles (distance center to center of dual tires greater than 6'-0") or the eight tire line axles.
  - b) For concrete decks, the transverse distribution can be taken as simply supported with a continuity factor applied and the longitudinal distribution as the analyst decides to be appropriate.
  - c) For longitudinal members, the transverse distribution could be according to how the analyst thinks the members will carry it.
3. Ignore the booster units in the first analysis of bridges that are to carry the vehicle combination proposed and use them only if they are determined necessary to reduce the bridge stresses to an acceptable level. The amount of load transferred to a booster unit in a positive way is difficult to determine other than by obtaining the weight of the unit's axles deactivated and then fully activated on truck weighing scales. Since these add-on type axles are not necessary to the successful operation of the conventional units to which they are attached, it is possible for them to malfunction or, inadvertently, not be activated resulting in a much different distribution of the load. The first analysis will give the analyst insight to potential problems that a deactivated condition could cause.
4. Restrict or eliminate entirely the other traffic on a bridge during the passage of an overweight vehicle.

5. Reduce the live load impact determined according to AASHTO specification or eliminate it entirely by requiring the vehicle to proceed at crawl speed (5 mph or less) while on a bridge other than a timber one.
6. Do not subject timber bridges to a crawl speed by an overweight vehicle since impact is not a consideration and timber is adversely affected by the increased duration of load. A speed of 15 mph, or more, depending upon the smoothness and general condition of the bridge deck is appropriate.
7. Compute stresses in a bridge at an absolute maximum of the operating stress level. This may be reduced if justified by poor structural condition of a bridge that cannot be verified by physical examination and measurement.
8. Do not analyze bridge substructures and foundations as well as box culverts and pipes unless their capacity is in question due to the relative size or configuration of the proposed vehicle combination.

# **STRUCTURAL RATING OF BRIDGES**

## **INTRODUCTION**

Structural rating deals with determining the load carrying capability of a bridge. This determination is made based on information gained from an in-depth inspection of the structure and the review of the "as-built" plans. The ultimate result of structurally evaluating all bridges accordingly is to provide a uniform, relative, load carrying capacity of all bridges, accounting for their "as-built" and current conditions.

## **SCOPE**

This article presents an approach to determining the live load carrying capacity of any given structure. It is limited to only the method and not a complete analysis of an entire structure in detail. The details of the analysis are governed by the "Manual for Condition Evaluation of Bridges" published by AASHTO, henceforth referred to as the manual.

## **COMMENTARY**

Structural rating of bridges as presented in the manual leaves a great deal of latitude in approach and procedure. Bridges may be rated by any of several vehicle configurations which include the standard AASHTO live load, "typical" legal vehicle configurations presented in the manual, or the legal vehicle configuration of any given state.

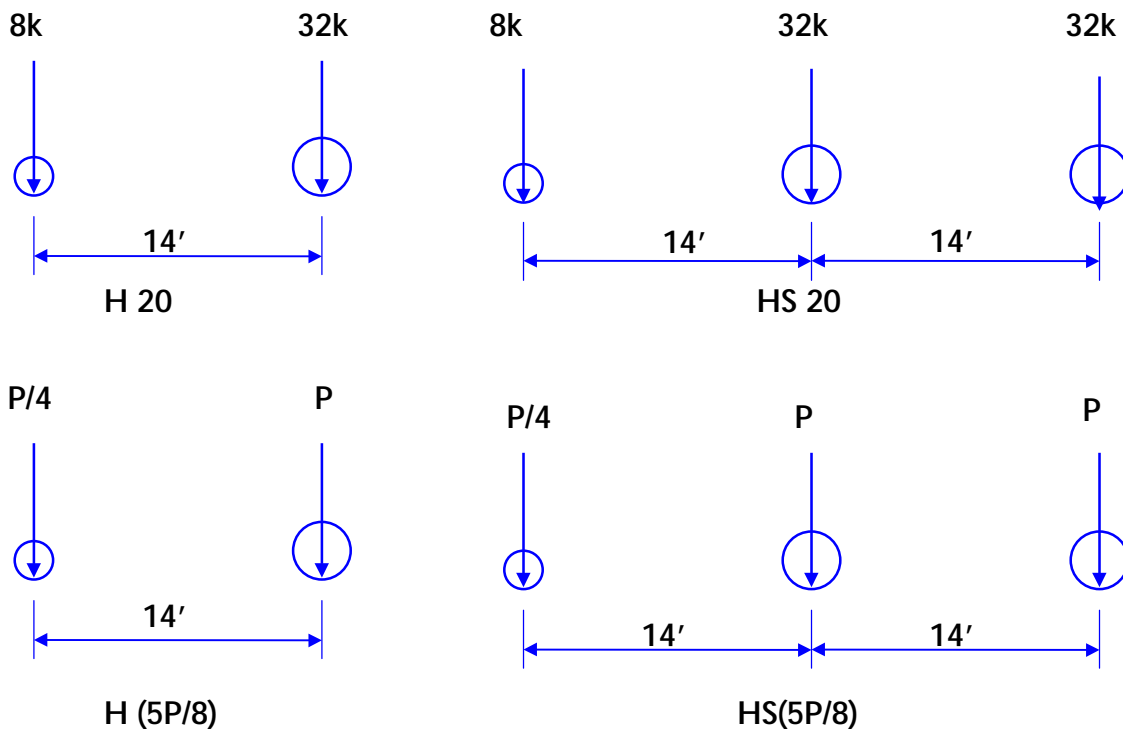
The importance of the structural rating of bridges both qualitatively and quantitatively is to determine the relative strength and safety of all the bridges on a highway system for the more obvious reason to protect the motoring public. The information will allow planners to determine the critical structures on a route that may be repaired, modified, or replaced to upgrade the whole route and permit commercial truck traffic with the least restricted condition.

There are many philosophical approaches to rating bridges. Some states determine the carrying capacity of bridges in terms of the maximum legal vehicle and/or permit vehicle a bridge can carry. Another approach that has favor of the Department is the use of the standard AASHTO load configurations (lane loads and truck loads) which are based on the "H" or "HS" truck followed by a number which is linearly interpolated or extrapolated from the usual "H" and "HS" 15 and 20.

It is felt that the latter approach will realistically depict the relative strength of bridges and that it is more readily understood by other agencies which may have use for the data but may not be familiar with the State's legal load configuration. Due to the severe wheel weight application of the "H" and "HS" trucks, a third vehicle configuration is added to avoid unnecessarily severe posting restrictions on bridges.

## ANALYSIS

1. The structural analysis of load carrying capacity of any particular bridge shall be limited to the structural carrying capacity of the prime structural members under normal loading. The loads to traffic rails, lateral systems, and such are not considered as normal loads. These items will be graded qualitatively.
2. The method of determining the "H" or "HS" truck load rating is as follows:
  - a. The axle loads are in algebraic symbols in the same proportion and spacing as the "H" and "HS" loads.



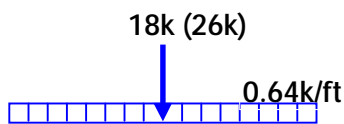
The H-20 truck is a 20-ton vehicle with two (2) axles with a rear to front weight ratio of four (4) to one (1). The HS-20 truck is a 36-ton vehicle with three (3) axles and rear to front axle ratios of 4:4:1. The 20 represents the sum of the weights of the front and adjacent axles in tons. The normal unit of weight for the axles is the kip or kilopound.

- b. The stress caused in each part of the structure is calculated in terms of "P", which includes live load and impact.
- c. The net maximum stress in the respective members is determined. This is the total allowable stress less the dead load stress that results in the stress reserved for live load and impact.

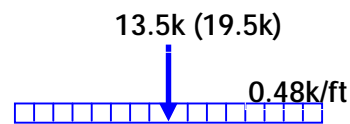


- d. The net maximum stress and the stress in terms of "P" are equated and the value of "P" is determined in kips.
  - e. The "H" or "HS" number as used will be  $5P/8$ .
3. The method of determining the "H" or "HS" lane loading is derived in a similar fashion as the trucks' loads. The loads are applied according to the applicable AASHTO Specifications as follows:

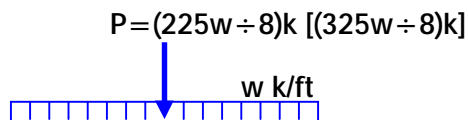
a. Lane Loads:



H20 and HS20



H15 and HS15



H(125w+4) and HS(125w+4)

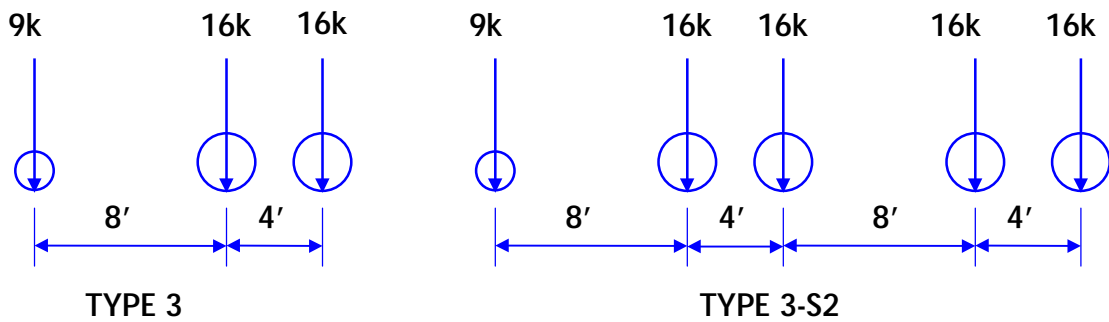
- b. The stresses in each part of the structure caused by the live load and impact are determined in terms of the uniform load "w" in kips per foot.
- c. The net maximum stress in the respective members is determined.
- d. The net maximum stress and the stress in terms of "w" are equated, and the value of "w" is determined in kips per foot.
- e. The "H" and "HS" number is calculated as  $125w \div 4$ .

4. The method of determining the "H" wheel load to bridge deck slabs will be computed as provided in the AASHTO specifications and as follows:



The same steps are used as described in computing truck loads under 2.b. through 2.d.

5. Posting vehicle configurations are utilized and evaluated similarly to the AASHTO "H" and "HS" vehicles and have the following configuration:



# **WEIGHT LIMITS FOR DEFICIENT BRIDGES IN LOUISIANA**

## **INTRODUCTION**

Louisiana law, as applicable to interstate highways, allows triple axle weights up to 42,000 pounds, maximum, tandem axle weights up to 34,000 pounds, maximum, single axle weights up to 20,000 pounds maximum, and a weight of 650 pounds per linear inch of tire tread width, maximum. For non-interstate highway see Louisiana Regulation for Trucks, Vehicles, and Loads. Assuming the typical truck tire to have a ten (10) inch tire tread width, the maximum steering axle weight could typically be 13,000 pounds. The maximum legal vehicle weight is 80,000 pounds with the exception of the Type 3-S3, which has a maximum legal weight of 88,000 pounds. Bridges which cannot accommodate these maximum legal loads must be provided with regulatory weight limits to protect the motoring public from their potential failure.

## **SCOPE**

The method of determining which bridges are structurally deficient is presented herein with the procedures for placing regulatory weight limits upon them. Also, advisory weight limits are discussed.

## **COMMENTARY**

Weight limits are required on all bridges found to be structurally deficient on the Federal Aid Highway System. This is established in Title 23 Highways, Part 650.303(C) National Bridge Inspection Standards of the Federal Register. It is the opinion of the Department's General Counsel that all bridges on the State maintained highway system which are known to be structurally deficient for carrying legal loads but not restricted to the appropriate weight limits are a legal liability to Louisiana if they were to result in loss of property or life.

The Department utilizes a policy of posting bridges for vehicles at one weight limit and combination of vehicles at another weight limit. Act 35 of the 1978 Louisiana Legislature created a non-standard sign for advisory weight limits as opposed to regulatory weight limits. The Department utilizes the advisory weight limits on bridges indicated in fair or better structural condition which require weight limits of fifteen (15) tons or more for vehicles and twenty-five (25) tons or more for combination of vehicles. All other bridges require regulatory weight limits. The posting of regulatory/advisory signs is in accordance with the EDSM 1.1.1.8.

Regulatory weight limits must be established legally. This is accomplished by filing the "Assistant Secretary's/Chief Engineer's Order" restricting the weight limits on a bridge in the Office of the Clerk of Court in the Parish in which the bridge is located. When the bridge is located on a Parish boundary, both Parish Clerks of Court must have the appropriate documents filed with them. Only then are the bridges in question legally posted and the appropriate authorities can enforce the weight limits.

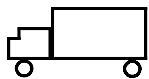
Advisory signs are not legally established and therefore not subject to enforcement. The only difference between the advisory weight limit signs and the regulatory weight limit signs is that there is not advance warning for advisory weight limits and the background color is yellow for the advisory sign as opposed to white for the regulatory sign.

## ANALYSIS

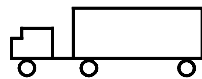
The posting evaluation vehicles consist of the (H vehicle configuration) Type 2 vehicle, and Type 3 vehicle, the (HS vehicle configuration) Type 2-S1 vehicle and the Type 3-S2 vehicle. Bridges are rated for the operating rating stresses, which are higher than the original design stress values. The weight of the "H" or "HS" vehicle configuration along with the weight of the Type 3 vehicle or Type 3-S2 vehicle respectively are computed which will produce the operating rating stresses. If the computed weights of either or both vehicle configurations are less than the maximum legal weight for their configurations, the bridge requires weight limits in accordance to the EDSM 1.1.1.8.

The rating/posting evaluation vehicles are coded by a three (3) digit number. This code (e.g., 117, 228, 430, and 544) is demonstrated in the following Vehicle Types and Weight Limit Requirement Table (see page 2 (22)). The first digit is designated as the Rating Vehicle Code and is unique to the vehicle type. The second two (2) digits are the gross vehicle weight to the nearest ton with leading zeros. This code is the same as specified in the "US DOT/FHWA Recording and Coding Guide".

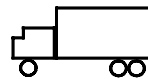
### Vehicle types



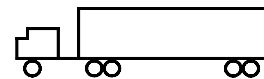
Vehicle type 2  
Rating Vehicle Code 1



Vehicle type 2-S1  
Rating Vehicle Code 2



Vehicle type 3  
Rating Vehicle Code 4



Vehicle type 3-S2  
Rating Vehicle Code 5

### Computation of Rating Factors

The following expressions are used in determining the load rating of a structure based on the moment capacity.

(a) Load Factor Method

$$\text{Inventory Rating Factor} = RF_{INV} = \frac{\left[ \frac{3}{5} \frac{M_u - M_{DL}}{1.3} \right]}{M_{LL} (1 + I)}$$

$$\text{Operating Rating Factor} = RF_{OPR} = \frac{\left[ \frac{M_u - M_{DL}}{1.3} \right]}{M_{LL} (1 + I)}$$

Where:  $M_u$  = moment capacity of the structure  
 $M_{DL}$  = moment due to dead load  
 $M_{LL}$  = moment due to live load  
 $I$  = the impact factor to be used with the live load

(b) Allowable Stress Method

$$RF_{INV} = \frac{\left[ M_{INV} - M_{DL} \right]}{M_{LL} (1 + I)}$$

$$RF_{OPR} = \frac{\left[ M_{OPR} - M_{DL} \right]}{M_{LL} (1 + I)}$$

Where:  $M_{INV}$  = moment capacity at the inventory level  
 $M_{OPR}$  = moment capacity at the operating level

$RT$  = Rating in tons =  $(RF) W$

Where  $W$  = weight (in tons) of the truck used in determining the live load effect.

Example: If we have used HS20 truck and have obtained  $(RF)_{INV} = 1.35$  and

$$(RF)_{\text{OPR}} = 2.25,$$

$$\begin{aligned}\text{Inventory Rating} &= (1.35) (36) \\ &= 48.6 \\ &= 48 \text{ (Decimal portion is truncated)}\end{aligned}$$

$$\begin{aligned}\text{Operating Rating} &= (2.25) (36) \\ &= 81\end{aligned}$$

If we have used the posting vehicle as Louisiana Type 3-S2 truck and have obtained

$$RF_{\text{OPR}} = 2.54$$

$$\begin{aligned}\text{Posting Rating} &= (2.54) (36.5) \\ &= 92.7 \\ &= 92 \text{ (Decimal portion is truncated)}\end{aligned}$$

NBIS (National Bridge Inspection Standard) code for Rating:

For Inventory and Operating ratings, add the digit 2 in front of the rating value in tons, if the HS20 truck is used.

For Posting rating, add the digit 5 in front of the rating value in tons.

Rating for the above example in NBIS Format:

Inventory: 248

Operating: 281

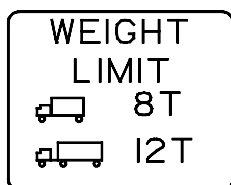
Posting: 592

## BRIDGE WEIGHT LIMIT REQUIREMENTS TABLE

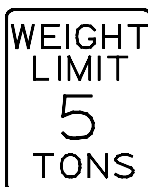
Operating Rating Limit Range or Value	Posting Vehicle Range or Value	Weight Requirements
100 - 102	400 - 402	Type IV (closed)
103	403	Type III (03T)
104	404	Type III (04T)
105 - 109	405 - 409	Type III (05T)
209 - 214	509 - 514	Type II (05T)
110 - 114	410 - 414	Type II (10T - 15T)
215 - 224	515 - 524	Type II (10T - 15T)
115 - 117	415 - 419	Type II (15T - 25T)
225 - 228	525 - 534	Type II (15T - 25T)
118 - 119		Type II (15T - 25T)
229 - 234		Type II (15T - 25T)
120 - 124	420 - 424	Type II (20T - 35T)
235 - 239	535 - 539	Type II (20T - 35T)
125 - 129	425 - 429	Type II (25T - 40T)
240 - 243	540 - 543	Type II (25T - 40T)
130 - 199	430 - 499	No Limit
244 - 299	544 - 599	No Limit

The table shows the rating requirements for the State of Louisiana. Select the lower weight limit requirement for the operating and posting vehicle for operating rating values above double line. Select the higher weight limit for the operating and posting vehicle for operating rating values below double line.

### EXAMPLES OF POSTING SIGN LEGENDS



TYPE II



TYPE III



TYPE IV

## **BRIDGE RATING AND PERMIT LOAD REVIEW PROCEDURE REFERENCE LIST**

1. AASHTO Virtis and BRASS/BARS computer program manuals and software.
2. AASHTO "Guide for Maximum Dimensions and Weights of Motor Vehicles and for the Operation of Non-Divisible Load Oversize and Overweight Vehicles", Rev. 1988.
3. AASHTO "Manual for Condition Evaluation of Bridges", 1994 and Interim Specifications.
4. AASHTO "Standard Specification for Highway Bridges", Sixteenth Edition, 1996 and Interim Specifications.
5. Bridge Gross Weight Formula, U.S. Department of Transportation and FHWA Publication, 1982.
6. Bridge Rating Procedure and Policy Guide Manual, 1988 (prepared by LA DOTD Bridge Rating Unit).
7. Code of Federal Regulation "23 CFR 650", Rev. 1988.
8. Engineering Directives and Standards Manual (EDSM) 1.1.1.8, & 1.1.1.15 for Posting and Frequency of Re-rating Policy.
9. FHWA "Bridge Inspector's Training Manual 70", 1979.
10. FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, 1988.
11. Louisiana Legislative Act 35 of 1978 for Posting Advisory Weight Limit Signs.
12. Louisiana Legislative Act 686 of 1987 (House Bill No. 1542) for Compliance of Bridge Formula.
13. Louisiana Legislative Act 1342 of 1997 (Senate Bill No. 792) for Permit Vehicle, Gross Vehicle Weight, and Axle Load and Spacing Limitation.
14. Louisiana Recording and Coding Guide for the Structure Inventory and Appraisal of the State Bridges, 1979.
15. Louisiana Regulation for Trucks, Vehicles and Loads, Fourteenth Edition, 1995, and Multi-State Permit Agreement for Oversize and Overweight Vehicle, 1996.
16. National Bridge Inspection Standards - Transmittal 427, 1989.
17. Timber Construction Manual, latest edition, and USDA Forest Service Timber Design Specifications.

NOTE: All of the above references are available in the Rating Unit Office.



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## **HIGHWAY DESIGN STANDARDS**

The Louisiana Department of Transportation and Development has adopted certain design standards for highways and roads. The following four (4) broad classifications have been established to classify our highways.

1. FREEWAYS
2. ARTERIAL ROADS AND STREETS
3. COLLECTOR ROADS AND STREETS
4. LOCAL ROAD AND STREETS

The classification applicable to any given segment of road has been established by the Traffic and Planning Section, and is available from maps and other publications such as the "Highway Needs Summary". The "Local" standards are generally applicable to off-system roads.

Within each classification, three (3) to six (6) sub-categories have been established. The designer may exercise some discretion and/or the pre-design committee in selecting the appropriate sub-category to be used for design based on factors such as:

1. TRAFFIC
2. TERRAIN
3. EXISTING ROADSIDE DEVELOPMENT
4. DESIGN CONTINUITY
5. OTHER PERTINENT FACTORS DESIGN STANDARDS FOR FREEWAYS

# LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT DESIGN STANDARDS FOR FREEWAYS

ITEM NO.	ITEM	F-1	F-2	F-3
1	Design Speed (K/H)	80 (1)	100	120
2	Level of Service	C (2)	C (2)	B (3)
3	Number of Travel Lanes (Minimum)	4	4	4
4	Width of Travel Lanes (m)	3.6	3.6	3.6
5	Width of Shoulders (Where Used) (m)			
	(A) Outside	3.0 (4)	3.0 (4)	3.0 (4)
	(B) Median	1.8 (5)	1.8 (5)	1.8 (5)
6	Type of Shoulders	Paved	Paved	Paved
7	Width of Median (m)			
	(A) Depressed	15 Min.	20 - 27	21 - 27
	(B) Continuous Barrier (4 Lane)	4.2 (6)	4.2 (6)	4.2 (6)
	Continuous Barrier (6 Lane)	8.0 (6)	8.0 (6)	8.0 (6)
8	Fore Slope - Ratio	4:1 - 6:1	6:1	6:1
9	Back Slope - Ratio	4:1	4:1	4:1
10	Pavement Cross Slope (m per m)	0.025 (7)	0.025 (7)	0.025 (7)
11	Stopping Sight Distance (m)	120-140 (8)	160-210 (8)	210-290 (8)
12	Maximum Superelevation (m per m)	0.10	0.10	0.10
13	Max. Horizontal Curvature (With Superelevation) (m) (9)	220	360	595
14	Maximum Grade (%)	4 (10)	3 (10)	3 (10)
15	Minimum Vertical Clearance (m)	4.9 (11)	4.9 (11)	4.9 (11)
16	Width of Right of Way (m)			
	(A) Depressed Median	As Needed	90	90
	(B) Median Barrier	As Needed	As Needed	As Needed
	(C) Minimum From Edge of Bridge Structure	4.5 - 6.0	4.5 - 6.0	4.5 - 6.0
17	Bridge Design Load	HS-20	HS-20	HS-20
18	Width of Bridges (m)(Min.)(Face to Face Bridge Rail)	12.0	12.0	12.0
19	Guardrail Required at Bridge Ends	Yes	Yes	Yes
20	Horizontal Clearance (m)(From Edge of Travel Lane)			
	(A) 4:1 Foreslope	9.0	N/A	N/A
	(B) 6:1 Foreslope	7.0	10.0	10.5

Numeric Ranges Indicate Minimum - Desirable.

- (1) For Use In Urban Areas Only.
- (2) Level of Service D Permissible For Heavily Developed Urban Areas.
- (3) Level of Service C Permissible For Urban Conditions.
- (4) 3.6m Paved Required With Truck DDHV Greater Than 250.
- (5) 1.2m To Be Paved; 3.0m To Be Paved On 6 Lane Facilities; 3.6m To Be Paved On 6 Lane Facilities With Truck DDHV Greater Than 250.
- (6) 10.0 Maximum.
- (7) 2% Permissible For Rehabilitation Projects.
- (8) Minimum Values Shown Permissible For Rehabilitation Projects. Maximum Values Shown To Be Used Where Conditions Permit.
- (9) It May Be Necessary To Increase The Radius Of The Curve And/Or Increase The Shoulder Width (Maximum of 3.6m) To Provide Adequate Stopping Sight Distance On Structure.
- (10) Grades 1% Higher May Be Used In Special Cases.
- (11) 150mm Additional To Allow For Future Surfacing; 5.2m Required For Trusses and Pedestrian Overpasses.

Sheet of 4

## DESIGN STANDARDS

Approved

*Dennis D. White*  
Chief Engineer

10-8-93  
Date

# LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT DESIGN STANDARDS FOR ARTERIAL ROADS AND STREETS

ITEM NO.	ITEM	RURAL				URBAN ①		
		TWO LANE		FOUR LANE		UA-1	UA-2	
		RA-1	RA-2	RA-3 ②	RA-4			
1	Design Speed (K/H)	100	110	100	110	60	70	
2	Design Hourly Volume	0-600 ③	0-600 ③	601-2300	601-2500	N/A	N/A	
3	Level of Service	B	B	B	B	C ④	C ④	
4	Number of Travel Lanes	2	2	4 ⑤	4 ⑤	2Min.-4Typ.	2Min.-4Typ.	
5	Width of Travel Lanes (m)	3.6	3.6	3.6	3.6	3.3 - 3.6	3.6	
6	Width of Parking Lanes (Where Used) (m)	N/A	N/A	N/A	N/A	3.0 - 3.6	3.0 - 3.6	
7	Width of Shoulders (Where Used) (m)							
	(A) Outside	2.4 - 3.0	3.0	3.0	3.0	N/A	N/A	
	(B) Median	N/A	N/A	1.8 ⑥	1.8 ⑥	N/A	N/A	
8	Type of Shoulders	Paved	Paved	Paved	Paved	N/A	N/A	
9	Width of Median (m)							
	(A) Depressed	N/A	N/A	12 - 20	20	N/A	N/A	
	(B) Raised	N/A	N/A	N/A	N/A	1.2 - 9.0	1.2 - 9.0	
	(C) Two Way Left Turn Lanes	N/A	N/A	N/A	N/A	3.3 - 4.3	3.3 - 4.3	
10	Width Of Sidewalk(Where Used)(Offset From Curb) (m)	N/A	N/A	N/A	N/A	1.2	1.2	
	Width Of Sidewalk(Where Used)(Adjacent From Curb)(m)	N/A	N/A	N/A	N/A	1.8	1.8	
11	Fore Slope - Ratio	6:1	6:1	6:1	6:1	3:1 - 4:1	3:1 - 4:1	
12	Back Slope - Ratio	4:1	4:1	4:1	4:1	3:1	3:1	
13	Pavement Cross Slope (m per m)	⑦	0.025	0.025	0.025	0.025	0.025	
14	Stopping Sight Distance (m)	⑧	160 - 210	180 - 250	160 - 210	180 - 250	80 - 90	100 - 120
15	Maximum Superelevation (m per m)		0.10	0.10	0.10	0.10	0.04	0.04
16	Max. Horiz. Curvature(W/out Superelevation)(+.025) (m) ⑨	N/A	N/A	N/A	N/A	175	N/A	
	Max. Horiz. Curvature(W/out Superelevation)(-.025) (m) ⑨	N/A	N/A	N/A	N/A	220	N/A	
17	Max. Horizontal Curvature(With Superelevation) (m) ⑨	360	500	360	500	160	235	
18	Maximum Grade (%)	3 ⑩	3 ⑩	3 ⑩	3 ⑩	7	6	
19	Minimum Vertical Clearance (m) ⑪	4.9	4.9	4.9	4.9	4.9	4.9	
20	Minimum Horizontal Clearance (m)							
	(A) From Edge of Travel Lane	9.0	10.0	10.0	10.5	N/A	N/A	
	(B) Outside (From Back of Curb)	N/A	N/A	N/A	N/A	1.8 - 4.6	1.8 - 4.6	
	(C) Median (Where Used)(From Back of Curb)	N/A	N/A	N/A	N/A	1.2 - 4.6	1.2 - 4.6	
21	Minimum Width Of Right of Way (m) ⑫⑬							
	(A) From C	23	23	As Needed	38	N/A	N/A	
	(B) From Edge of Travel Lane	N/A	N/A	N/A	N/A	2.4 - 5.2	2.4 - 5.2	
22	Bridge Design Load	HS-20	HS-20	HS-20	HS-20	HS-20	HS-20	
23	Width of Bridges (m) (Min.)(Face to Face Bridge Rail)	Shldr. Width	13.2	12.0	12.0	Rdwy. + 2.4 ⑭	Rdwy. + 2.4 ⑭	
24	Bridge End Treatment Required at Bridges	Yes	Yes	Yes	Yes	Yes	Yes	

Numeric Ranges Indicate Minimum - Desirable.

- ① Applies To Curbed Sections Only. For Uncurbed Sections Use Rural Standards.
- ② Used When Adding Two Lanes To Existing Two Lane Facility.
- ③ For Rolling Terrain, Limited Passing Sight Distance and High Percentage Trucks, 4 Lanes May Be Required When DHV is Above 400.
- ④ Level Of Service D Permissible In Heavily Developed Areas.
- ⑤ Consider Increasing To 6 Lane Facility When DHV is Above Figure Shown in Item No. 2.
- ⑥ 1.2m Paved.
- ⑦ 2% Permissible For Rehabilitation Projects.
- ⑧ Minimum Values Shown Permissible For Rehabilitation Projects. Maximum Values Shown To Be Used Where Conditions Permit.
- ⑨ It May Be Necessary To Increase The Radius Of The Curve And/Or Increase The Shoulder Width (Maximum of 3.6m) To Provide Adequate Stopping Sight Distance on Structure.
- ⑩ 4% Permissible In Rolling Terrain.
- ⑪ 150mm Additional To Allow For Future Surfacing.
- ⑫ Minimum Required For New Location and As Needed For Existing Alignment.
- ⑬ Obtain Additional Right of Way For Future Lanes Where Justified.
- ⑭ For Approach Roadways Without Curb, Use Shoulder Width. 1.8m Sidewalk Behind Curb To Be Carried Across Bridge When Justified By Pedestrian Traffic.

Sheet 2 of 4

<b>DESIGN STANDARDS</b>	
Approved <i>Dempsey D. White</i>	10-8-93
Chief Engineer	Date

# LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

## DESIGN STANDARDS FOR COLLECTOR ROADS AND STREETS

ITEM NO.	ITEM	RURAL			URBAN		
		RC-1	RC-2	RC-3	UC-1	UC-2	UC-3
		100 ①	100 ①	100	50	60	70
1	Design Speed (K/H)	0-400	Over 400	Over 400	N/A	N/A	N/A
2	Current Average Daily Traffic	N/A	100-200	Over 200	N/A	N/A	N/A
3	Design Hourly Volume	C	C	C	D	D	D
4	Level of Service	2	2	2 to 4 ②	2 to 4	2 to 4	2 to 4
5	Number of Travel Lanes	N/A	N/A	N/A	3.0 - 3.6	3.0 - 3.6	3.6
6	Width of Travel Lanes (m)	3.3	3.3	3.6	3.3 - 3.6 ③	3.3 - 3.6 ③	3.6
	(A) With Curb	N/A	N/A	N/A	2.4 - 3.0	2.4 - 3.0	2.4 - 3.0
	(B) With Shoulder	N/A	N/A	N/A			
7	Width of Parking Lanes (Where Used) (m)	0.6 - 1.2	1.8 - 2.4 ④	2.4 - 3.0 ④	2.4	2.4 - 3.0 ⑤	2.4 - 3.0 ⑤
	(A) Outside	N/A	N/A	1.2	N/A	N/A	1.2
	(B) Median	Aggregate	Agg. - Pav.	Paved	Paved	Paved	Paved
8	Type of Shoulders	Width of Median (m)					
	(A) Depressed	N/A	N/A	12.0 - 18.0	N/A	N/A	N/A
	(B) Raised	N/A	N/A	N/A	1.2 - 9.0	1.2 - 9.0	1.2 - 9.0
	(C) Two Way Left Turn Lanes	N/A	N/A	N/A	3.3 - 4.3	3.3 - 4.3	3.3 - 4.3
9	Width of Sidewalk (Where Used)(Offset From Curb)(m)	N/A	N/A	N/A	1.2	1.2	1.2
	Width of Sidewalk (Where Used)(Adjacent To Curb)(m)	N/A	N/A	N/A	1.8	1.8	1.8
10	Fore Slope - Ratio	4:1	4:1	6:1	3:1 - 4:1	3:1 - 4:1	3:1 - 4:1
11	Back Slope - Ratio	3:1	4:1	4:1	2:1 - 3:1	2:1 - 3:1	3:1
12	Pavement Cross Slope (m per m)	⑥ 0.025	0.025	0.025	0.025	0.025	0.025
13	Stopping Sight Distance (m)	⑦ 160 - 210	160 - 210	160 - 210	60 - 70	80 - 90	100 - 120
14	Maximum Superelevation (m per m)	0.10	0.10	0.10	0.04	0.04	0.04
	Max. Horiz. Curvature (W/out Superelevation)(+.025)(m) ⑧	N/A	N/A	N/A	85	175	N/A
	Max. Horiz. Curvature (W/out Superelevation)(-.025)(m) ⑧	N/A	N/A	N/A	105	220	N/A
15	Max. Horizontal Curvature (With Superelevation)(m) ⑧	360	360	360	80	160	235
16	Maximum Grade (%)	7	6	5	9	9	8
17	Minimum Vertical Clearance (m)	4.6	4.6	4.6	4.6	4.6	4.6
	Minimum Horizontal Clearance (m)						
	(A) From Edge of Travel Lane	9	9	9	⑨	⑨	⑩
	(B) Outside (From Back of Curb)	N/A	N/A	N/A	0.3 - 1.8	0.3 - 1.8	1.8 - 4.6
	(C) Median (Where Used)(From Back of Curb)	N/A	N/A	N/A	0.3 - 1.8	0.3 - 1.8	1.2 - 4.6
18	Width of Right of Way (m) (Minimum) ⑪ ⑫						
	(A) From C	18	18	23	N/A	N/A	N/A
	(B) From Edge of Travelway	N/A	N/A	N/A	2.4 - 3.4	2.4 - 3.4	2.4 - 5.2
19	Bridge Design Load	HS-20	HS-20	HS-20	HS-20	HS-20	HS-20
20	Width of Bridges (m) (Min.)(Face to Face Bridge Rail)	9	Shldr. Width ⑬	Shldr. Width	Rdwy. + 2.4 ⑭	Rdwy. + 2.4 ⑭	Rdwy. + 2.4 ⑭
21	Bridge End Treatment Required at Bridges	YES	YES	YES	YES	YES	YES

Numeric Ranges Indicate Minimum - Desirable.

- ① For Spot Projects, Lesser Design Speeds May Be Used When Conditions Require.
- ② For Rolling Terrain, Limited Passing Sight Distance and High Percentage Trucks, 4 Lanes May Be Required When DHV is Above 700.
- ③ For DHV > 400 Use 3.6m Lanes.
- ④ For Spot-Replacement Bridge Projects Where No Future Improvements To The Roadway Are Planned, Construction May Be To The Design Minimums.
- ⑤ For DHV > 400 Use 3.0m.
- ⑥ 2% Acceptable For Rehabilitation Projects.
- ⑦ Minimum Values Shown Permissible For Rehabilitation Projects. Maximum Values Shown To Be Used Where Conditions Permit.
- ⑧ It May Be Necessary To Increase The Radius Of The Curve And/Or Increase The Shoulder Width (Maximum of 3.6m) To Provide Adequate Stopping Sight Distance on Structure.
- ⑨ If Not Curbed, Clearance = 3m
- ⑩ If Not Curbed, Clearance = 6m
- ⑪ Minimum Required For New Location And As Needed For Existing Alignment.

- ⑫ Obtain Additional Right of Way For Future Lanes Where Justified.
- ⑬ 9.0m Minimum Width is Allowable With Aggregate Shoulders. 11.4m Required For Paved Shoulders.
- ⑭ For Approach Roadways Without Curb, Use Shoulder Width. 1.8m Sidewalk Behind Curb To Be Carried Across Bridge When Justified By Pedestrian Traffic.

Sheet 3 of 4

### DESIGN STANDARDS

Approved D. J. White 10-8-93  
Chief Engineer Date

# LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT DESIGN STANDARDS FOR LOCAL ROADS AND STREETS

ITEM NO.	ITEM	RURAL			URBAN	
		RL-1	RL-2	RL-3	UL-1	UL-2
1	Design Speed (K/H) ①	50	65	80	30	50
2	Current Average Daily Traffic	0-250	250-400	Over 400	N/A	N/A
3	Design Hourly Volume	N/A	N/A	Over 100	N/A	N/A
4	Level of Service	D	D	D	D	D
5	Number of Travel Lanes	2	2	2	2	2
6	Width of Travel Lanes (m)	2.8	3.0	3.3 ②	2.8 - 3.6	2.8 - 3.6
7	Width of Parking Lanes (Where Used) (m)	N/A	N/A	N/A	2.1 - 2.7	2.1 - 2.7
8	Width of Shoulders (Where Used) (m)	0.6	0.6	1.8 - 2.4 ③	N/A	N/A
9	Type of Shoulders	Aggregate	Aggregate	Aggregate ④	N/A	N/A
10	Width of Sidewalk (Where Used)(Offset From Curb)(m)	N/A	N/A	N/A	1.2	1.2
	Width of Sidewalk (Where Used)(Adjacent To Curb)(m)	N/A	N/A	N/A	1.8	1.8
11	Fore Slope - Ratio ⑤					
	(A) Cut	3:1 ⑥	4:1	4:1	3:1	3:1
	(B) Fill	3:1 ⑥	4:1	4:1	3:1	3:1
12	Back Slope - Ratio ⑤	2:1	2:1	3:1	2:1	2:1
13	Pavement Cross Slope (m per m) ⑦	0.025	0.025	0.025	0.025	0.025
14	Stopping Sight Distance (m)	60 - 70	90 - 110 ⑧	120 - 140 ⑧	30	60 - 70
15	Maximum Superelevation (m per m)	0.10	0.10	0.10	0.04	0.04
16	Max. Horiz. Curvature (W/out Superelevation)(+.025)(m) ⑨	N/A	N/A	N/A	25	85
	Max. Horiz. Curvature (W/out Superelevation)(-.025)(m) ⑨	N/A	N/A	N/A	30	105
17	Max. Horizontal Curvature (With Superelevation) (m) ⑨	75	140	220	24	80
18	Maximum Grade (%)	9	9	8	10	9
19	Minimum Vertical Clearance (m)	4.6	4.6	4.6	4.6	4.6
20	Minimum Horizontal Clearance (m)					
	(A) From Edge of Travel Lane	3.0	3.0	3.0	N/A	N/A
	(B) From Back of Curb	N/A	N/A	N/A	0.3 - 1.8	0.3 - 1.8
21	Bridge Design Load	HS-20	HS-20	HS-20	HS-20	HS-20
22	Width of Bridges (m) (Min.)(Face to Face Bridge Rail)	6.8	7.3	Rdwy.+ 1.8 ⑩	Rdwy.+ 2.4 ⑩	Rdwy.+ 2.4 ⑩
23	Bridge End Treatment Required at Bridges	Yes	Yes	Yes	Yes	Yes

Numeric Ranges Indicate Minimum - Desirable.

- ① Shall Not Be Less Than The Speed For Which The Road Or Street Is To Be Posted, Upon Completion Of The Project.
- ② 3.6m Lanes Required For DHV Over 200.
- ③ For DHV > 400 Use 2.4m Shoulder.
- ④ Paved Shoulders Required For DHV Over 200.
- ⑤ Side Slopes As Steep As 1:1 May Be Used, If Necessary, To Stay In Existing R/W.
- ⑥ For Gravel Roads, 2:1 Acceptable.
- ⑦ 2% Permissible On Rehabilitation Projects.
- ⑧ Minimum Values Shown Permissible For Rehabilitation Projects. Maximum Values Shown To Be Used Where Conditions Permit.
- ⑨ It May Be Necessary To Increase The Radius Of The Curve And/Or Increase The Shoulder Width (Maximum of 3.6m) To Provide Adequate Stopping Sight Distance On Structure.
- ⑩ Use Shoulder Width For DHV of 400 or More.
- ⑪ For Approach Roadways Without Curb or Sidewalk, Use Rural Standards.

#### GENERAL NOTES :

These Standards Shall Not Apply To:  
 (a) Dead - End Roads (Open At One End Only)  
 (b) Roads Which Are Dependent On Dead - End Roads For Access.

Urban Standards May Be Applied To Any Street For Which Curb Is To Be Used, Or Any Street For Which A Posted Speed of 50 K/H Or Less Would Be Appropriate.

Overlay Design Standards (Separate Sheet) Shall Be Applicable To Those Projects For Which The Primary Purpose Is To Improve The Riding Surface.

The Appropriate Local Governing Body Is Authorized To Make Design Exceptions For Specific Items Listed In These Standards, With Proper Engineering Justification.

Sheet 4 of 4

### DESIGN STANDARDS

Approved Dempsey D. White 10-8-93  
 Chief Engineer Date



STRUCTURE NO. \_\_\_\_\_

**CHECK LIST FOR DISTRICT WHILE REVIEWING PROPOSED  
CONSTRUCTION SITES.**

1. Are there debris or obvious scour problems ?
2. Does the site get inundated? If so, do other areas of the roadway within eight (8) km get inundated ?
3. Would it be possible to close the road during the construction period ?
4. Where are the utilities located relative to the existing structure ?
5. If a detour is to be required, which side of the existing structure would you recommend ?
6. Are there any obstructions other than utilities within 150 m of the existing structure ?
7. If alternate routes are available for detour purposes, is there any construction scheduled for these routes ?
8. Are there any churches, schools, parks, or recreational facilities in the vicinity of the proposed project ?
9. Are there any existing conditions which would prevent the replacement of the bridge with a pipe ?
10. Are there any wetlands, hazardous waste sites, above ground storage tanks, water wells, cemeteries, or historical sites in the area of the project ?

## LIST OF PUBLICATIONS USED IN THE DESIGN OF BRIDGE STRUCTURES

	PUBLICATION	ORGANIZATION	Address
1	Standard Specifications For Highway Bridges	AASHTO	444 N. Capitol St., NW Suite 249, Washington, DC 20001
2	LRFD Bridge Design Specifications	AASHTO	" "
3	A Policy on Geometric Design of Highway and Streets	AASHTO	" "
4	Guide For Selecting, Locating and Designing Traffic Barriers	AASHTO	" "
5	Guide Specifications For Bridge Railing	AASHTO	" "
6	Bridge Welding Code	AASHTO, AWS, ANSI	" "
7	Roadside Design Guide	AASHTO	" "
8	Structural Welding Code	AWS (American Welding Society)	550 NW Lejeune Rd. PO Box 351040 Miami, FL 33135
9	Guide Specification For Seismic Design of Highway Bridges	AASHTO	444 N. Capitol St., NW Suite 249 Washington, DC 20001
10	Guide Specifications For Fracture Critical Nonredundant Steel Bridge Members	AASHTO	"
11	Guide Specifications For Horizontally Curved Highway Bridges	AASHTO	"
12	Standard Specifications For Movable Highway Bridges	AASHTO	"
13	Guide Specifications And Commentary For Vessel Collision Design Of Highway Bridges	AASHTO	"
14	Guide Specifications for Strength Design of Truss Bridges	AASHTO	"
15	Standard Specifications For Structural Supports, Highway Signs, Luminaries and Traffic Signals	AASHTO	444 N. Capitol St., NW Suite 249 Washington, DC 20001
16	A Guide To Standardized Highway Lighting Pole Hardware(Task Force 13)	AASHTO, ARTBA, AGC	525 School St. SW Washington, DC 20402
17	MUTCD (Manual on Uniform Traffic Control Devices)	FHWA (Superintendents of Documents)	U.S.G.P.O. Washington, DC 20402
18	Bridge Design Manual	LADOTD	General Files PO Box 94245 Baton Rouge, LA 70804
19	All Bridges Design Revisions Subsequent To This Manual	LADOTD	"
20	Hydraulics Manual	LADOTD	"
21	Roadway Plan Preparation Manual	LADOTD	"

## LIST OF CONSTRUCTION SPECIFICATIONS MANUALS

1	Louisiana Standard Specifications For Roads and Bridges	LADOTD	General Files PO Box 94245 Baton Rouge, LA 70804
2	Manual For Quality Control For Plants & Products Of Precast-Prestressed Concrete Products	PCI Prestressed Concrete Institute	20 North Wacker Drive Chicago, IL 60601

IT IS THE RESPONSIBILITY OF THE ENGINEER TO UTILIZE THE MOST UP -TO-DATE COPIES OF ALL APPLICABLE SPECIFICATIONS LISTED HEREIN.

## LIST OF PUBLICATIONS USED AS GUIDES IN THE DESIGN OF BRIDGE STRUCTURES

	PUBLICATION	ORGANIZATION	Address
1	Highway Curves	Authors: Ives, Kissam Publisher: John Wiley & Son, Inc.	
2	Moments, Shears and Reactions For Continuous Highway and Bridges	AISC (American Institute of Steel Construction)	PO Box 806276 Chicago, IL 60680
3	Manual of Steel Construction Ninth Edition	AISC (American Institute of Steel Construction)	"
4	ACI Code	ACI American Concrete Institute	PO Box 19150 Redford Station Detroit, MI 48219
5	ACI Manual of Concrete Practice	ACI	"
6	Notes on Load Factor Design For Reinforced Concrete Bridge Structures With Design Applications	PCA Portland Cement Association	Old Orchard Road Skokie, IL 60076
7	PCI Design Handbook Precast and Prestressed Concrete	PCI Prestressed Concrete Institute	20 North Wacker Drive Chicago, IL 60601
8	CRSI Handbook	CRSI (Concrete Reinforcing Steel Institute)	180 North LaSalle Street Chicago, IL 60601
9	Manual Of Standard Practice (Rebar)	CRSI (Concrete Reinforcing Steel Institute)	"
10	Manual of Standard Practice (Welded Wire Fabric)	WRI (Wire Reinforcing Institute, Inc.)	7900 Westpark Drive McLean, VA 22102
11	Manual Of Steel Construction Allowable Stress Design and Load and Resistance Factor Design	AISC American Institute of Steel Construction	PO Box 806276 Chicago, IL 60680
12	Highway Structures Design Handbook	USS (AISC Marketing Inc.)	Suite 750 650 Smithfield St. Pittsburgh, PA 15222
13	Steel Sheet Piling Design Manual	USS	"
14	Steel Sheet Piling Handbook	USS	"

## LIST OF MATERIALS SPECIFICATIONS MANUALS

1	ASTM Standards	ASTM	100 Barr Harbor Ave. W. Conshohocken, PA 19428-2959
2	AASHTO Materials	AASHTO	Box 19150, Redford Station Suite 225 Detroit, MI 48219
3	Qualified Products List	LADOTD	Materials Section PO Box 94245 Baton Rouge, LA 70804-9425

## LIST OF BRIDGE RATING AND BRIDGE INSPECTION MANUALS

1	Manual For Condition Evaluation Of Bridges	AASHTO	Box 19150, Redford Station Suite 225 Detroit, MI 48219
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FOR A COMPLETE LISTING OF AASHTO PUBLICATIONS FOR HIGHWAY DESIGN, CONTACT AASHTO.

IT IS THE RESPONSIBILITY OF THE ENGINEER TO UTILIZE THE MOST UP -TO-DATE COPIES OF ALL APPLICABLE SPECIFICATIONS LISTED HEREIN

## **BRIDGE SPECIFIC DESIGN CRITERIA**

### **LOADING**

All bridges on freeways, arterials or collectors shall be designed to carry HST-18(M) loading as well as MS-18 loading. See section on "Special Loading Considerations".

### **BRIDGE WIDTH**

Shoulder widths on the inside of horizontal curves may need to be increased from the values shown herein in order to meet horizontal stopping sight distance requirements. See section on "Stopping Sight Distance for Barrier Rail Clearance".

A minimum clear roadway width of 9.0 m shall be used for bridges on collector roads. For temporary travel lanes, it is desirable to meet the lane widths as indicated for typical detour details, (types, A, B, C, &D). For instances when constraints may warrant a narrower condition, such as during phased construction, the engineer may utilize a narrower width without a design exception. The width shall be acceptable to all parties at the plan-in-hand meeting and shall take into account local conditions such as farm equipment crossing the structure.

### **BRIDGE FINISH GRADE ELEVATION**

In general, finish grades of bridges should be set with the following criteria as a guide:

#### Hydraulic Criteria

1. If debris is a consideration, the finish grade should be set to provide 0.6 m of freeboard between the bottom chord and the design year flood. The bottom chord should clear the 100 year flood elevation by 0.30 m.
2. If debris is not a consideration, the finish grade should be set to provide 0.30 m of freeboard between the bottom chord and the design year flood. The bottom chord should clear the 100 year flood elevation.
3. On minor bridge replacement jobs, with the approval of the bridge design engineer, criteria 1 and 2 may be relaxed under the following conditions:
  - a) Applying criteria 1 and 2 would result in a substantial raise to the approaching roadway grade.
  - b) The bridge replacement is a spot replacement with no future plans to raise the approaching roadway.

## Overpasses

See normal highway clearances in this chapter.

## **TYPICAL ORDER FOR BRIDGE PLAN SHEETS**

Plan sheets shall be organized to facilitate construction. Shown below is an example for a moderate size project.

1. General Notes, Summary of Quantities and Bridge Index
2. General Plan
3. Superelevation Transition Detail
4. Detour Layout
5. Foundation Layout
6. Pile Data Sheet
7. End Bent Details
8. Intermediate Bent Details
9. Bent Elevations and Layout Sheets
10. Column Details
11. Framing Plan
12. Girder Details
13. Span Details<sup>1</sup>
14. Miscellaneous Span and Girder Details
15. Approach Slab Details
16. Joint Details
17. Optional Span Details
18. Standard Pile Details
19. Bridge End Drain Details
20. Core Borings & Test Piles

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<sup>1</sup> Steel Span Details can be grouped together and include; typical sections, pouring sequence, framing plans, camber diagrams, girder details showing all connections, splices and bearing details.

## **PROCEDURES FOR REVISIONS AND PLAN CHANGES**

### **DEFINITIONS**

#### Revisions

Any change made to the plans after they have been signed by the Chief Engineer and prior to the letting is classified as a revision.

#### Plan Change

Any change made to the plans after the project has been let to contract is classified as a plan change.

### **REVISION PROCEDURES**

In the event that a revision is required, a written request for the plans must be submitted to the General Files Section along with an approval of the Contracts Engineer in order to receive the plans from General Files. This request must specify the nature of the intended revision, the anticipated amount of time required, and the name of the person in charge of the revision. A speed letter will suffice for this request.

When a revision is made, a circle with a number inside is used to "bug" the change and to reference it to the revision block. All sheets involved in the revision will have the same numerical bug and date. All sheet numbers are to be recorded on the title sheet revision block including the title sheet numbers.

Once the revision is completed, the cost estimate should be revised as required, and the plans and estimate sent to the Contracts and Specifications Section for review. Once accepted by the Contracts and Specification Section, the person in charge and Chief Engineer shall sign the title sheet and the plans returned to General Files.

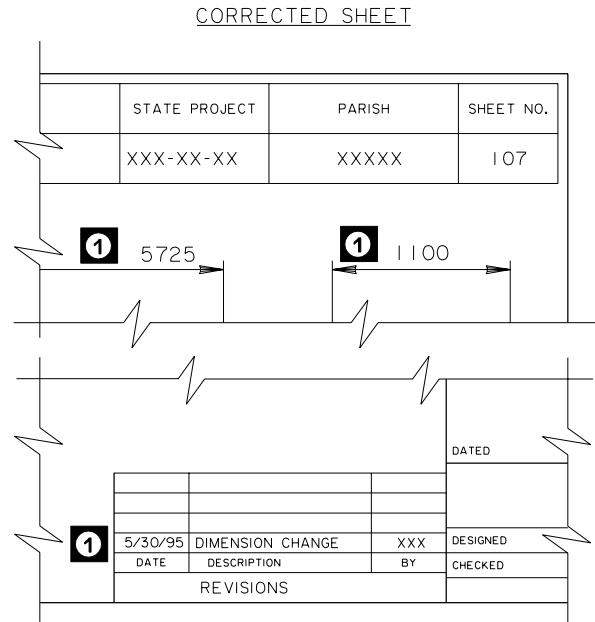
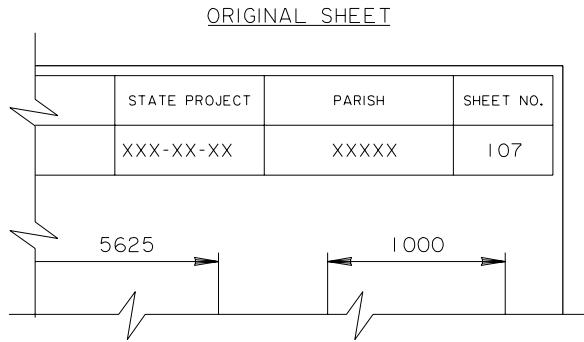
### **PLAN CHANGE PROCEDURES**

For a plan change, the plans may be verbally requested from the General Files Section. A triangle with a number inside should be used to "bug" the change and reference it to the revision block. Plan changes are not recorded on the title sheet revision block. No erasures are allowed for a plan change. For minor changes, the changes are superimposed on the existing sheet. In the case of major changes, new sheets may be created and added to the plans. If a new sheet is created to replace an existing sheet, the old sheet is stamped "VOID". The replacement sheet will have an "A" added to the sheet number. Once the plan change is finalized, a letter must be sent to the Construction Section transmitting 18 sets of prints of all affected sheets explaining the plan change. A set of prints will be transmitted to the Project Engineer by copy of the letter. If consultants are involved, a separate set of plans should be transmitted to the consultant by copy of the letter sent to the Construction Section. If Real

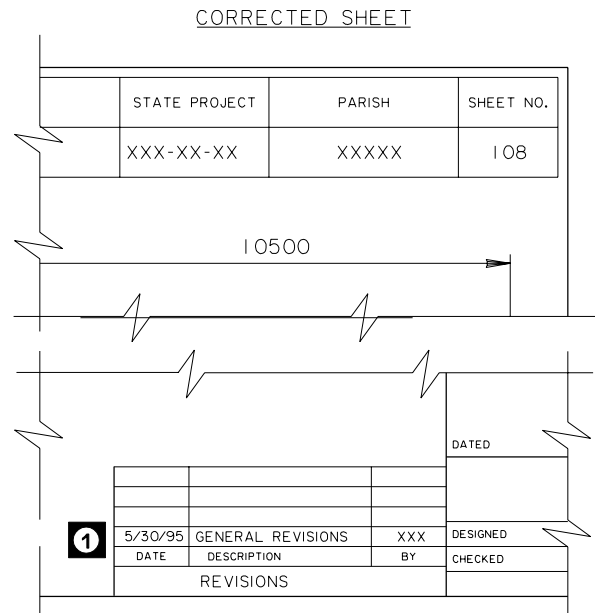
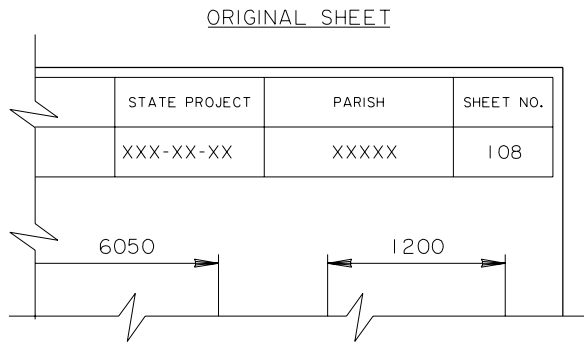
Estate and Utilities are involved, full-sized sets are to be transmitted, 10 sets to Real Estate and 1 set to Utilities, by copy of the letter. (See example)



1. IF MINOR REVISIONS ARE NEEDED, MAKE CHANGES ON THE ORIGINAL SHEET.  
ERASURES ARE ALLOWED. FOR EXAMPLE:



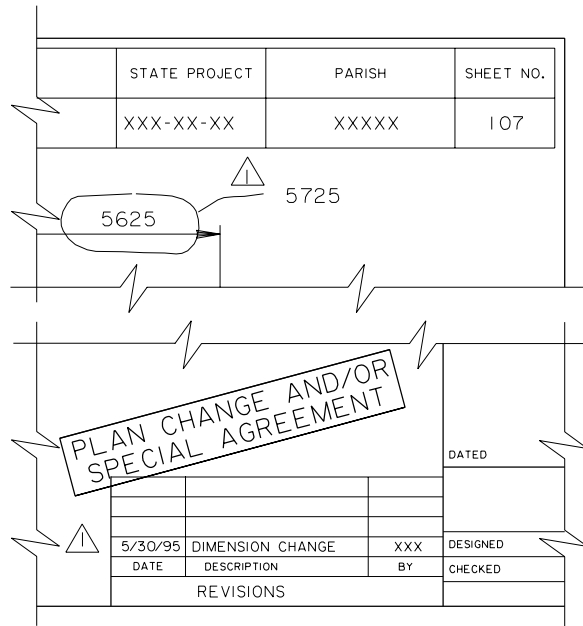
2. IF MAJOR REVISIONS ARE NEEDED, DESTROY THE ORIGINAL SHEET AND MAKE CHANGES ON THE NEW SHEET FOR EXAMPLE:



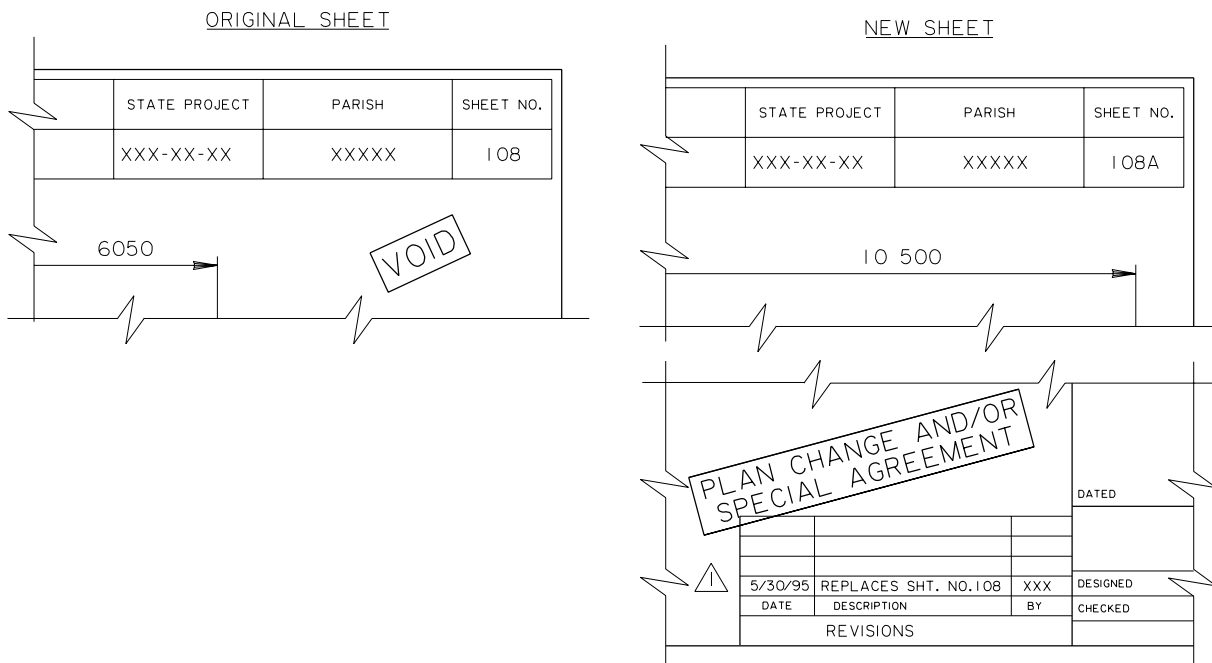
3. SHOW REVISION NUMBER (①) FOR ALL REVISED SHEET NUMBERS (INCLUDING TITLE SHEET NUMBER) IN THE TITLE SHEET REVISION BLOCK.
4. IF QUANTITIES ARE INVOLVED, REVISE COST ESTIMATE.
5. THE TITLE SHEET REVISION BLOCK MUST BE SIGNED BY THE CHIEF ENGINEER.
6. TRANSMIT A SET OF PRINTS AND A COPY OF ESTIMATE TO CONTRACTS AND SPECIFICATIONS SECTION.
7. RETURN THE REVISED PLANS TO GENERAL FILES.

## REVISION PROCEDURE

1. IF A MINOR PLAN CHANGE IS REQUIRED, MAKE THE CORRECTIONS ON THE ORIGINAL SHEET. (NO ERASURES!) NOTE THE CORRECTIONS WITH A "BUG" (Δ) AND SHOW IT IN THE REVISION BLOCK. FOR EXAMPLE:



2. IF MAJOR PLAN CHANGE, MAKE CORRECTIONS ON NEW SHEET, ADD "A" TO SHEET NUMBER, AND STAMP "VOID" ON ORIGINAL SHEET. FOR EXAMPLE:



3. DON'T SHOW ANYTHING ON THE TITLE SHEET.
4. IF THE CHANGES ARE SIGNIFICANT, SHOW QUANTITY CHANGES ON BRIDGE SUMMARY SHEET.
5. TRANSMIT 18 HALF-SIZED SETS OF PRINTS OF AFFECTED SHEETS, WITH A MEMORANDUM TO THE CHIEF CONSTRUCTION ENGINEER. TRANSMIT ONE SET OF HALF-SIZED PRINTS TO THE PROJECT ENGINEER, BY COPY OF THE MEMORANDUM. IF CONSULTANTS ARE INVOLVED, SEND THEM A HALF-SIZED SET BY COPY OF THE MEMORANDUM. IF REAL ESTATE AND UTILITIES ARE INVOLVED, FULL-SIZED SETS ARE TO BE TRANSMITTED, 10 TO REAL ESTATE AND 1 TO UTILITIES, BY COPY OF MEMORANDUM.
6. RETURN PLANS TO GENERAL FILES.

## PLAN CHANGE PROCEDURES

## **STOPPING SIGHT DISTANCE**

### **GENERAL**

The effects of stopping sight distance (SSD) bring a challenging aspect to the design of bridge geometrics. The SSD will impact bridge economics, right-of-way, and environmental considerations. The designer should take all factors into consideration during the early stages of plan development when selecting the design criteria for horizontal and vertical alignments.

Sight distance, the ability to see ahead adequately, is of extreme importance in a properly designed structure. SSD is the sum of the brake reaction distance and the braking distance required to stop on a wet surface for the speed in question and is a function of many variables. For each specific design speed, AASHTO has computed a range of distances required to stop when traveling at that particular speed. The upper value (desirable value) utilizes the design speed to compute the required stopping distance. The minimum values utilize the average running speed associated with the design speed.

In selecting proper horizontal and vertical geometry, the designer should first consider minimum values of SSD. Circumstances do occur where increasing the SSD above the minimum value is required. Such cases should be evaluated on a case by case basis.

### **VERTICAL ALIGNMENT**

When a bridge is in a vertical curve, the actual roadway surface can be detrimental to sight distance. The designer should begin the vertical curve length selection by providing a minimum value of SSD. If conditions exist where increased value of SSD is desirable, it will be acceptable for the designer to use vertical curves providing SSD greater than the minimum. In cases where neither minimum nor desirable values produce a practical layout, consideration should be given to lowering the design speed to something less than what the design standards have dictated. (The lowering of the design speed will require a design exception approved by the Chief Engineer.)

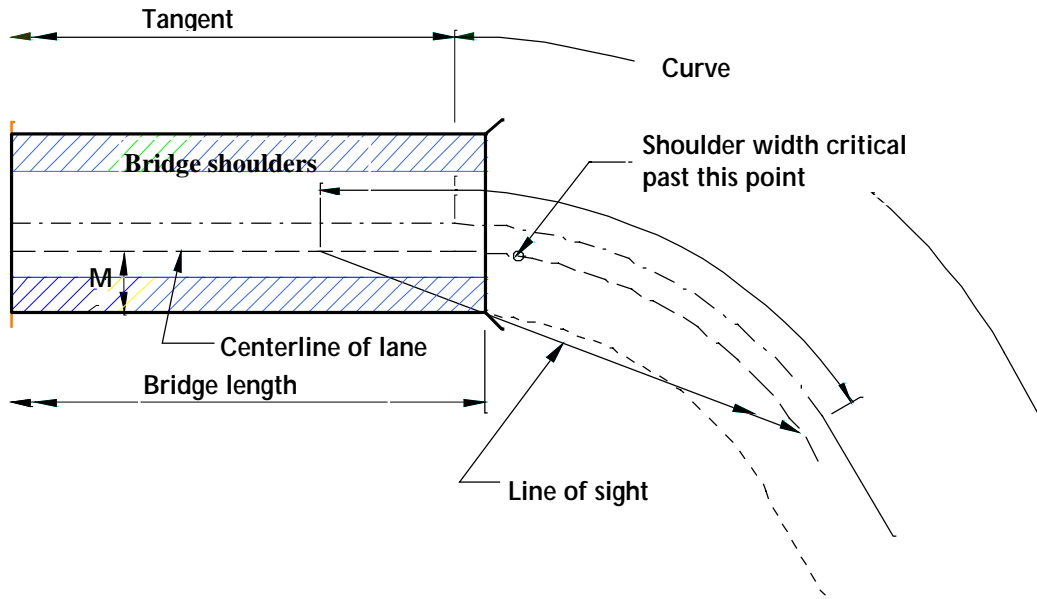
### **HORIZONTAL ALIGNMENT**

When a bridge is in a horizontal curve, the barrier rail can become a sight obstruction on the inside of the curve if the shoulder does not have adequate width. For this reason, the shoulder widths specified by the design standards must be checked to verify if the minimum SSD criteria are being provided. "A Policy on Geometric Design of Highways and Streets" shows the geometry involved in determining the SSD and a table of minimum shoulder width values for various conditions is being provided herein for use in making this determination. It should be noted that the SSD requirements become more critical when a downgrade is being encountered.

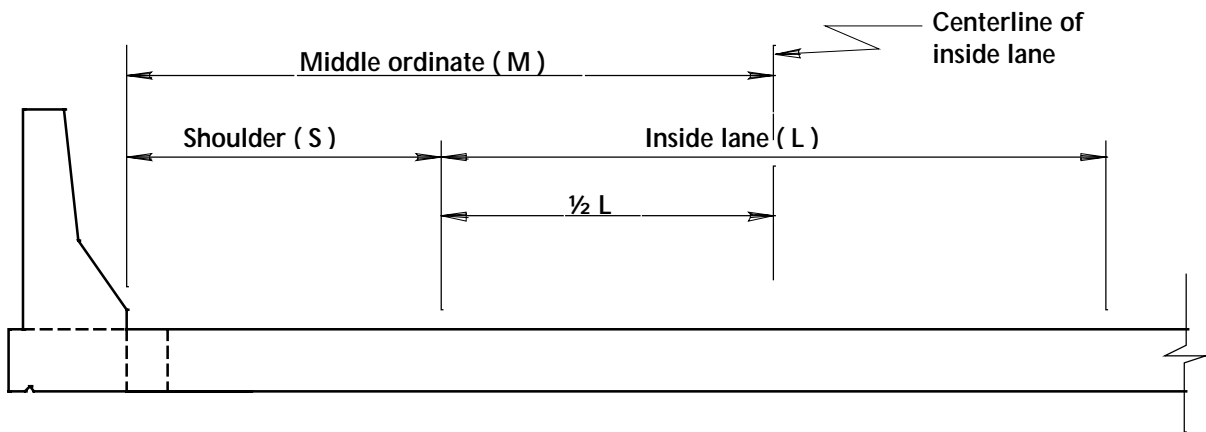
After the roadway classification has been determined, the minimum shoulder width is obtained utilizing the design standards. The sketch for determining SSD and/or the table of shoulder widths (See this Section) can be used to verify if the requirements of SSD are met. If only a short section of the bridge falls within the horizontal curve, sight distance may not be a problem and can be determined by a graphical representation. If the shoulder width obtained from the design standard does not provide minimum SSD; the designer should;

1. First consider widening the inside shoulder (shoulder widths should not exceed 3.6 m). For collector and local roads and streets, see the design standards for instructions for lowering the design speed for certain roadway classifications that will not require a design exception.
2. If the required shoulder to meet adequate SSD exceeds 3.6 m, the engineer should consider realigning the project to increase the horizontal curve radius.
3. If realignment is not a feasible alternative, the designer should consider reducing the design speed from that dictated by the design standards. This will require a design exception approved by the Chief Engineer. (If the project is a complete improvement to a section of roadway or if it has a high probability of being improved by a future project, or the route has a high ADT, a reduction in the design speed should be considered only as a last resort.)

## BRIDGE RAILING EFFECTS ON HORIZONTAL SIGHT DISTANCE



PLAN VIEW



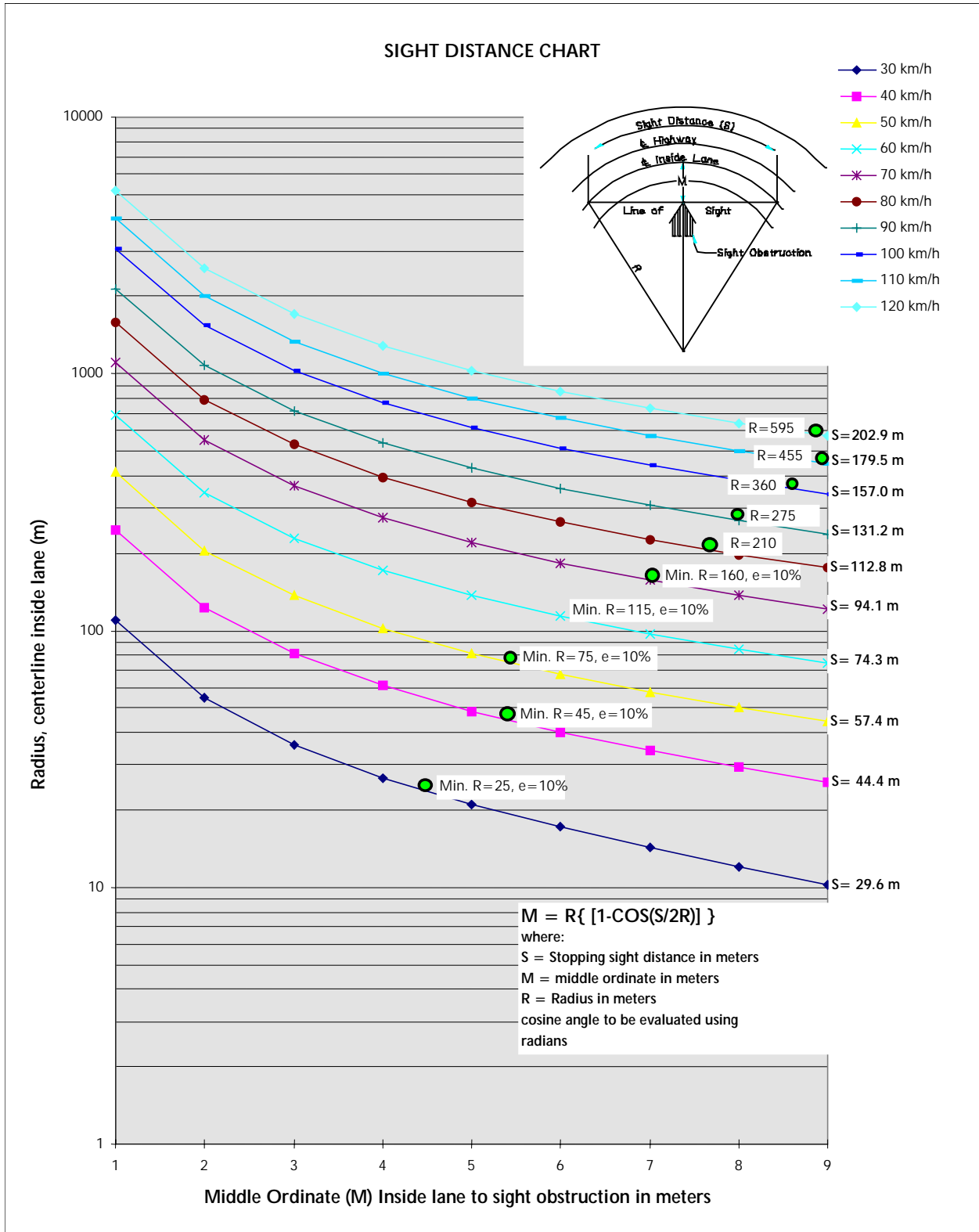
ELEVATION VIEW

M = Minimum distance to meet stopping sight distance requirements. (See Table)

L = Width of travel lane.

S = Shoulder Width required for SSD =  $M - \frac{1}{2} L \geq$  Minimum Design Standard  
 $\leq 3.6$  m (in no case shall shoulder width exceed 3.6 m)

# HORIZONTAL SIGHT DISTANCE CHART



## TABLE OF "M" VALUES IN METERS

VELOCITY	50 km/hr			70 km/hr			80 km/hr			100 km/hr			120 km/hr		
SSD(m)	57.4	65.5	68.6	94.1	117.5	125.8	112.8	148.8	160.5	157.0	220.8	240.6	202.9	310.1	341.0
GRADE (%)	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0
RADIUS(m)															
20.00															
40.00															
60.00															
80.00	5.09														
100.00	4.08	5.31													
120.00	3.41	4.44	4.86												
140.00	2.93	3.81	4.18												
160.00	2.56	3.34	3.66												
180.00	2.28	2.97	3.25												
200.00	2.05	2.67	2.93												
220.00	1.87	2.43	2.66	5.01											
240.00		2.23	2.44	4.59											
260.00		2.06	2.26	4.24											
280.00		1.91	2.10	3.94											
300.00			1.96	3.68			5.28								
320.00			1.83	3.45	5.37		4.95								
340.00				3.25	5.06		4.66								
360.00				3.07	4.78		4.40								
380.00				2.91	4.53	5.19	4.17								
400.00				2.76	4.30	4.93	3.96								
420.00				2.63	4.10	4.69	3.78								
440.00				2.51	3.91	4.48	3.60								
460.00				2.40	3.74	4.29	3.45								
480.00				2.30	3.59	4.11	3.31								
500.00				2.21	3.44	3.95	3.17								
520.00				2.12	3.31	3.79	3.05	5.31							
540.00				2.05	3.19	3.65	2.94	5.11							
560.00				1.97	3.07	3.52	2.83	4.93							
580.00				1.90	2.97	3.40	2.74	4.76	5.30						
600.00				1.84	2.87	3.29	2.65	4.60	5.35	5.12					
620.00					2.78	3.18	2.56	4.45	5.18	4.96					
640.00					2.69	3.08	2.48	4.31	5.02	4.80					
660.00					2.61	2.99	2.41	4.18	4.87	4.66					
680.00					2.53	2.90	2.33	4.06	4.72	4.52					
700.00					2.46	2.82	2.27	3.94	4.59	4.39					
720.00					2.39	2.74	2.20	3.84	4.46	4.27					
740.00					2.33	2.67	2.15	3.73	4.34	4.15					
760.00					2.27	2.60	2.09	3.63	4.23	4.04					
780.00					2.21	2.53	2.04	3.54	4.12	3.94					
800.00					2.15	2.47	1.98	3.45	4.02	3.84					
820.00					2.10	2.41	1.94	3.37	3.92	3.75					
840.00					2.05	2.35	1.89	3.29	3.83	3.66					
860.00					2.00	2.30	1.85	3.21	3.74	3.58					
880.00					1.96	2.24	1.80	3.14	3.65	3.49					
900.00					1.91	2.19		3.07	3.57	3.42					
920.00					1.87	2.15		3.00	3.49	3.34					
940.00					1.83	2.10		2.94	3.42	3.27					
960.00						2.06		2.88	3.35	3.20				5.35	
980.00						2.02		2.82	3.28	3.14				5.24	
1000.00						1.97		2.76	3.21	3.08				5.13	
1500.00								1.84	2.14	2.05	4.06	4.81		3.42	
2000.00											3.04	3.61		2.57	
2500.00											2.43	2.89		2.06	4.80
3000.00											2.03	2.41			4.00

\*TABLE OF M VALUES BASED ON MINIMUM VALUES OF STOPPING SIGHT DISTANCE IN WET CONDITIONS.  
RADIUS=THE RADIUS TO CENTERLINE OF INSIDE LANE

## NORMAL HIGHWAY CLEARANCES

### STRUCTURES

#### Vertical Clearance

Freeways and Arterials	5.05 m ( min.) <sup>2</sup>
Truss Portals	5.35 m (min.) <sup>2</sup>
Pedestrian Bridge	6.00 m ( Desirable ) <sup>2</sup> 5.35 m (min.) <sup>2</sup>
All other roads and streets	4.75 m (min.) <sup>2</sup>

#### Horizontal Clearance

All roadways<sup>3</sup>

### OVERHEAD SIGNS<sup>4</sup>

#### Vertical Clearance

From high point of pavement to bottom of sign face	5.5 m (min.) <sup>2</sup>
From high point of pavement to bottom of lighting or other appurtenances	5.2 m (min.) <sup>2</sup>

#### Horizontal Clearance

From edge of roadway (with flat shoulders) <sup>3</sup>	
From edge of curbed roadways	0.6 m (min) behind the curb

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<sup>2</sup> Includes 150 mm for future overlays

<sup>3</sup> See G.R.-200(M) Standard Plans to determine clear zones. In general, guardrail or crash protection shall be provided where horizontal clearances are less than the minimum.

<sup>4</sup> For additional information see AASHTO "Roadside Design Guide", the current MUTCD, and the "Louisiana Manual on Uniform Traffic Control Devices".



## SHOULDER MOUNTED SIGNS<sup>4</sup>

### Vertical Clearance (Freeways)

(above the pavement edge)

Guide signs	2.1 m (min.)
Guide signs with secondary signs mounted below	2.4 m (min.)
Route markers, warning	1.8 m (min.)
Regulatory signs	1.5 m (min.), rural 2.1 m (min.), urban

### Horizontal Clearance

Freeway from roadway edge<sup>3</sup>

All other roadways:

from edge of roadway	3.1 m (min.) <sup>5</sup>
from edge of curb	0.6 m (min.) <sup>5</sup>

## LIGHT STANDARDS

### Vertical

Above pavement	9.1 m (min.)
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### Horizontal Clearance

From edge of traveled roadway	4.5 m (min.) <sup>5</sup>
From edge of ramps	3.1 m (min.) <sup>5</sup>

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<sup>5</sup> Breakway design assumed

## **RIGHT-OF-WAY FOR BRIDGES**

The following general guidelines should be considered when setting right-of-way for bridges:

The right-of-way clearance shown in the design standards shall be generally applicable for the bridges, as well as the roadways, with the additional restrictions noted herein.

1. The required right-of-way line should clear the toe of the embankment slope a minimum of 1.5 m to 3 m.
2. A minimum dimension of 7.5 m should generally be provided from the outside face of the structure to the required right-of-way line.
3. Construction servitude must be provided for detour bridges.
4. It should be recognized that while it is desirable to follow the above guidelines, there are certain situations which demand exceptions. For example, in congested urban areas, the right-of-way costs are often prohibitive and required right-of-way should be kept to a minimum.

For additional information and the Department's right-of-way policy, see the "Engineering and Directives Manual", EDSM No.II.1.1.1 .

## **BRIDGE AESTHETICS**

The purpose of this article is to suggest design guidelines concerning bridge details which affect the aesthetic appearance of bridge structures.

There are numerous conventional considerations, such as cost estimates and geometric requirements, necessary in arriving at an economical and efficient design for any particular bridge structure in a given location. However, there is another requirement that should be considered. Specifically it is the appearance of the completed structure. Generally, structural efficiency does not include the good appearance of the individual structural element, but attention to the details as to how the overall structure fits together is also an important aspect to a completed structure in order to be visually pleasing.

### **BRIDGE DETAILS**

1. The centerline of exterior girders shall be aligned with exterior girders in adjacent spans.
2. Short bridges used for grade separation will have flanking spans, adjacent to the fill, of a length not less than one half the length of the main interior span(s). The exterior girders should be the same depths throughout, if possible.
3. In areas where spans can be observed by passing motorists, businesses and/or residences on adjacent properties, attention should be paid to surface finishes on the exposed concrete surfaces of substructures and superstructures.
4. Gutter drains should be omitted from overpasses where staining presents a problem.
5. The number of columns used in column bents should be kept to a minimum.
6. The exterior columns of column bents and the exterior piles of pile bents shall be aligned with the column/piles of adjacent bents where practical.
7. In urban areas, consideration should be given to placing cover walls at ends of bent caps to hide joint openings, anchor bolts and risers normally seen in the elevation view.
8. When weathering steel is to be used, special considerations should be given to keep runoff from staining the substructure.

## **CONSTRUCTION SIGNING AND PHASING**

The maintenance of traffic during construction of a project is an important aspect of design. It is incumbent on the designer to take all precautions necessary to provide for the most efficient flow of traffic. This is normally accomplished in one of four ways:

1. Detours
2. Lane Closure
3. Road closure
4. Split-Slab Construction

Detours are the most common means of maintaining traffic. Lane closures are often associated with repair projects. A road closure may be used if the route primarily serves local traffic, or if an alternate state route can be used as a detour. A pre-design questionnaire that is to be submitted to the district will normally provide adequate information to determine how traffic will be maintained. Split-slab construction is often used for bridge widening projects, where traffic is alternately maintained between sections of the new and existing bridge.

In some instances, specifications must be written to provide for traffic and construction needs. Under certain conditions, it may be necessary to require the contractor to work 24 hours shifts or to place an incentive clause in the contract to minimize disruption to traffic. Flagmen may be required and/or provisions to halt the traffic at certain periods during construction may be specified by the contract. Temporary precast barriers may be required to divert traffic for repair or widening projects. In many instances, these barrier sections are stored in the various districts, and specifications for hauling, erecting and returning the temporary barriers may be required as part of the contract. These conditions are only a few that may require written specifications.

The plan-in-hand affords a good opportunity for discussing traffic provisions, as district personnel are often better informed of traffic patterns under their jurisdiction. During the final plan phase of a project, The Traffic and Planning Section should be consulted to discuss strategies and requirements for the construction-signing layout.

For routine projects, the construction signing/phasing layout may involve only a line diagram. In the case of widening or repair projects, a more extensive layout along with explanatory notes for each traffic phase are normally included. This is especially true in the case of complicated interchanges where different ramps must be alternately closed and opened to traffic. Sometimes the construction-signing layout is superimposed on an aerial photograph. Once the "blank" layout is completed, it is then sent to the Traffic and Planning Section who adds the construction signing.

## EXAMPLE OF TRAFFIC SIGNAL CALCULATIONS

Calculations to determine if phased (split-slab) construction using traffic signals is a possible option for traffic control.

### Demand:

$$\text{ADT} = 3500 \quad (\text{site specific})$$

$$\begin{aligned} \text{Peak Hourly Volume} &= \text{assume } 15 \% \text{ of ADT} \\ &= 3500 \times 0.15 \\ &= 525 \text{ VPH} \end{aligned}$$

ADT is generally given as averaged two-way traffic, so adjust for maximum one-way

Directional split = assume 80 / 20 split during commute hours

$$\begin{aligned} \text{Peak one way traffic} &= 525 \text{ VPH} \times 0.8 \\ &= 420 \text{ VPH}_{\text{one-way}} \end{aligned}$$

Maximum traffic signal cycle length is about 100 seconds

$$\begin{aligned} \text{Arrivals: } 80\% \text{ split} &= 420 \text{ VPH}_{\text{one-way}} \times 1 \text{ hour} \div 3600 \text{ sec} \times 100 \text{ sec/cycle} \\ &= 11.7 \end{aligned}$$

$$\approx 12 \text{ vehicles per cycle}$$

$$\begin{aligned} \text{Arrivals: } 20\% \text{ split} &= 3500 \times 0.15 \times 0.20 \times 100 \div 3600 \\ &= 2.9 \end{aligned}$$

$$\approx 3 \text{ vehicles per cycle}$$

### Capacity:

$$\text{Operating Speed } V_{os} = \text{assume } 30 \text{ MPH} = 44 \text{ ft/sec} \quad (\text{site specific})$$

$$\begin{aligned} \text{Minimum safe vehicle spacing at operating speed} &= 1.50 \times 20 \text{ feet} + V_{os} = 1.96 \\ &\approx 2 \text{ seconds per vehicle} \end{aligned}$$

$$\begin{aligned} \text{Length closed between signals} &= \text{bridge length} + [\text{approach slabs} + \text{taper for barriers}] \\ &= 650' + [40' + 60'] \times 2 \\ &= 850' \end{aligned}$$

$$\begin{aligned} \text{Time to travel closed length} &= 850' \div 44 \text{ ft/sec} \\ &= 19.3 \\ &\approx 20 \text{ seconds} \end{aligned}$$

Assume 100 second cycle with a 60 / 40 phase split, determine available vehicle travel time

	60% phase	40% phase
green time	$100 \times 0.60 = 60.0 \text{ sec}$	$100 \times 0.40 = 40.0 \text{ sec}$
lost time (start-up)	$= -3.5 \text{ sec}$	$= -3.5 \text{ sec}$
effective green	$56.5 \text{ sec}$	$36.5 \text{ sec}$
time to travel closed length	$-20.0 \text{ sec}$	$-20.0 \text{ sec}$
available vehicle travel time	$36.5 \text{ sec}$	$16.5 \text{ sec}$

$$\begin{aligned} \text{VPC}_{60} &= \text{vehicles per cycle [60\%]} \\ &= 36.5 \text{ sec per cycle} \div 2 \text{ sec per vehicle} \\ &= 18.25 \text{ vehicles per cycle} \\ &\approx \mathbf{18 \text{ (capacity)}} \geq 12 \text{ (demand)} \end{aligned}$$

$$\begin{aligned} \text{VPC}_{40} &= \text{vehicles per cycle [40\%]} \\ &= 16.5 \text{ sec per cycle} \div 2 \text{ sec per vehicle} \\ &= 8.25 \text{ vehicles per cycle} \\ &\approx \mathbf{8 \text{ (capacity)}} \geq 3 \text{ (demand)} \end{aligned}$$

## **DETOUR BRIDGES AND ROADWAYS**

Detour bridge details shall be in accordance with the standard bridge detour details

### **BRIDGE DETOUR TYPE OPTIONS**

At the contractors option, the detour bridge may be one of the following:

1. LA DOTD detour bridge metric standard details.
2. Other approved alternatives: The contractor will be required to submit drawings and calculations for this alternate to the bridge design engineer for approval. These drawings and calculations shall be stamped by a civil engineer registered in the State of Louisiana. The alternate shall be designed according to the latest AASHTO standard specifications for highway bridges. design live load shall be MS-18 and HST-18 (M). all drawings shall be submitted according to section 801 of the Louisiana Standard Specifications For Roads And Bridges to be approved by the bridge design engineer.
3. Acrow prefabricated steel panel bridge: The use of this bridge type must be approved for use by the bridge design engineer. If approved, the department will provide the contractor with the superstructure and substructure details for the bridge(s).

### **SUBSTRUCTURE OPTIONS**

1. Bent caps will be precast concrete. Piles may be timber or steel.
2. Pile lengths: The contractor shall be responsible for determining the pile lengths. A factor of safety of 2.0 will be used in determining the pile lengths. Calculations stamped by a civil engineer registered in the state of Louisiana to justify the pile lengths will be sent to the bridge design engineer for approval

## GUARDRAILS

Guardrails shall be installed at all four (4) corners of detour bridges with a minimum length of 19.05 m for bridges having flexible rail, concrete or barrier types. All guardrails for detour bridges shall be included in the price for "Temporary Detour Bridging". For details, see DOTD Bridge Detour Standard Details.

## LOCATION OF DETOUR, PLAN AND PROFILE DETAILS, AND FINISH GRADE

The determination of the detour location should be made on the plan-in-hand inspection or at the subsequent office review. The detour details shall include a plan and profile of the bridge indicating the finish grade, span types and lengths, natural ground line, substructure types, and any geometric information needed.

The length and finish grade of the detour bridge shall be determined using a flood frequency equal to the detour service life multiplied by the drainage design factor (DDF).

Flood Frequency = Service Life x DDF (Service Life  $\geq$  1 year)

$$\text{DDF} = 3 \text{ (ADT } \leq 750)$$

$$= 5 \text{ (ADT } > 750)$$

$$= 7 \text{ (4-lane crossover)}$$

A discharge and high water elevation is then computed for the detour flood frequency. The finish grade of the detour bridge should be set approximately 1 m above the detour high water, and the length should be set as required to pass the detour discharge, Q. In many instances (particularly in North Louisiana) the requirements of spanning bank to bank will govern over the hydraulics. Bulkheads will be used as per our detail shown in our detour bridge standard detail. A profile of the natural ground should be drawn as an aid in establishing the detour profile. The profile can then be superimposed on the ground line in order that the fill/cut areas may be balanced as much as possible. Profile grades should not exceed 5%. Slope stability of the embankments must be a consideration when determining the length of the detour bridge. The Geotechnical Section should review the detour embankments when deemed necessary and provide comments concerning slope stability.

When placing a detour over deep ravines, pile slenderness ratios (L/D) must be considered.

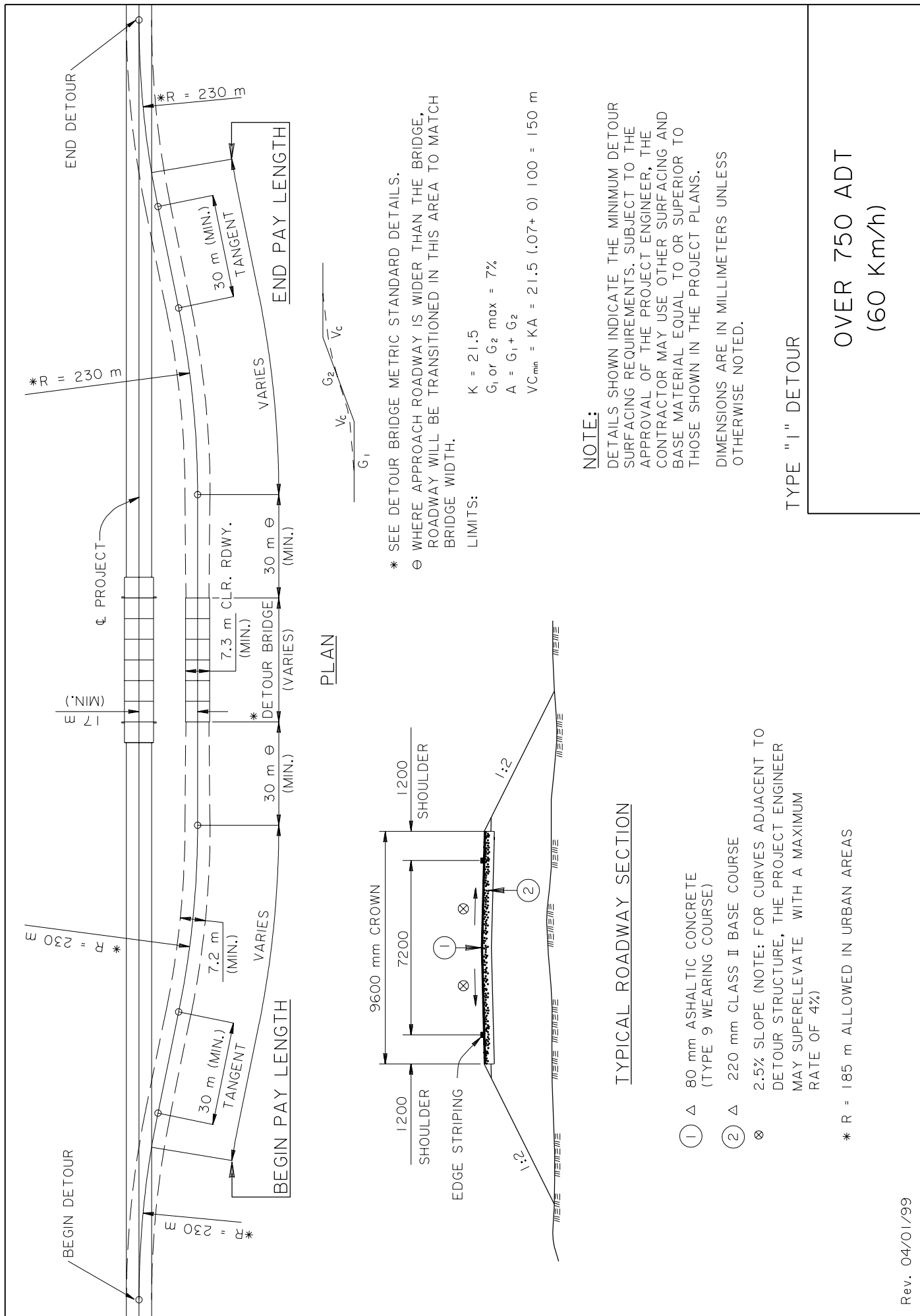
## DETOUR LAYOUT SHEET

Detour layout will be set up in accordance with the following guidelines:

1. Detour stations will be relative to the survey centerline and shown at the beginning and the end of detour. Other stations along the detour shall be shown as projected stations off the centerline.
2. The profile shown shall represent the true profile along the detour alignment. Since the lengths shown along the profile will not add up to the difference in stations at the beginning and the end of detour, the following note should be added for clarification:

NOTE: LENGTHS ARE MEASURED ALONG DETOUR CENTERLINE AND STATIONS ARE PROJECT CENTERLINE STATIONS.





BEGIN DETOUR

\*R = 230 m

30 m (MIN.) TANGENT

7.2 m (MIN.)

VARIABLES

30 m  $\phi$  (MIN.)

DETOUR BRIDGE (VARIES)

7.3 m (MIN.) CLR. RDWY.

30 m  $\phi$  (MIN.)

END DETOUR

\*R = 230 m

30 m (MIN.) TANGENT

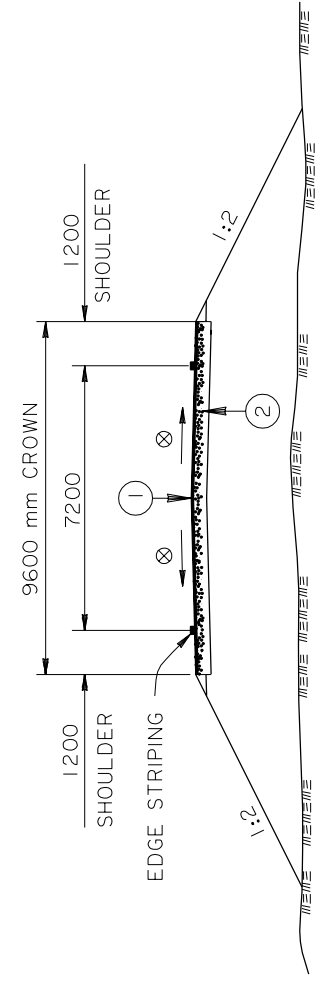
END PAY LENGTH

BEGIN PAY LENGTH

CL PROJECT

CL

PLAN



TYPICAL ROADWAY SECTION

- ①  $\Delta$  80 mm ASHALTIC CONCRETE (TYPE 9 WEARING COURSE)
- ②  $\Delta$  220 mm CLASS II BASE COURSE
- $\otimes$  2.5% SLOPE (NOTE: FOR CURVES ADJACENT TO DETOUR STRUCTURE, THE PROJECT ENGINEER MAY SUPERELEVATE WITH A MAXIMUM RATE OF 4%)

\* R = 185 m ALLOWED IN URBAN AREAS

\* SEE DETOUR BRIDGE METRIC STANDARD DETAILS.

$\phi$  WHERE APPROACH ROADWAY IS WIDER THAN THE BRIDGE, ROADWAY WILL BE TRANSITIONED IN THIS AREA TO MATCH BRIDGE WIDTH.

LIMITS:

$K = 21.5$

$G_1 \text{ or } G_2 \text{ max} = 7\%$

$A = G_1 + G_2$

$VC_{min} = KA = 21.5 (.07 + 0) 100 = 150 \text{ m}$

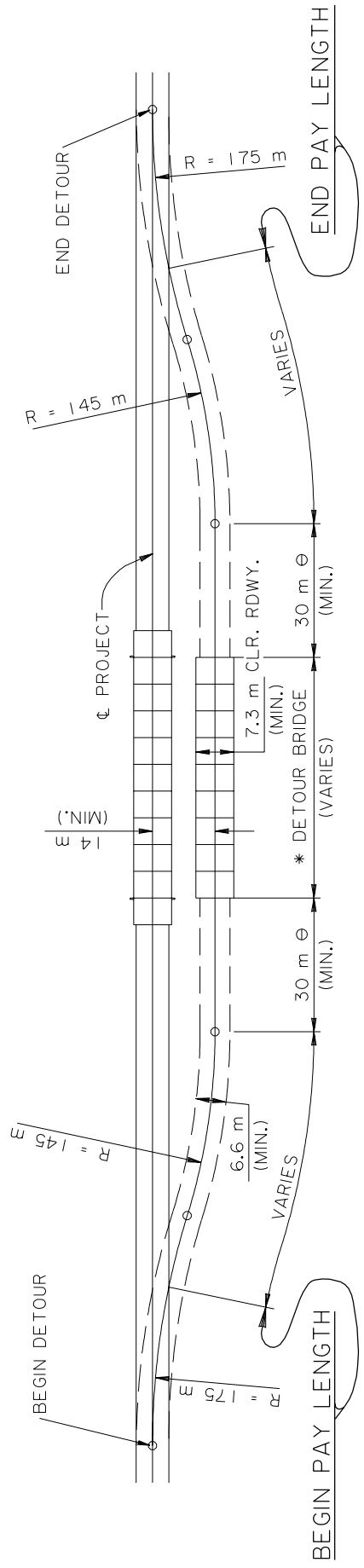
NOTE:

DETAILS SHOWN INDICATE THE MINIMUM DETOUR SURFACING REQUIREMENTS. SUBJECT TO THE APPROVAL OF THE PROJECT ENGINEER, THE CONTRACTOR MAY USE OTHER SURFACING AND BASE MATERIAL EQUAL TO OR SUPERIOR TO THOSE SHOWN IN THE PROJECT PLANS.

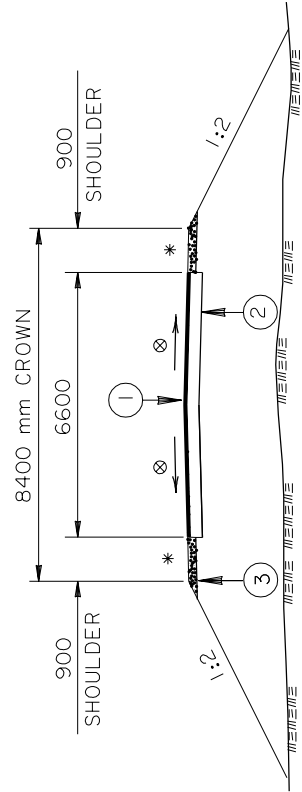
DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

TYPE "I" DETOUR

OVER 750 ADT  
(60 Km/h)



**PLAN**



**TYPICAL ROADWAY SECTION**

- ① 50 mm ASHALTIC CONCRETE (TYPE 9 WEARING COURSE)
  - ② 220 mm CLASS II BASE COURSE
  - ⊗ 2.5% SLOPE (NOTE: FOR CURVES ADJACENT TO DETOUR STRUCTURE, THE PROJECT ENGINEER MAY SUPERELEVATE WITH A MAXIMUM RATE OF 2.5%)
  - \* 5% SLOPE
  - ③ 100 mm AGGREGATE SURFACE COURSE
- △ AGGREGATE SURFACING MAY BE USED AT THE DISCRETION OF THE PLAN-IN-HAND PARTY. IN NO CASE SHALL A HARD SURFACED DETOUR BE USED FOR MAINTAINING TRAFFIC ON AN EXISTING AGGREGATE SURFACED ROAD.

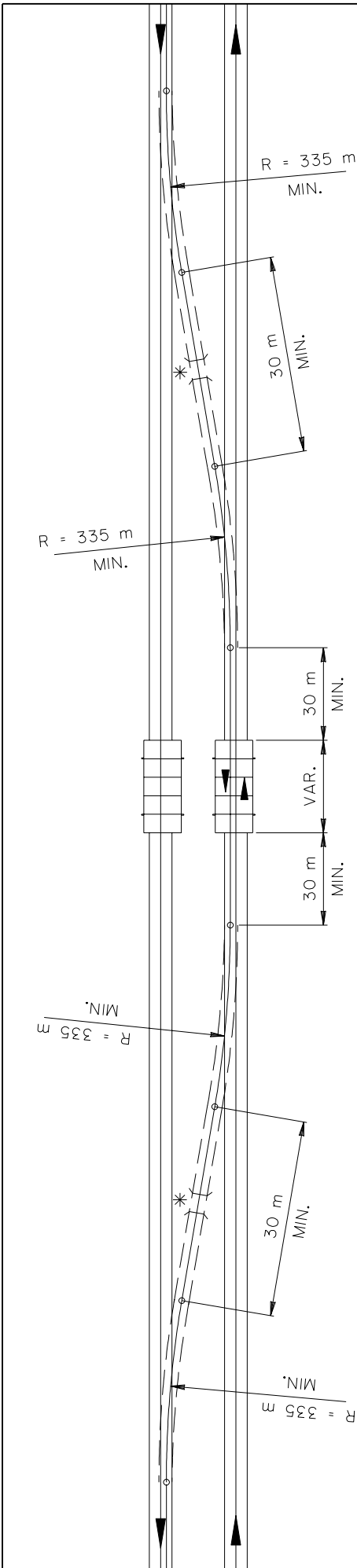
\* SEE DETOUR BRIDGE METRIC STANDARD DETAILS.  
 ⊕ WHERE APPROACH ROADWAY IS WIDER THAN THE BRIDGE, ROADWAY WILL BE TRANSITIONED IN THIS AREA TO MATCH BRIDGE WIDTH.  
 LIMITS:  
 $K = 12$   
 $G_1 \text{ or } G_2 \text{ max} = 7\%$   
 $A = G_1 + G_2$   
 $VC_{min} = KA = 12 (.07 + 0) 100 = 84 \text{ m}$

**NOTE:**

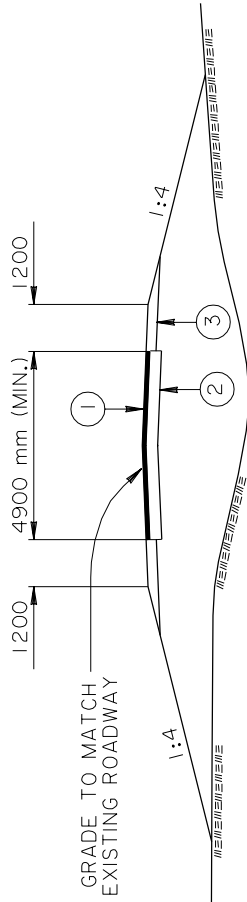
DETAILS SHOWN INDICATE THE MINIMUM DETOUR. SURFACING REQUIREMENTS ARE SUBJECT TO THE APPROVAL OF THE PROJECT ENGINEER. THE CONTRACTOR MAY USE OTHER SURFACING AND BASE MATERIAL EQUAL TO OR SUPERIOR TO THOSE SHOWN IN THE PROJECT PLANS.

TYPE "2" DETOUR

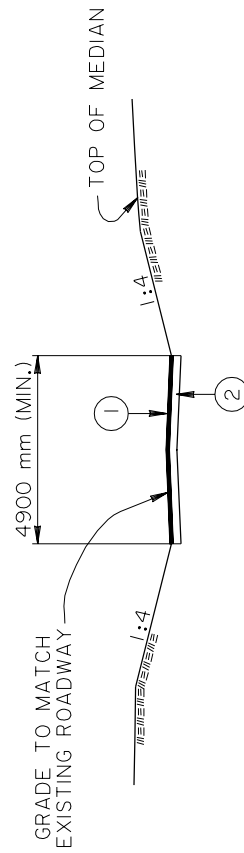
UNDER 750 ADT  
 (50 km/h)



PLAN



TYPICAL ROADWAY SECTION  
DEPRESSED MEDIAN



TYPICAL ROADWAY SECTION  
RAISED MEDIAN

- ① 100 mm ASHALTIC CONCRETE (50 mm WEARING COURSE)(50 mm BINDER COURSE) (TYPE 9)
- ② 220 mm TYPE II BASE COURSE
- ③ 100 mm AGGREGATE SURFACE COURSE

LIMITS:  
 $K = 25$   
 $G_1$  or  $G_2$  max = 7%  
 $A = G_1 + G_2$   
 $VC_{min} = KA = 25 (.07 + 0) 100 = 175$  m

\* TEMP DRAINAGE DITCH, PIPE SIZE & LOCATION TO BE DETERMINED IN FIELD

**NOTE:**

DETAILS SHOWN INDICATE THE MINIMUM DETOUR SURFACING REQUIREMENTS. SUBJECT TO THE APPROVAL OF THE PROJECT ENGINEER, THE CONTRACTOR MAY USE OTHER SURFACING AND BASE MATERIAL EQUAL TO OR SUPERIOR TO THOSE SHOWN IN THE PROJECT PLANS.

TYPE "3" DETOUR

TYPICAL CROSSOVER DETOUR  
 FOUR-LANE HIGHWAY (70 km/h)

## **SPECIAL LOADING CONSIDERATIONS**

### **DEAD LOAD**

The dead loads shall be distributed as specified in the AASHTO Specifications except as follows: railings, parapets, and sidewalks shall normally be assumed to be carried by the exterior girder only. If in the judgment of the design engineer, the dead load of the sidewalk parapet is cantilevered "excessively" out from the exterior girder, he may sum moments due to dead load components supported by the exterior girder about the first interior girder. A load of 600 N/m<sup>2</sup> shall be applied to the deck to account for future wearing surface.

### **EARTHQUAKE LOADING**

Earthquake loading shall be investigated in accordance with the "AASHTO Guide Specifications for Seismic Design of Highway Bridges". (See Chapter 6)

### **LIVE LOAD**

#### Stresses

Live load stresses shall be determined as specified in the AASHTO Specifications except as follows: for moments, shears and reactions, the design load shall be AASHTO MS-18 truck or lane load, or Louisiana HST-18(M) truck load, whichever governs, except that for local (farm-to-market) roads HST-18(M) loading shall generally not be used. When lane loading is used, it shall be distributed as equivalent concentrated wheel loads.

#### Serviceability

For fatigue serviceability requirements and deflection considerations, HST-18(M) loading shall not be used. Live load deflection shall be computed in accordance with the AASHTO Specifications except that the number of loaded lanes shall equal to the number of actual travel lanes.

#### Military Loading

Alternate military loading shall be applied on the interstate system for the design of main bridge members. Transversely reinforced concrete slabs which are supported by main longitudinal members are not considered as main load carrying members. Military loading shall be as specified in the AASHTO Specifications with the following modifications: The standard MS-18 loading has been supplemented by the addition of a tandem axle modified loading consisting of 108 kN on each of two (2) axles, spaced 1200 mm apart as shown herein. Military loading is only required on interstate bridges.

## Impact

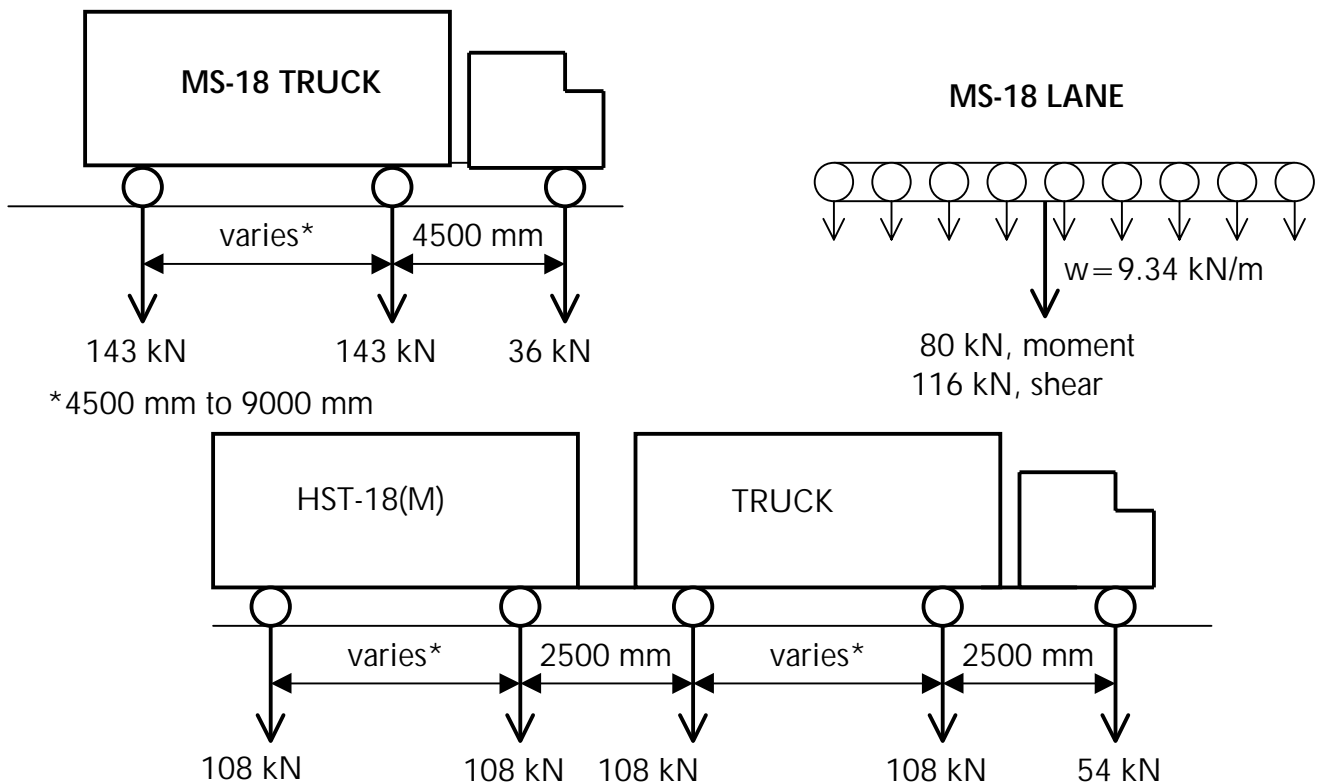
Impact shall be applied as specified in the AASHTO Specifications except as follows: impact shall be applied to caps of pile bents and to all portions of column bents except piles.

## Summary Of Live Loads

TRUCK TYPE	WHERE USED	SPECIAL CONSIDERATIONS
<b>MS-18</b>	All bridges	Truck or lane <sup>6</sup> , whichever governs
<b>HST-18(M)</b>	All bridges except on local (farm to market) roads	Not used for serviceability requirements, fatigue or camber calculations
<b>MILITARY</b>	Interstate bridges only	Generally governs only for spans < 9.15 m

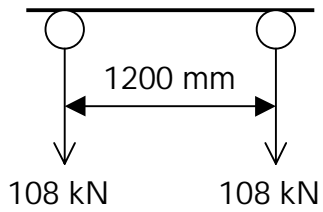
### Longitudinal View of Loading

Axle Load shown, wheel load = ½ axle load

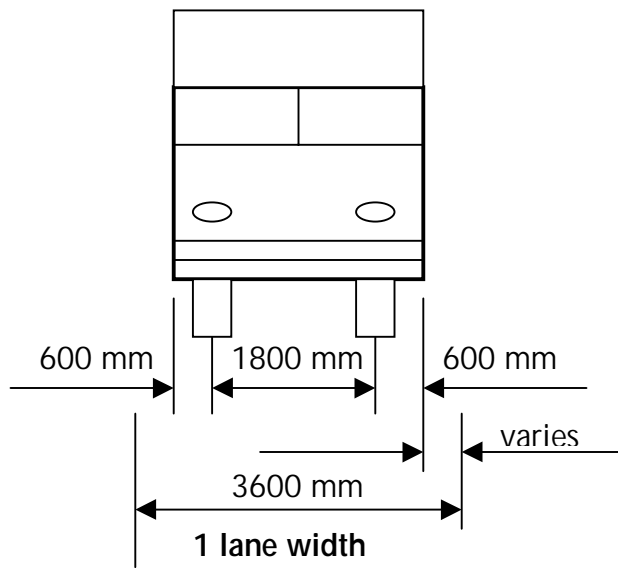


<sup>6</sup> Additional concentrated load requirements for continuous spans, see AASHTO Specifications

### Military Loading



### Transverse View of Loading



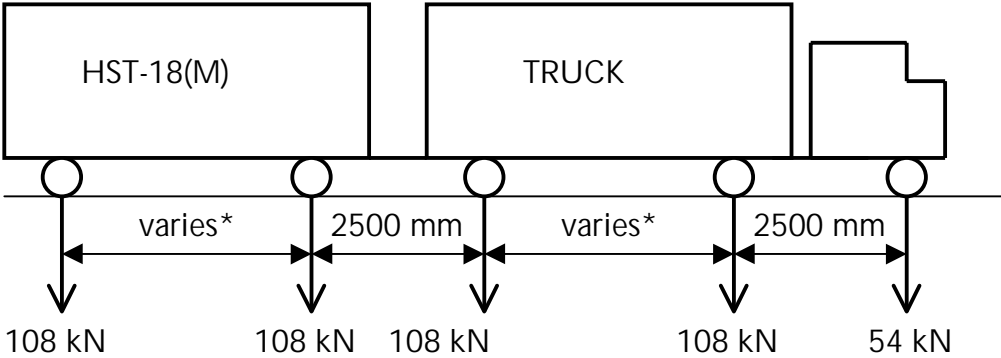
### Sound Wall Load:

Bridges which require installation of Sound Walls shall be designed to accommodate the appropriate dead, live and wind loads for the required wall height. Dead loads of the wall shall be minimum of 45 kg/m for wall heights up to 3 meters and 90 kg/m for walls greater than 3 meters.

# SUMMARY OF GENERAL NOTES COMMONLY USED IN BRIDGE PLANS

## GENERAL ITEMS

- 1. Design Specifications: Structural design is in accordance with AASTHO Standard Specifications for Highway Bridges, 1996, and interim specifications. Geometric Design is in accordance with " A Policy on Geometric Design of Highway and Streets, 1994".
- 2. Design Criteria: The bridge is designed for a future wearing surface equal to 600 N/m<sup>2</sup>.
- 3. Live Loading: MS-18 truck or lane load, or HST-18(M) truck load, whichever governs. HST-18(M) shall not be used for fatigue criteria or for service load requirements for steel members designed by the load factor method. (Add military loading for interstate routes.)



\*4500 mm to 9000 mm

- 4. Design speed: km/h.
- 5. Construction Specifications: Construction shall be in accordance with the Louisiana Department of Transportation and Development Standard Specifications for Roads and Bridges, 1992, except as supplemented or amended by the plans, Supplemental Specifications and/or Special Provisions
- 6. Elevations: All elevations are based on N.A.V.D.- 88<sup>7</sup>
- 7. Dimensions: All dimensions are given at normal temperature of 20 degrees Celsius.
- 8. Year Plate: Date of construction is required at right wingwalls of structures for oncoming traffic lanes. (See standard detail YP-01(M)).

<sup>7</sup> In most cases, the survey datum is based on N.A.V.D.-88, however the Engineer is responsible to check the level books for datum reference used prior to placing this sentence in the plans.

9. All areas of disturbed embankment slopes not having revetment are to receive seeding and fertilizing (no direct pay).

## CONCRETE ITEMS

All superstructure concrete is to be Class "AA" concrete, all substructure concrete is to be Class "A", all precast prestressed concrete members are to be Class "P" or "P(M)" concrete unless otherwise specified in the plans. Chamfer all exposed edges of concrete 20 mm except all corners of bents which shall be chamfered 40 mm unless otherwise noted. No deductions are to be made in concrete quantities for chamfers 40 mm or less. Concrete and steel in concrete railing to be paid for per linear meter of concrete railing including No. 15 bars that project into railing.

### Concrete Construction Joint Notes

- A. Construction Joints: Where construction joints are used, not less than seven (7) days shall have elapsed between adjacent pours. The vertical surfaces of the construction joints between adjacent pours shall be coated prior to each succeeding pour with a type II epoxy resin system in accordance with subsection 805.06(B)(2) of the Standard Specifications. Epoxy is to be applied in accordance with the manufacturer's instructions. No direct payment for this work.
- B. Concrete Bonding: Where new concrete is to be bonded to existing concrete surfaces, the contractor shall coat the existing concrete surface with a type II epoxy resin system in accordance with subsection 805.06(B)(2) of the Standard Specifications prior to placing of new concrete, (no direct payment). After pouring the entire deck, a minimum of three (3) days must elapse (or concrete shall attain a minimum compressive strength of 11 MPa before placement of reinforcing steel and forms for barrier railing. The slab shall attain a minimum compressive strength of 24 MPa before pouring the barrier railing.

### Concrete Repair Notes

- A. Concrete Removal: Existing concrete to be removed shall be designated in the plans. Where concrete is designated to be removed, a 20 mm deep saw cut shall be made along the face of the concrete around the perimeter of the removal area. All existing concrete removed from the bridge shall become the property of the contractor and shall be disposed of outside the limits of the right-of-way.



- B. Epoxy Application: An approved epoxy resin system in accordance with QPL-32, shall be used to bond the new concrete to the existing concrete. Epoxy shall be applied in accordance with the manufacturer's instructions.
- C. Reinforcing Steel Repairs: Existing reinforcing steel to remain shall project from the concrete surface the minimum distance shown in the plans. This steel shall be straightened and cleaned of old concrete and foreign material before the new concrete is poured. Care shall be taken to insure that the existing reinforcing steel is not broken during concrete removal, straightening or cleaning. In the event that any projecting steel is broken, it must be repaired either by welding an equivalent sized bar in accordance with AWS D 1.4-92 or by using an approved mechanical splice in accordance with QPL-44.
- D. Deck Patching: This item consists of removing and replacing areas of existing bridge deck where delaminations have occurred in accordance with the standard specifications and the following requirements:

Areas requiring patching shall be determined by sounding the deck with hammers or chains as directed by the engineer. Unsound concrete shall be removed to a minimum depth of 65 mm below the surface. All reinforcing bars and exposed surfaces of concrete shall be thoroughly cleaned by sandblasting prior to placement of patching material. Feather edges shall be eliminated by saw cutting sound concrete to a vertical surface 15 mm deep around the patch. Care shall be taken to prevent damaging any exposed reinforcing steel.

Patching shall be made with a rapid setting patching material from the Qualified Products List No. 24. Surface preparation, mixing, equipment, and application shall be in accordance with the manufacturer's recommendations, except as amended herein. A four-hour minimum set retard time will be required for the patching material.

## REINFORCING STEEL

Dimensions relating to reinforcing steel fabrication are out to out of bar unless otherwise noted. Dimensions relating to reinforcing steel spacing are center to center of bar. The minimum covering from the surface of the concrete to the face of any deformed reinforcing bar shall not be less than the following:

Top of slab	= 50 mm
Bottom of slab	= 25 mm <sup>8*</sup>

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<sup>8</sup> Use 50 mm in areas where brackish or salt water is encountered.

All other reinforcing steel cover shall be 50 mm unless otherwise noted in the plans. See standard plan SWBS-100 (M) for bar supports for reinforcing steel.

When epoxy coated reinforcing is specified, all bar supports and tie wire in contact with the epoxy coated rebar shall be non corrosive and non conductive. See Standard Plan SWBS-100 (M) for bar supports for reinforcing steel. All reinforcing steel shall be grade 420. All reinforcing steel is designed and detailed as metric. Bar designations are specified with the prefix "B" followed by the bar size and mark.

The contractor will be allowed to substitute english for metric bars. The substitution shall be made on a one to one basis for the designated metric bar. The substitution will be made at no additional pay.

<b>TABLE FOR REINFORCING BAR SIZE SUBSTITUTIONS (english for metric)</b>		
<b>HARD METRIC</b>	<b>SOFT METRIC</b>	<b>ENGLISH</b>
<b>10</b>	13	<b>4</b>
<b>15</b>	16	<b>5</b>
<b>20</b>	22	<b>7</b>
<b>25</b>	25	<b>8</b>
<b>30</b>	32	<b>10</b>
<b>35</b>	36	<b>11</b>

## **PILES**

The pile notes are dependent on several factors particular to each project. See chapter 6 for detailed notes and information.

## **DRILLED SHAFTS**

Drilled shafts size, type, length, and maximum design load shall be described in the plans and project specifications. All excavation or fill shall be complete prior to the installation of drilled shafts affected.

## PRESTRESSED GIRDERS

For general notes on precast-prestressed concrete girders, see Miscellaneous Span and Girder Details. For spans without intermediate diaphragms, the contractor will be required to provide bracing between girders to ensure stability and proper alignment during erection and pouring sequence.

## OPTIONAL DECK FORMING SYSTEMS

Optional Span Details: The contractor may use precast-prestressed optional span details. See the plans and the Standard Specifications.

Galvanized Stay-In-Place Metal Forms: The contractor will be allowed to use galvanized stay-in-place metal forms provided the use of the forms does not add weight or thickness to the concrete deck. The stay-in-place forms must conform to ASTM A 653M (table 1) designation G165.

## EXISTING BRIDGE REMOVAL

The existing bridge to be removed under item 202(02)(A)( ), per each, includes the following structure:

Structure Number: \_\_\_\_\_

The contractor is to remove all parts of the existing bridge in their entirety as stipulated in the Construction Specifications. Salvageable existing guardrails shall be hauled and unloaded by the contractor to the \_\_\_\_\_ maintenance unit, (at no direct pay). All other materials shall become property of the contractor and disposed of by the contractor outside the limits of the right-of-way.

## STRUCTURAL METALWORK

### Steel (minor)

Structural Steel: All steel shall be structural carbon steel conforming to ASTM A 709M (GR250) unless otherwise shown in the plans. Any necessary substitution must have prior approval of the Bridge Design Engineer. Anchor bolts, nuts and washers shall be hot dipped galvanized. Payment for structural steel is made under item 807(06), Structural Metalwork, per lump sum.

### Steel (major)

Structural Metalwork: Unless indicated in the plans, all structural steel shall be structural carbon steel in accordance with ASTM A 709M, (GR250). High strength low-alloy steel shall be in accordance with ASTM A 709M, (GR345) or A 709M, (GR345W). . All steel shall be positioned in the members or splice plates so as to place the direction of finish rolling parallel to the direction of primary stress. For continuous spans, detailed erection drawings outlining complete procedures along with the equipment to be used for erection shall be submitted to the Bridge Design Engineer for approval.

### Welding Items

Welding: Welding of all structural steel and steel pipes shall conform to Section 815 welding of the Louisiana Standard Specifications for Roads and Bridges.

### Bolted Connections

All field connections shall be made with high strength bolts conforming to ASTM A 325. Bolt spacing shall be in accordance with design drawings, shop drawings, and the requirements of design specifications. Unless otherwise shown, bolted connections shall be made with 22 mm diameter high strength bolts. One washer will be required beneath the turning element. Bolted connections are designed as friction type.

### Galvanized Steel

All miscellaneous hardware which is specified to be galvanized shall be coated in accordance with ASTM A 153. All structural steel shapes which are specified to be galvanized shall be coated in conformance with ASTM A 123 after fabrication. Damaged galvanized coats that are not to be embedded in more than 75 mm of concrete shall be repaired with cold applied, zinc rich, organic paint, from the approved Qualified Products List or any other approved method of repair.

### Charpy V-notch Testing

All structural members described below are designed as primary members and shall meet the longitudinal charpy V-notch test described in subsection 1013.01 of the Standard Specifications:

1. Tension flanges, webs and splice plates.
2. Stringers and stringer splice plates.
3. Specific members noted elsewhere in the plans.
4. Longitudinal stiffeners in tension areas.

### Fracture Critical Members (FCM)

Members noted as "FCM" in the plans shall meet the requirements that are provided in the project specifications. Heat numbers shall be shown on the shop drawings for all FCM noted members.

### Erection

Detailed erection drawings outlining the procedure and equipment to be used shall be submitted to the Bridge Design Engineer for approval.

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## INTRODUCTION

Welcome to the metric system. Most of us will be using the simple term "metric" to describe a rather detailed set of rules known formally as the *Système Internationale* or International System of units (SI). There are several variations of the system and all have much in common. The version known as SI is the one most trusted by highway agencies in this country.

The original metric system was proposed and adopted by the French during the time of the French Revolution and rapidly spread throughout Europe during the Napoleonic wars. Its use was first proposed in the United States by Thomas Jefferson and later by John Quincy Adams. In 1866 Congress authorized its use as a measurement system in the United States.

Recent enactment of several federal laws has renewed the interest in the widespread use of the metric system in this country. Executive Order No. 12770 signed by President Bush on July 25, 1991 requires that all federal agencies implement the use of the metric system. Subsequently, the Federal Highway Administration, which authorizes federal aid to LA DOTD, has established a plan and schedule for converting to metric. **Our deadline is October 1, 2000.** Changing to metric will not be as difficult as you might expect. Other nations did not find it to be difficult. Every engineer's college studies included some training in metric, and many now work exclusively with metric. The Department has already adopted several national and international metric standards. These include some standards which have been in existence and use for many years such as those of the American Society of Testing Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO). Additionally, many DOTD materials tests are already conducted in metric measurements.

## **BRIDGE DESIGN SECTION POLICIES**

1. For reasons of uniformity and consistency, the following note will be added to the General Notes for all construction and required standard plans. **"ALL DIMENSIONS ARE IN MILLIMETERS (mm) UNLESS OTHERWISE NOTED"**.
2. **Centimeter dimensions** will not be used.
3. **Kilogram (kg)** is the base unit of mass, which is the unit quantity of matter independent of gravity.
4. All new surveys will be prepared using metric measurements, unless instructed otherwise by the Department.
5. Foreslope and backslope ratios will be expressed as **rise/run**, example **1:3**.
6. **1000 m or km stationing** will be used for metric plans.
7. **Radius** definition of curves will be used.
8. **Angular measurements** shall continue to be made in degrees, minutes, and seconds.
9. **Length conversion.** In converting feet to meters, it should be noted there are two definitions of the foot in the metric system. They are:
  - a) The international foot is defined as exactly 0.3048 meters.
  - b) The U.S. Survey foot is defined as  $1200 \div 3937$  m, which is 0.30480060960. By law, the Louisiana DOTD must use the U.S. Survey foot definition.



## BASIC METRIC INFORMATION

The metric system is formally referred to as the International System of Units or *Système Internationale* (SI), and it is acceptable to use the terminology interchangeably.

To help you get started in the metric system, here are some of the fundamental items that you should know.

**Meter (m):** The basic unit for measurement of length in the metric system is the meter. The meter is slightly longer than a yard and is generally used for measuring short distances. The length of a football field is approximately 91 m.

**Kilometer (km):** The metric unit that is generally used to denote longer distances is the kilometer. The kilometer is equal to 1000 m and is slightly longer than 0.6 miles.

**Millimeter (mm):** The metric unit that is often applied to the measurement of small distances or thickness is the millimeter. The millimeter is equal to one-thousandth of a meter, or 0.001 m. An inch is approximately 25 mm. Have you ever used any 35 mm film in your camera?

**Square meter (m<sup>2</sup>):** The unit commonly used for the measurement of area is the square meter. A square meter is approximately 20% larger in area than a square yard. A room that is ten feet long and ten feet wide has a floor area of approximately 9 m<sup>2</sup>.

**Hectare (ha):** The unit of measurement commonly used to express the area of bodies of land or water is the hectare. A hectare is equal to 10 000 m<sup>2</sup>, which is approximately 2.5 acres.

**Cubic meter (m<sup>3</sup>):** The unit of volume in the metric system is the cubic meter. The cubic meter has approximately 30% more volume than a cubic yard.

**Liter (L):** The unit that is used for the measurement of liquids or gases is the liter. The liter is defined as the volume occupied by the mass of a kilogram of pure water at 4°C (its maximum density under normal atmospheric pressure). A liter is slightly more than a quart. Have you ever purchased a soft drink in a 2 liter bottle?

It should be noted that a liter is also equivalent to one-thousandth of a cubic meter (0.001 m<sup>3</sup>).

**Gram (g):** The unit most commonly used to express the mass of small items is the gram. A gram is equivalent to one-thousandth of a kilogram, or 0.001 kg. The mass of a penny is approximately 3 g.

**Kilogram (kg):** The basic unit that is used to express the mass of an item is the kilogram. This unit is commonly used to express the mass of large items such as televisions and refrigerators. A kilogram is approximately 2.2 pounds.

It should be pointed out that what is commonly referred to as "weight" in our current system of units is defined as "mass" in the metric system. For example, an individual or item that "weighs" 150 pounds has a mass of approximately 68 kg.

**Megagram (Mg):** The unit commonly used to express the mass of very large items or quantities is the Megagram. The metric ton is equivalent to 1000 kg.

**Newton (N):** The newton is the basic unit of force that is required to accelerate a mass of one kilogram at a rate of one meter per second per second, and is denoted by the formula  $\text{kg}\cdot\text{m}/\text{s}^2$ . This acceleration is commonly referred to as the acceleration of gravity.

It should be pointed out that the descriptive terminology "weight" as currently applied to an individual or an object is in fact the result of the acceleration due to gravity that is acting upon the "mass" of the individual or object. The same object on the earth's surface and on the moon's surface would have the exact same mass, but on the moon, the object would weigh much less due to the much lower acceleration of gravity on the moon. This phenomenon is due to the force of gravity, which is equal to the mass of an object multiplied by the acceleration of gravity. In the metric system, the acceleration of a body due to the earth's gravity at sea level is  $9.81 \text{ m}/\text{s}^2$ .

**Second (s):** The second is the fundamental unit of time and is the same unit as currently used in everyday terminology.

**Temperature (°C):** The metric unit that is widely used in the measurement of temperature is the degree Celsius (°C). On a hot summer day, when the temperature is normally expressed as 95°F (Fahrenheit scale), the metric equivalent would be 35°C.

**Velocity (km/h):** Velocity, or speed, is expressed in kilometers per hour (km/h). A residential speed limit of 25 miles per hour (mph) is approximately 40 km/h.

**Pascal (Pa):** The basic unit of pressure or stress in the metric system is the pascal. The pascal is the pressure or stress of one newton per square meter of area.

A typical automobile tire pressure of 35 pounds per square inch (psi) is approximately equal to 241 000 Pa, or more appropriately 241 kPa (kilopascals). A typical value of concrete compressive strength is 3000 psi, which is approximately equal to 20 000 000 Pa, or more appropriately 20 MPa (megaPascals).

## BUILDING BLOCKS FOR SI UNITS

### SI Base Units

Base Units	Units	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	Celsius	°C
electrical current	ampere	A
luminous intensity	candela	cd
amount of material	mole	mol
Supplementary Units	Units	Symbol
angles in the plane	deg, min & sec	° , ' , "
solid angles	steradian	sr

### Prefixes

Sub multiples			Multiples		
deci	$10^{-1}$	d	deka	$10^1$	da
centi	$10^{-2}$	c	hecto	$10^2$	h
milli	$10^{-3}$	m	kilo	$10^3$	k
micro	$10^{-6}$	μ	mega	$10^6$	M
nano	$10^{-9}$	n	giga	$10^9$	G
pica	$10^{-12}$	p	tera	$10^{12}$	T
femto	$10^{-15}$	f	peta	$10^{15}$	P
atto	$10^{-18}$	a	exa	$10^{18}$	E
zepto	$10^{-21}$	z	zetta	$10^{21}$	Z
yocto	$10^{-24}$	y	yotta	$10^{24}$	Y

NOTE: AASHTO DOES NOT USE DECI, CENTI, DECA & HECTO UNITS.

Derived Units with special names

Quantity	Name	Symbol	Expression
frequency	hertz	Hz	s <sup>-1</sup>
force	newton	N	kg·m/s <sup>2</sup>
pressure, stress	pascal	Pa	N/m <sup>2</sup>
energy, work, heat quantity	joule	J	N·m
power, radiant flux	watt	W	J/s
electric charge, quantity	coulomb	C	A·s
electric potential	volt	V	W/A
capacitance	farad	F	C/V
electric resistance	ohm	Ω	V/A
electric conductance	siemens	S	A/V
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m <sup>2</sup>
inductance	henry	H	Wb/A
luminous flux	lumen	lm	cd·sr
illuminance	lux	lx	lm/m <sup>2</sup>

## PHILOSOPHIES OF CONVERSION

Conversion from the English system of measurement to SI is an important topic for the transition period. It affects standards, specifications, guidelines, numerical regulatory limits, and manufacturing. There are two philosophies of conversion which may be applied in a given circumstance:

1. **Soft Conversion:** Direct mathematical conversion. The physical dimensions of a standard or product is unchanged, only the numerical value changes. For products this results only in changing of the label.

Examples: A 55 mph speed limit becomes 88.514 km/h.  
A 12 foot lane becomes a 3.6576 m lane.

2. **Hard Conversion:** Converting to an nominal number. Results in changing product size as well as label.

Examples: A 55 mph speed limit becomes 90 km/h.  
A 12 foot lane becomes a 3.6 m lane.

For a transition period it will be necessary to convert existing English quantities into the equivalent SI units. The following Conversion Factors Tables summarize several conversion factor useful in highway engineering.

## USEFUL CONVERSION FACTORS

QUANTITY	FROM ENGLISH UNITS	TO METRIC UNITS	MULTIPLY BY*
length	mile	km	1.609347
	yard	m	0.914401
	foot	m	0.304800
	inch	mm	25.40005
area	square mile	km <sup>2</sup>	2.590
	acre	m <sup>2</sup>	4047
	acre	hectare	0.4047
	square yard	m <sup>2</sup>	0.8361
	square foot	m <sup>2</sup>	0.09290
	square inch	mm <sup>2</sup>	645.2
volume	acre foot	m <sup>3</sup>	1233
	cubic yard	m <sup>3</sup>	0.7646
	cubic foot	m <sup>3</sup>	0.02832
	cubic foot	L (1000 cm <sup>3</sup> )	28.32
	1000 board feet	m <sup>3</sup>	2.360
	gallon	L (1000 cm <sup>3</sup> )	3.785
	cubic inch	cm <sup>3</sup>	16.39
mass	lb	kg	0.4536
	kips (1,000 lb)	metric ton (1000 kg)	0.4536
mass/unit length	plf	kg/m	1.488
mass/unit area	psf	kg/m <sup>2</sup>	4.882
mass density	pcf	kg/m <sup>3</sup>	16.02
force	lb	N	4.448
	kip	kN	4.448
force/unit length	plf	N/m	14.59
	klf	kN/m	14.59
pressure, stress, modulus of elasticity	psf	Pa	47.88
	ksf	kPa	47.88
	psi	kPa	6.895
	ksi	MPa	6.895
bending moment, torque, moment of force	ft lb	N · m	1.356
	ft kip	kN · m	1.356

\* SIGNIFICANT FIGURES

## USEFUL CONVERSION FACTORS

QUANTITY	FROM ENGLISH UNITS	TO METRIC UNITS	MULTIPLY BY*
moment of mass	lb · ft	kg · m	0.1383
moment of inertia	lb · ft <sup>2</sup>	kg · m <sup>2</sup>	0.04214
second moment of inertia	in <sup>4</sup>	mm <sup>4</sup>	416 200
section modulus	in <sup>3</sup>	mm <sup>3</sup>	16 390
power	ton (refrig)	kW	3.517
	Btu/s	∕W	1.054
	hp (electric)	W	745.7
	Btu/h	W	0.2931
volume rate of flow	ft <sup>3</sup> /s	m <sup>3</sup> /s	0.02832
	cfm	m <sup>3</sup> /s	0.0004719
	cfm	L/s	0.4719
	mgd	m <sup>3</sup> /s	0.0438
velocity, speed	ft/s	m/s	<u>0.3048</u>
acceleration	f/s <sup>2</sup>	m/s <sup>2</sup>	<u>0.3048</u>
momentum	lb · ft/sec	kg · m/s	0.1383
angular momentum	lb · ft <sup>2</sup> /s	kg · m <sup>2</sup> /s	0.04214
plane angle	degree	rad	0.01745
		mrاد	17.45

\* 4 SIGNIFICANT FIGURES; UNDERLINE DENOTES EXACT CONVERSION

## **RULES FOR WRITING METRIC**

1. Print unit symbols in lower case except for liter (L) and megagram (Mg) or unless the unit name is derived from a proper name (**example: meter (m), kilogram (kg), newton (N), volt (V)**).
2. Print unit names in lower case, even those derived from a proper name. The first letter of a unit name is not capitalized except at the beginning of a sentence or in a capitalized material. (**exception: Always capitalized the word Celsius or the abbreviation for it, (C)**).
3. Print decimal prefixes in lower case for magnitudes  $\leq 10^3$  and print prefixes in upper case for magnitudes  $\geq 10^6$  (**example: kilometer (km), millimeter (mm), megaliter (ML)**).
4. Leave a space between numeral and symbol (**example write 45 kg not 45kg**).
5. Do not leave space or hyphen between prefix and unit name. (**example write kilometer not kilo-meter or kilo meter**)
6. Do not leave a space between a unit symbol and its decimal prefix (**example write km not k m**)
7. For area and volume quantities only, use the power modifier before the unit name (**example: cubic meter, square meter**).
8. For technical writing, use symbols in conjunction with numerals (**example: the area is 10 m<sup>2</sup>**); write the unit names if numerals are not used (**example: Area of wearing course is measured in square meters**). Numerals may be combined with written unit names in non-technical writing, (**example, 10 meters**).
9. Do not use the plural of unit symbol (**example: write 45 km**) but do use the plural of written unit names (**example: write 45 kilometers**)
10. Do not mix names and symbols (**example: write N·m or Newton meter, not N·meter**)
11. Do not use a period after a symbol, except when it occurs at the end of a sentence. (**example: write "12 g", not "12 g."**).
12. When text appears in dimensions, show units when needed for clarity. (**example: write B1002 @ 150 mm spaces**).
13. Use a zero before the decimal for values less than one (**example: write 0.45 m, not .45 m**).



14. Use spaces instead of commas to separate blocks of three digits, counting from the decimal point to both the right and left, for any number over **four** digits (**example: write 45 138 m, or 0.000 446 kg**). Note that this does not apply to the expression of amounts of money. (**example: write \$ 6,000,000.00**) or when used in formulas.
15. When compound units are formed by multiplication, leave space between unit names (**example: write Newton meter**); however, when using unit symbols, indicate the product by placing a dot between symbols (**example: write N·m**).
16. When dividing two units use "**per**" between the numerator and denominator **not "/"** or "**p**" if written out. (**example: kilometer per hour not kilometer/hour**) If symbols are used use the "/" and not "**p**". (**example: km/h not kmph**).
17. Never use fractions, always use decimals. (**example: write 0.75 m, not  $\frac{3}{4}$  m**)
18. Indicate the product of two or more units in symbolic form by using a raised dot. (**example: kg·m**)
19. 1000 m stations should be shown as follows; (**example: 34 + 192.300**).

## PRECISION AND ROUNDING

Conversion to SI is a good opportunity to highlight the topics of precision and rounding. However, it must be emphasized that these are not topics unique to SI. Precision of a measurement refers to the degree of mutual agreement between individual measurements such that they are reproducible. Rounding refers to the process of reducing the number of significant digits in a quantity to those appropriate for representing the precision of a quantity. In a unit system such as the English system, we are constantly converting from feet to inches, from horsepower to watts, and others. The rules of precision followed on those occasions should also be followed when converting from English to metric units or from mass (in kilograms) to force of gravity (in newtons). Two rules are available:

### Primary Rule:

Maintain precision of a measurement. This must always be achieved.

### General Rule:

When implementing the primary rule, it is often effective to round the value to the same number of significant digits. This will approximately give the same implied precision. When maintaining the same number of significant digits provides misleading information on precision, the primary rule overrides the general rule.

Example where general rule applies; 5.2 miles at 1.609 km/mi = 8.369 km = 8.4 km.

Example where primary rule governs;      8.6 miles at 1.609 km/mi = 13.837 km = 13.8 km.

The highway engineer is already familiar with the notion of precision. The engineer reports a value, such as 5.2 miles, and there is an implied level of accuracy or precision. 5.2 miles implies a number between 5.15 and 5.25. When converting to metric, this same precision rule should be followed. Generally speaking, it is a good idea to round the metric value off to the same number of significant digits as the former example shows. The latter example shows this is not always the case. In order to maintain precision, the result has three significant digits instead of two.

If a quantity is described by more than one unit, then convert to the smaller unit before converting to metric. This will also cause the metric value to reflect the accuracy that was implied in the original value. For example, if a measurement is provided as 6 feet 4½ inches, it should be converted to metric in two steps. First, its equivalence in inches must be found as 76.5 inches. Then, it can be converted to metric using the appropriate conversion factor as follows (note only three significant figures are retained):

76.5 inches x 25.4 mm/inch = 1943.1 mm to 3 significant figures = 1940 mm.

The procedures for rounding are generally familiar to most technically trained personnel and are summarized below. The rules presented here are those specified in ASTM E380-92a.

Round up if the next digit is larger or down if the next digit is less than 0.5.

Examples:    43.87 mm → 43.9 mm

                  279.4 K → 279 K

If the number is exactly 0.5, then round up only if it makes the digit an even number.

Examples:    Round up    77.5 J → 78 J

                  Round down 76.5 J → 76 J

## **REFERENCE MATERIAL**

- a) AASHTO "A policy on Geometric Design of Highways and Streets, 1994"
- b) Standard Metric Practice Guide, AASHTO Designation: R1-91 or  
ASTM Designation: E380-92a

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## DESCRIPTION OF SUPERSTRUCTURE TYPES

The following is a list of superstructure types that are most commonly used:

1. Concrete slab spans (precast or cast-in-place)
  - a) Solid
  - b) Voided
2. Precast-prestressed concrete girder spans
3. Steel
  - a) Rolled Beam Span
  - b) Welded Plate Girder Span
    - 1) Multi-Girder Frame
    - 2) Girder, Floorbeam, Stringer Frame
4. Steel horizontally curved girder span (plate or box girder)
5. Precast-prestressed concrete box girder span
6. Movable bridges

Slab span bridges are the most common bridge type and are generally used at stream crossings where span requirements are not critical and aesthetics are not a major concern. This is generally the most economical bridge type for bridges to **120 m** in total length and even longer depending on pile lengths. Cast-in-place slab spans have been the norm for on-system bridges while precast slab spans are generally used on parish off-system bridges.

Voided slabs are used where 12 m spans are required with depth limitations. Please note that a method to drain and vent each void to prevent water and methane gas accumulation is required.

The next most common bridge type is the concrete precast prestressed concrete girder span, which is used for stream crossings with span requirements exceeding slab span capability, for grade separation structures, and approaches to high level structures.



Rolled beams are used primarily in rehabilitation projects. For new construction, rolled beam spans are seldom used, except for spans where depth limitations are insufficient or inefficient for prestressed girder spans.

Steel plate girder spans are used for longer spans such as river crossings or grade separation structures that require span lengths in excess of **40 m**. Steel box girders are occasionally used in urban areas for aesthetics. The box girder's effectiveness in resisting torsion makes it suitable for horizontally curved girders with long or tightly curved spans. However, I-girders are preferable unless box girders are necessary.

In urban areas where an elevated roadway is required, the precast concrete box girder may be considered in special cases where aesthetics and right-of-way restrictions are critical.

Movable bridge types are discussed in Chapter 12.

## **BRIDGE RAILING**

### **HISTORY**

Since 1928 AASHTO has provided various specifications to address the design and details of bridge railings.

Understanding the evolution of these specifications over the many years is instrumental to the comprehension of the specifications in AASHTO as they appear today.

The reason for a dramatic change in bridge railing specifications has been the need to adapt to the changes in the auto-industry and the wide variety of vehicles, which are present on our highways. In the sixties, AASHTO defined the primary purpose of bridge railing as the ability to **contain** the **average** vehicle. The application of the 10 kip load was established for the design of such railing and it remained the primary criteria in AASHTO through the eighties.

Multiple fatality truck and school bus accidents involving bridge railing, throughout the nation, focused the bridge engineer's attention on whether the 10 kip load closely represented the real life impact loads. The load indicator walls in the crash test sites suggested that the actual loads are in the range of 30 to 200 kips.

In August 1986, FHWA required the full scale crash testing of all bridge rails that are to be used on the federal aid projects. At the same time AASHTO requested the FHWA to assist them in the development of a new bridge rail specification.

### **THE 1989 GUIDE SPECIFICATION**

In 1989 AASHTO adopted a Guide Specification for Bridge Railing. This specification is intended to be a basis for the design of prototype bridge railings that are to be crash tested, and for the design of one-of-a-kind bridge railing where the cost of crash test program may not be justified. The Guide Specification is based on a multiple performance levels' theory, which basically requires a different rail for a different situation. There exist five (5) primary performance levels in this publication. These performance levels are as follows:

<u>PL1</u>	<u>PL2</u>	<u>PL3</u>	<u>PL4</u>	<u>PL4T</u>
Cars & Pick-up trucks	Single unit trucks	Tractor trailers	18 Wheeler	Tanker trucks
5,400 lbs. & less (2450 kg) & less	18,000 lbs. (8165 kg)	50,000 lbs. (22 680 kg)	80,000 lbs. (36 285 kg)	80,000+ lbs. (36 285+kg)

The Guide Specification contains criteria based on which appropriate performance level is selected. In addition, this publication specifies the various design loads and their strategic locations on the railing for when an analysis is required.

## AASHTO LRFD BRIDGE SPECIFICATIONS

In 1994 AASHTO published its first series of LRFD Specifications, both in English and metric units. There exists great similarity between the LRFD railing specification and the Guide Specification. In fact the performance levels and the design loads have been extracted from the Guide Specification and placed in the LRFD Specifications, with the exception that the LRFD offers step by step design criteria and analysis procedures for various bridge railings.

## LOUISIANA PRACTICE

Louisiana's primary bridge rail in recent history has been the New Jersey safety shape made of reinforced concrete and in special cases, steel plates. This particular shape has been successfully crash tested for performance level (PL-2). The most recently developed safety shape is referred to as the F-shape. This shape, although not much different than the Jersey shape, has proven to gain a slight advantage over the Jersey shape in redirecting the 8165 kg (18000 lb.) vehicle. For this reason Louisiana has opted to gradually eliminate the use of the New Jersey shape and adopt the F-shape for use on new projects. The application of the F-Shape shall begin with the metric plans. Another advantage in the adoption of the F-shape is the fact that it is the only safety shape that has been crash tested for PL-3 at 1070 mm (42 inch) height.

## SELECTION AND DESIGN CRITERIA

Selection of the performance level for all new projects or major rehabilitation projects such as redecking of an existing bridge shall be in accordance with the 1989 AASHTO Guide Specifications and the latest LRFD Specifications. All bridge rails shall be an approved crash tested rail for the specific performance level. All plan details and designs shall also be in accordance with these specifications. The **810 mm** barrier (F-shape PL-2) is currently the standard rail being used on nearly all bridges. When a PL-3 bridge rail is warranted by the AASHTO Guide Specifications, a 1070 mm F-shape is the preferred rail unless the designer deems necessary to use a different rail. When detailing the slab and its reinforcing steel supporting the bridge rail, the minimum slab thickness shown on the crash tested detail shall apply. If thicker slabs are utilized for other design reasons, the reinforcing steel shown in the crash tested detail may be reduced to that amount which provides the same or a greater ultimate moment capacity as the crash tested detail. Additional reinforcing steel may also be required for reasons other than the crash tested quantity, i.e., when using a wider sidewalk than what is shown on the detail. Under the majority of situations, the "F" shape is the bridge rail of choice, however, there are several other crash tested rails which may be applicable. A side mounted open rail system and a solid concrete vertical wall rail is shown here for a PL-2 application. Open rail systems are particularly useful where sight distance, bridge drainage and aesthetics may be of concern.

Although open rail systems are usually more expensive, they can significantly improve visibility and drainage.

Steel plate barriers formed to an F-shape are used on movable bridges with steel grid floor.

Additionally, crash tested combination traffic-pedestrian railing is shown here for both PL-1 and PL-2. In majority of cases a combination railing is applied in design speeds of 75 km/h or less, and unless the percentage of truck traffic is high, a PL-1 rail is suitable. However, just as bridge traffic railing, AASHTO Guide Specification shall be used to arrive at the proper performance level for the combination railing. The PL-1 and PL-2 combination railing shown here have been crash tested with a 205 mm curb and a 1525 mm wide sidewalk. The more desired sidewalk width is 1830 mm, and the expert's opinion is that the wider sidewalk will practically enhance the rail performance, as long as the curb height is not increased. The reinforcing steel shown in these details is adequate to resist the crash loads. However, if the sidewalk width or other configuration change, the reinforcing steel and members supporting the sidewalk shall be designed accordingly.

For information on bridge railing end treatments, impact attenuators, roadway barriers, and temporary barriers see Chapter 11, "Barrier and End Treatment Systems".

#### Miscellaneous Details

A 15 mm open joint is provided in the concrete barrier every 6 to 10.5 m for expansion and contraction. This joint need not be sealed where open deck drainage is not allowed (it is expected to dam itself with debris). For unusual conditions, the engineer could require 150 mm PVC waterstops.

The gap between adjacent barriers at expansion joints shall not exceed 140 mm maximum unless a sliding armored plate is employed to close off the opening.

Rail transition is an important aspect of design involving engineering judgement. The ends of the bridge rail must be protected with some type of transition such as guardrail or other end treatment. Guardrail should be in accordance with latest Standard Plans GR-200 (M), GR-201(M), and GR-202(M). In cases where new construction ties to existing construction there must be adequate transition between sections of F-shape barrier and Brush Curb Rail used on earlier bridges.

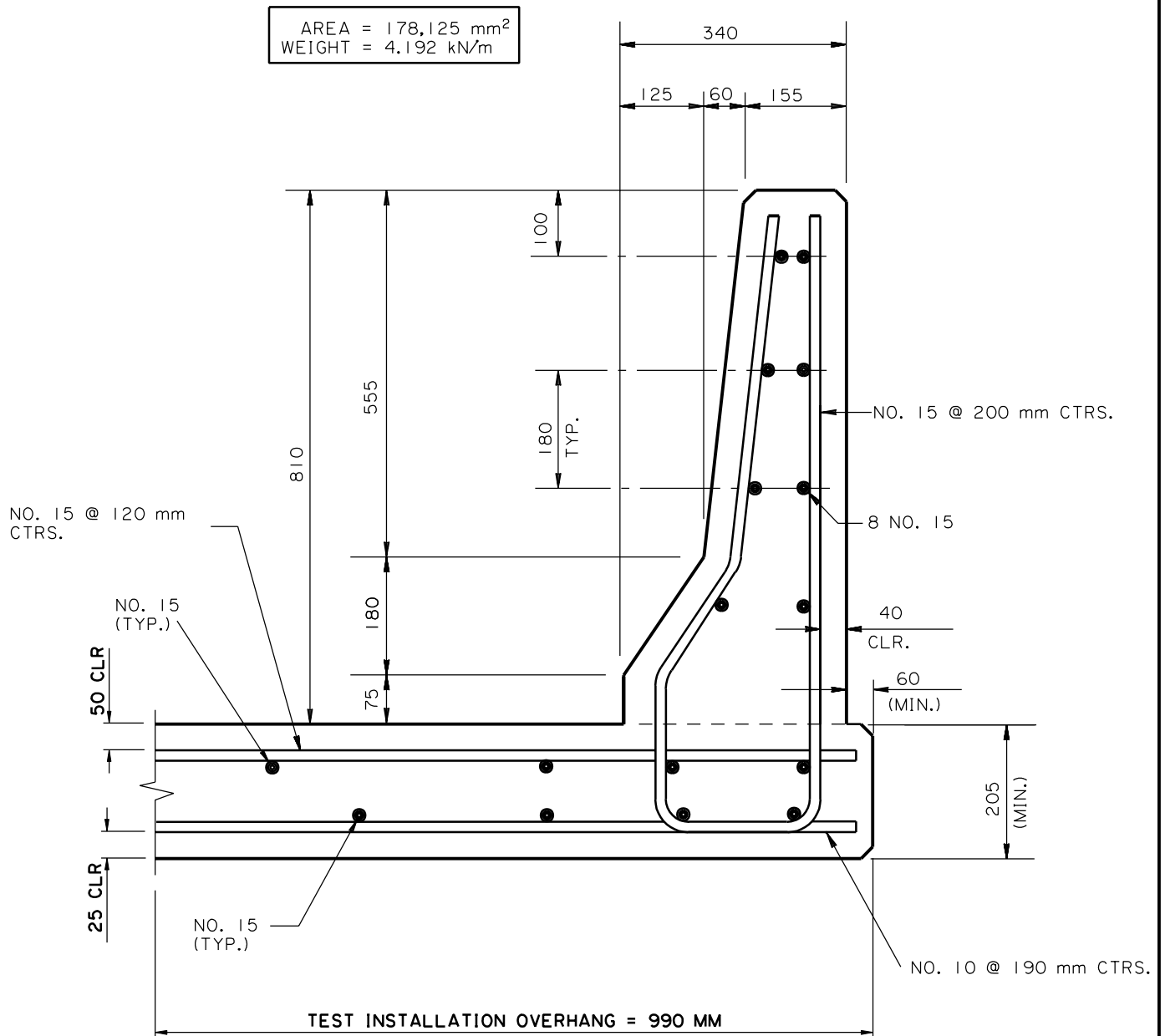
Impact attenuators with back up blocks must be designed for gore areas with oncoming traffic or where typical guardrail can not be used. See the section for crash cushions (impact attenuators) for design.

### Bridges in Urban Areas

For bridges with curbed roadway approaches and without sidewalks, F-shape barrier will generally be used with a 1220 mm offset from the edge of travel lane. The roadway curbs will be flared out and discontinued at the guardrail ends. However, in some instances it may be necessary to extend the flared curb behind the guardrail to provide for drainage. This is particularly true when bridge end drains are required.

For bridges with curbed roadway approaches and sidewalks or bikeways, the curb and sidewalk (or bikeway) shall be carried through the bridge. A vertical face parapet with pipe rail is generally used on the outside of the sidewalk, and must meet the requirements for "Combination Rail" mentioned in the AASHTO Bridge Specifications. The guardrail standard will apply and the guardrail shall be placed on the outside of the sidewalk. For higher design speeds, a barrier rail shall be required to separate the sidewalk from the travel lane, and a pedestrian or bicycle rail shall be used on the outside of the sidewalk. The guardrail standard shall apply and the sidewalk will be flared out behind the guardrail.

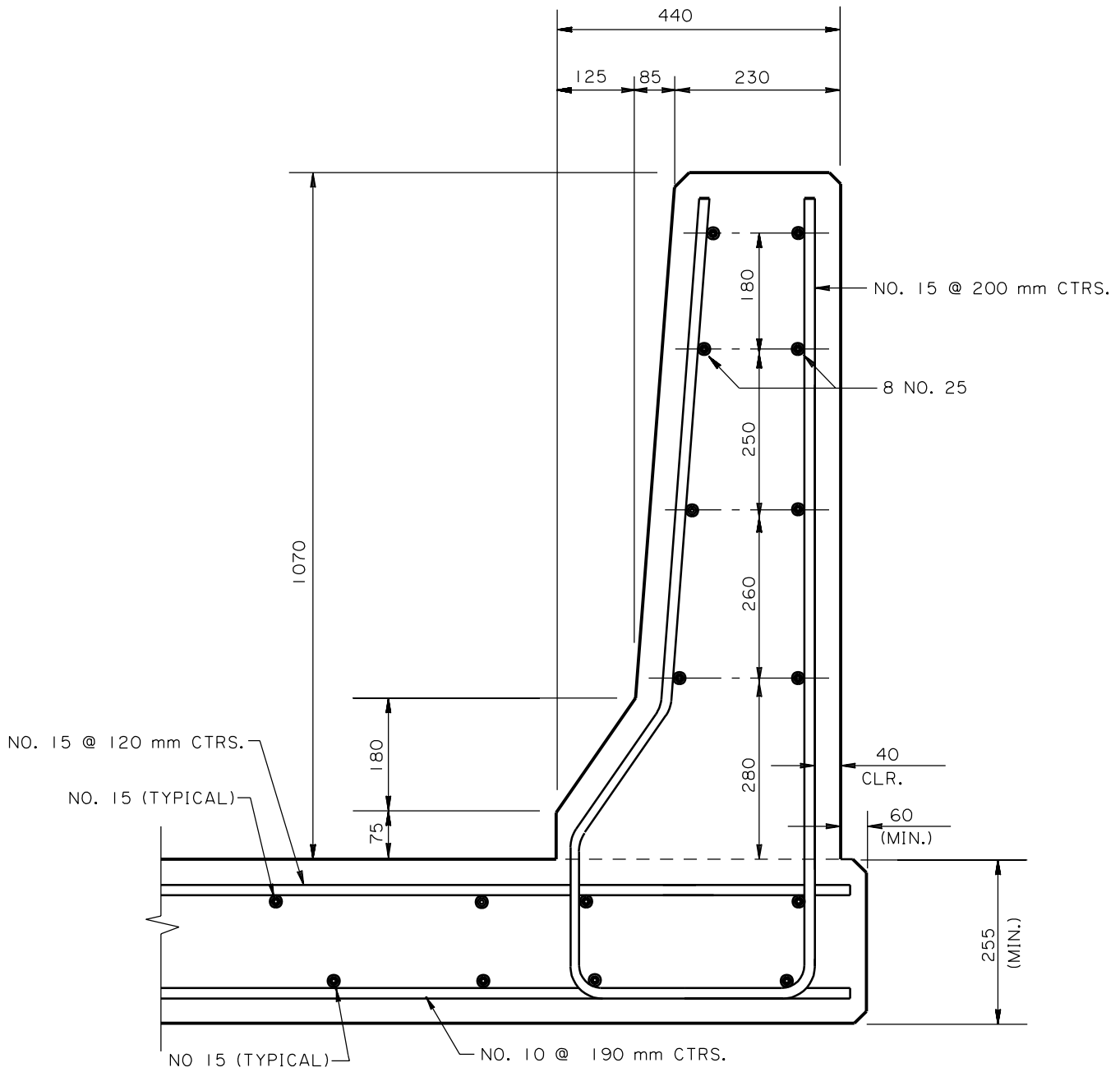
For bridges with design speeds of 70 km/h or less, for barrier end treatment, and sidewalk and curb placement, see EDSM 11.3.1.4.



**NOTES:**

- 1) THE ABOVE DETAILS ARE FROM FHWA-RD-93-058 (JUNE 1997) AND HAVE BEEN MODIFIED. SEE 5(4) FOR DESIGN REQUIREMENTS.
- 2) CONCRETE TO BE CLASS AA
- 3) REINFORCING STEEL TO BE GRADE 420

**F-SHAPE  
(PL-2)**



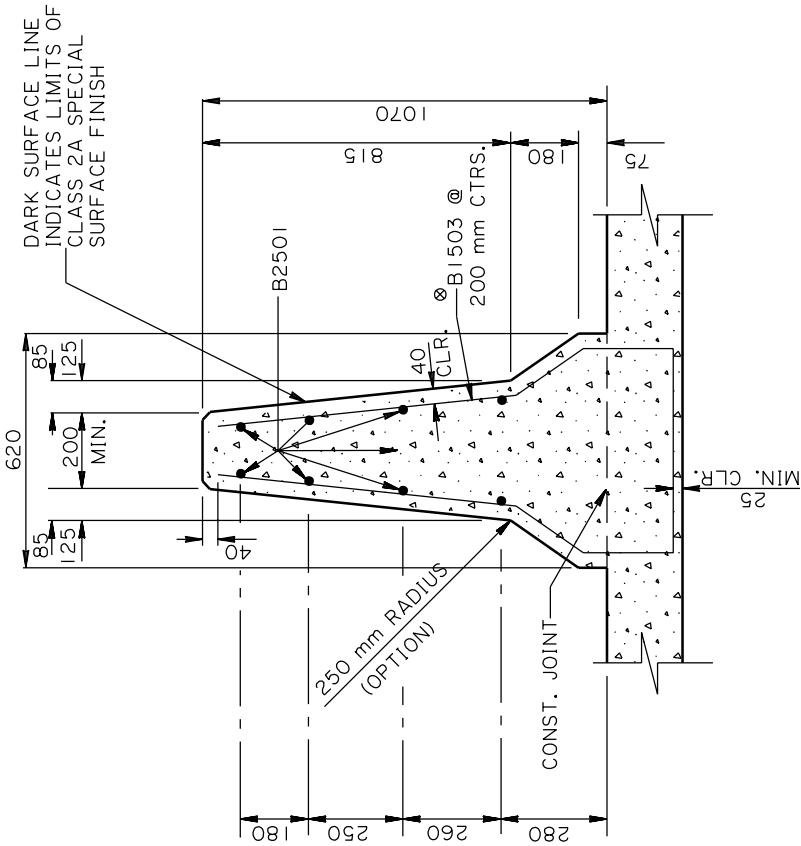
**NOTES:**

- 1) THE ABOVE DETAILS ARE FROM FHWA-DR-93-058 (JUNE 1997) AND HAVE BEEN MODIFIED. SEE 5(4) FOR DESIGN REQUIREMENTS.
- 2) CONCRETE TO BE CLASS AA
- 3) REINFORCING STEEL TO BE GRADE 400

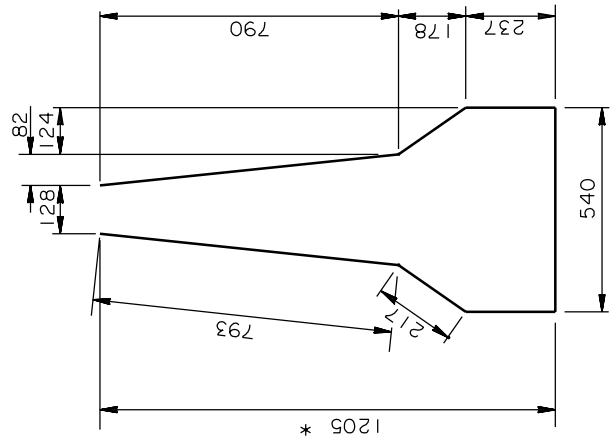
**F - SHAPE  
(PL - 3)**







AREA - 367 875 mm<sup>2</sup>  
 WEIGHT - 8.829 kN/m



**MEDIAN BARRIER (BRIDGE)**

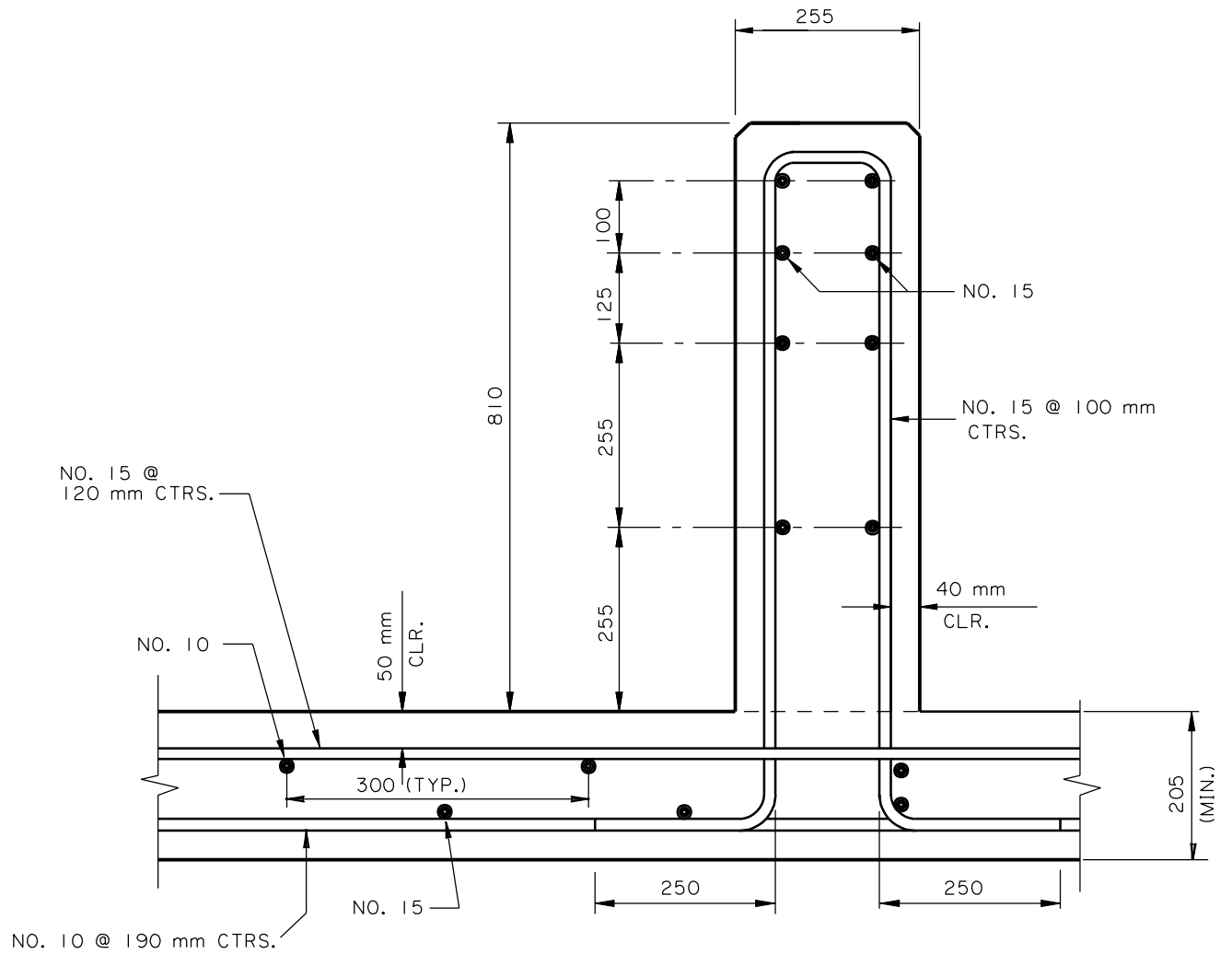
⊗ AT THE CONTRACTOR'S OPTION, NO. 10 BARS AT 100 mm CENTERS MAY BE SUBSTITUTED IN LIEU OF B1503 AT 200 mm CENTERS. USE 50 mm φ PIN FOR BENDING.

\* DIMENSIONS SHOWN ARE BASED ON 200 mm THICK DECK UNDER BARRIER; ADJUSTMENTS MUST BE MADE FOR DECKS WITH OTHER THICKNESSES.

**BARS B1503<sup>⊗</sup>**  
 (60 mm φ PIN)  
 (3034 mm LONG)

(F-SHAPE PL-3)

**MEDIAN BARRIER (BRIDGE)**



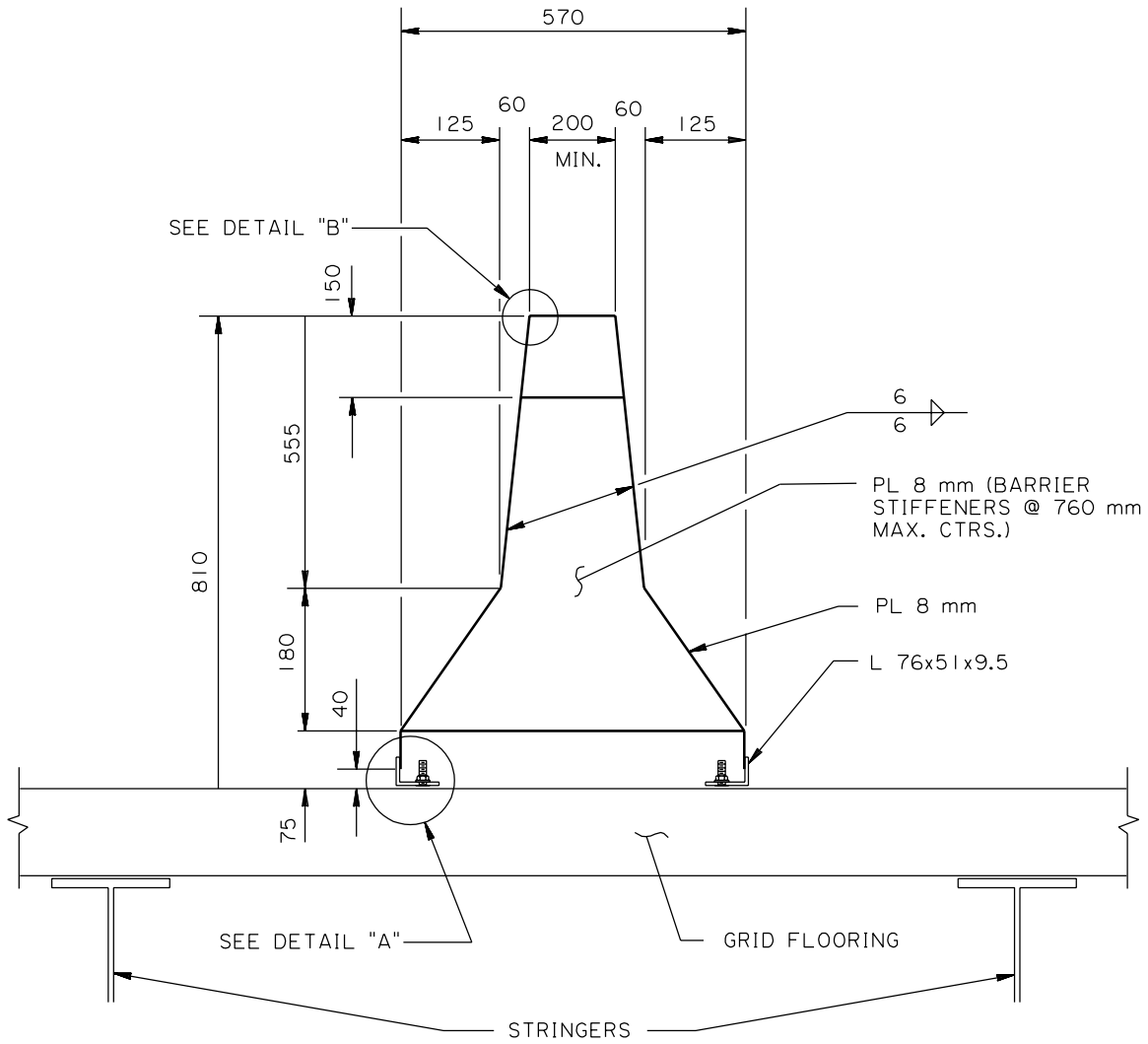
**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420

(VERTICAL WALL PL-2)

**MEDIAN BARRIER (BRIDGE)**



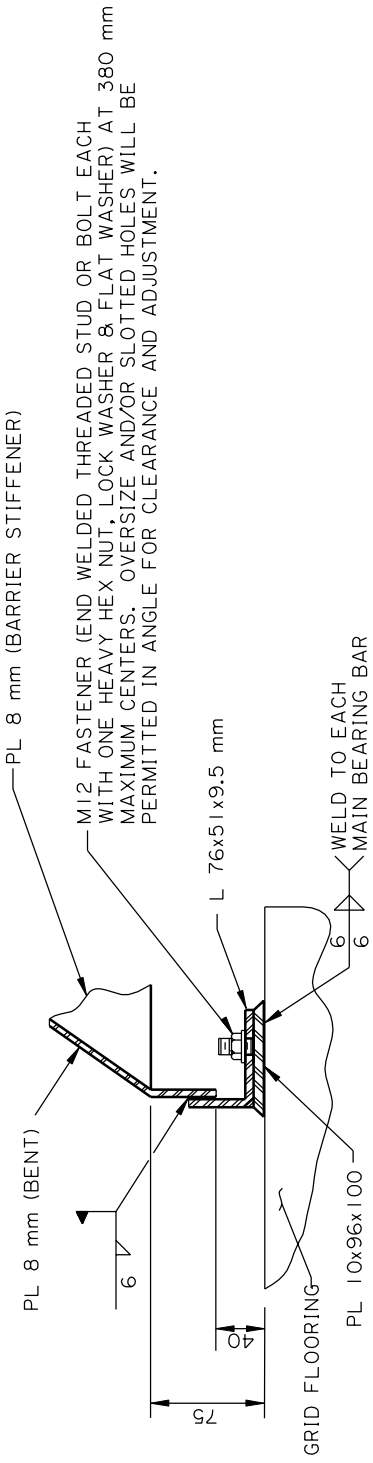


TYPICAL PART SECTION THRU BRIDGE  
SHOWING GRID FLOORING AND MEDIAN BARRIER

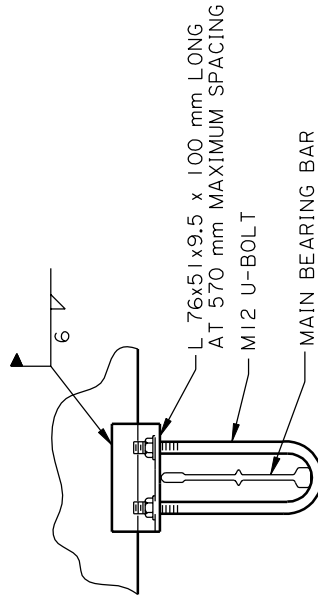
(F-SHAPE)

**STEEL MEDIAN BARRIER**

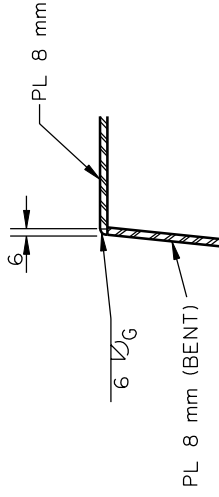
1 OF 2



DETAIL "A"



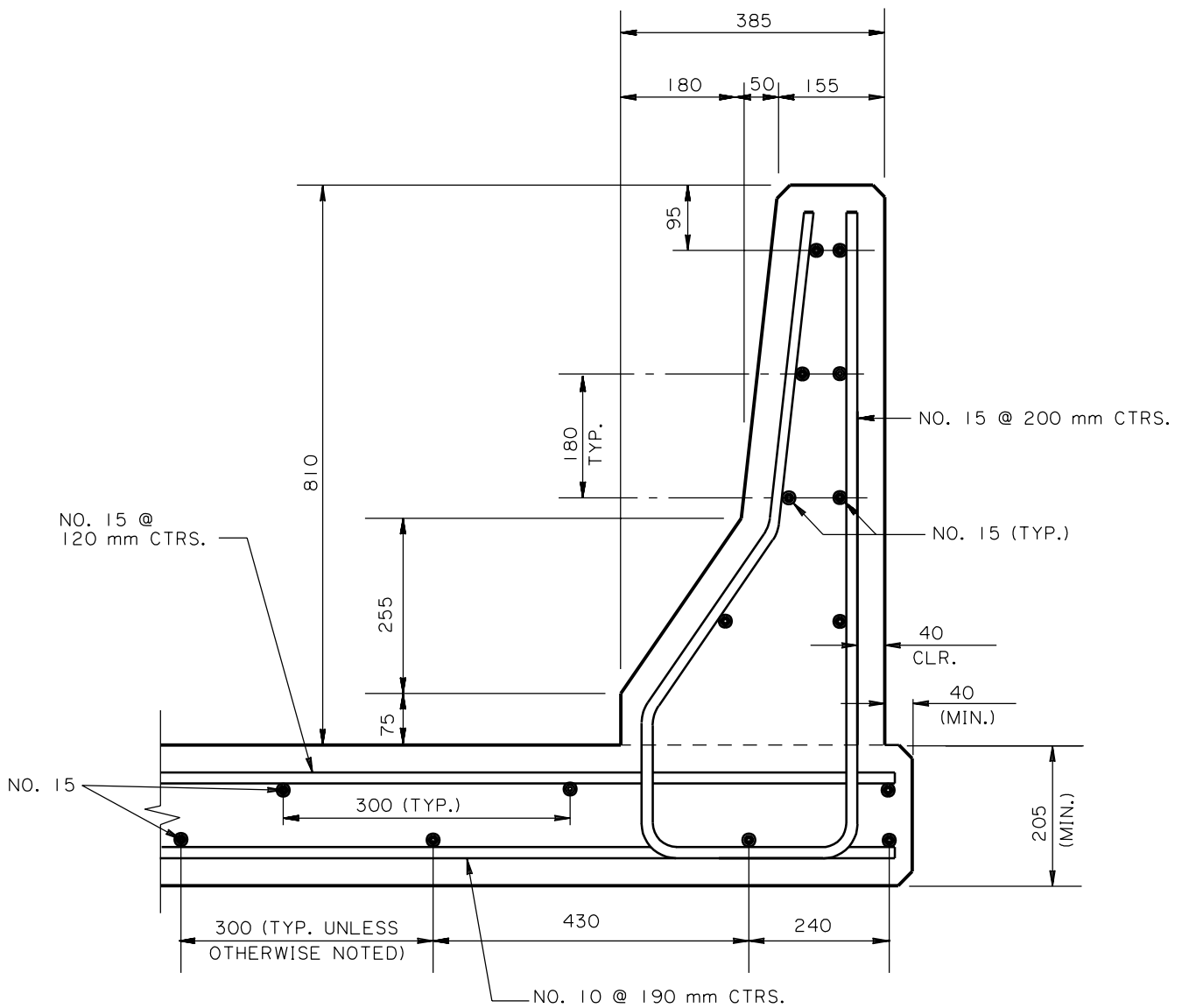
ALTERNATE



DETAIL "B"

(F-SHAPE)

**STEEL MEDIAN BARRIER**



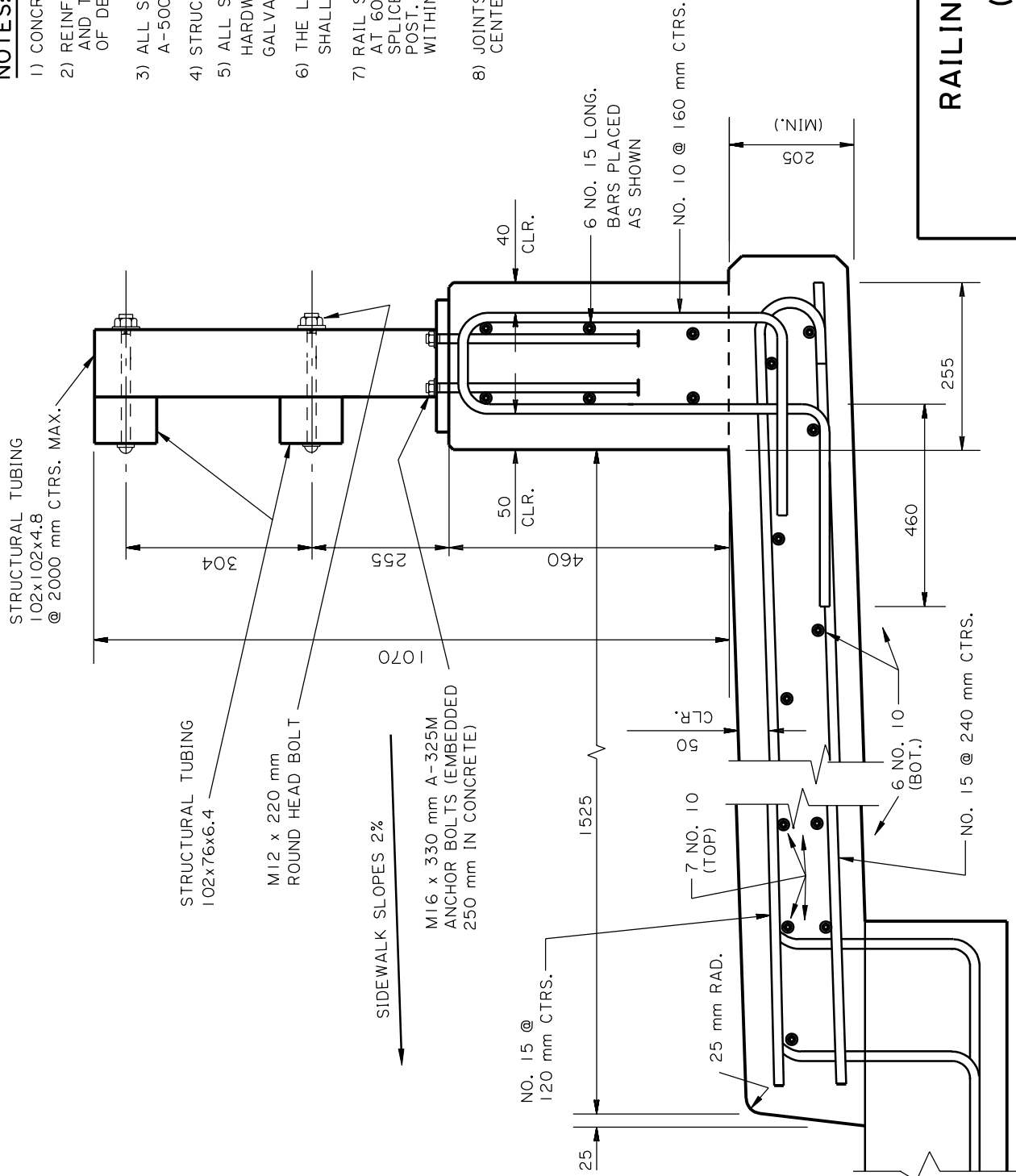
**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420

**NEW JERSEY SHAPE  
(PL-2)**

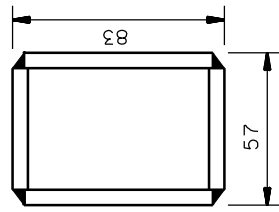
**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420 AND TO MATCH CORROSION PROTECTION OF DECK STEEL.
- 3) ALL STRUCTURAL TUBING IS ASTM A-500M, GRADE B MATERIAL.
- 4) STRUCTURAL STEEL TO BE A-709M.
- 5) ALL STRUCTURAL STEEL AND HARDWARE SHALL BE HOT-DIPPED GALVANIZED AFTER FABRICATION.
- 6) THE LENGTH OF THE RAIL SEGMENT SHALL NOT EXCEED THIRTY METERS.
- 7) RAIL SPLICES ARE TYPICALLY AT 6000 mm WITH CENTER OF SPLICES 500 mm FROM NEAREST POST. NO SPLICES ARE ALLOWED WITHIN 5000 mm FROM OPEN JOINT.
- 8) JOINTS ARE REQUIRED AT 30 000 mm CENTERS (MAX.)

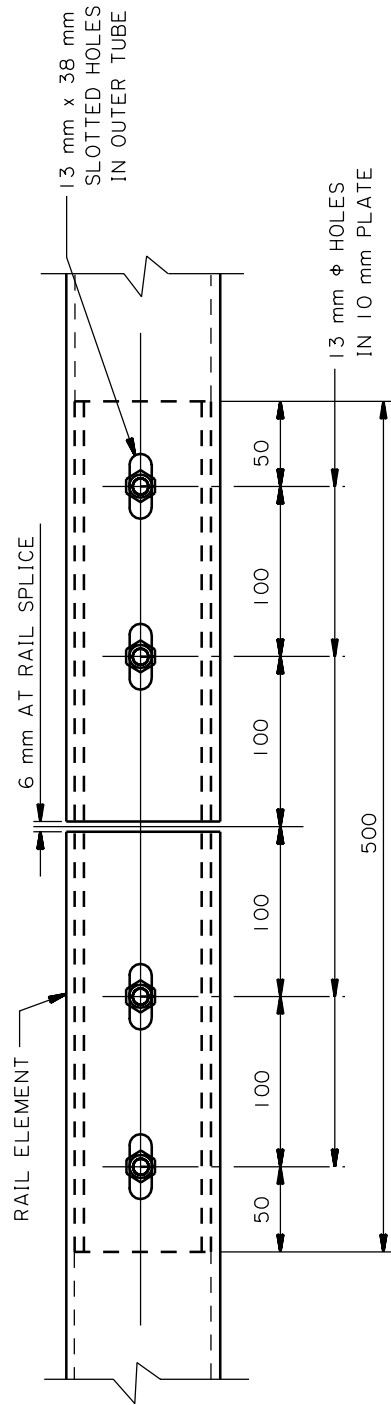
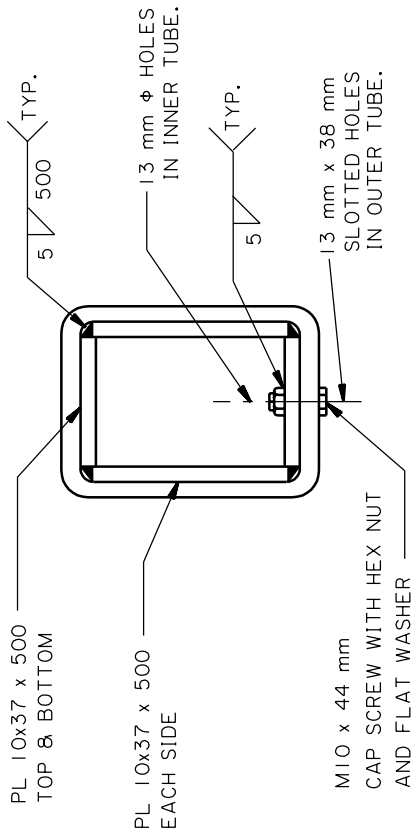


**RAILING / SIDEWALK  
(PL-1)**

1 OF 3



FINISHED DIMENSIONS  
OF INNER SLEEVE

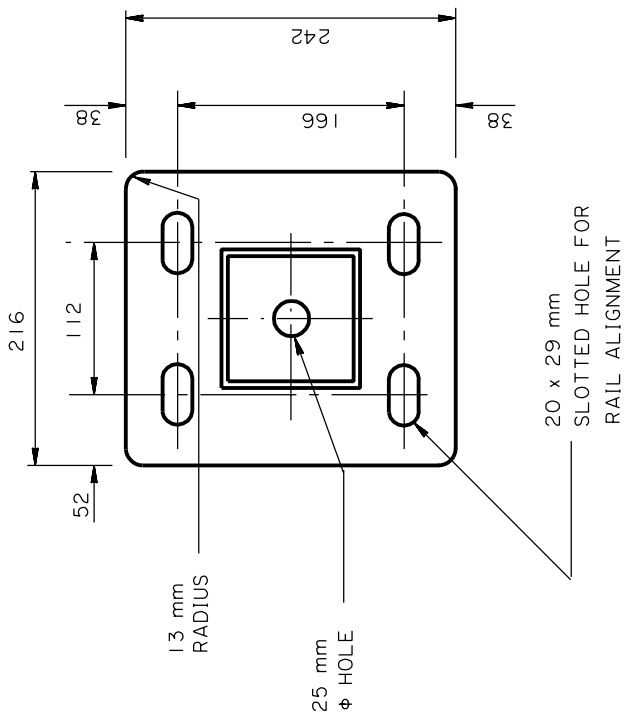
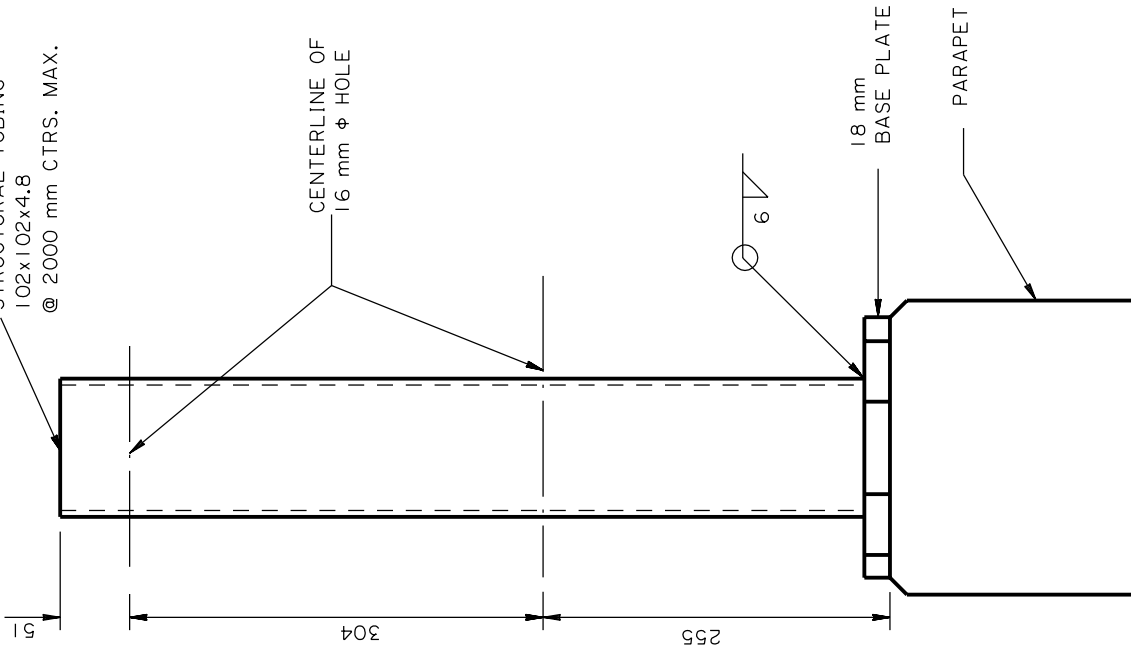


BOTTOM PLATE INTERNAL SPLICE



STRUCTURAL TUBING  
102x102x4.8  
@ 2000 mm CTRS. MAX.

CENTERLINE OF  
16 mm  $\phi$  HOLE



**BASE PLATE DETAIL**

**NOTE:**

INTERMEDIATE RAIL SPLICES ARE AT EVERY 6000 mm WITH CENTER OF CONNECTION AT SPAN QUATER POINTS. RAIL SPLICES SHALL NOT BE ALLOWED ON THE LAST TWO SPANS AT THE END OF THE SEGMENTS.

**RAILING / SIDEWALK  
(PL - 1)**

3 OF 3

STRUCTURAL TUBING  
102x102x4.8  
@ 2000 mm MAX. CTRS.

**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420 AND TO MATCH CORROSION PROTECTION OF DECK STEEL.
- 3) ALL STRUCTURAL TUBING IS ASTM A-500M GRADE B MATERIAL.
- 4) STRUCTURAL STEEL TO BE A-709M.
- 5) ALL STRUCTURAL STEEL AND HARDWARE SHALL BE HOT DIPPED GALVANIZED AFTER FABRICATION.
- 6) JOINTS ARE REQUIRED AT 30 000 mm
- 7) RAIL SPLICES ARE TYPICALLY AT 6000 mm WITH CENTER OF SPLICE 500 mm FROM NEAREST POST. NO SPLICES ARE ALLOWED WITHIN 5000 mm FROM OPEN JOINT.
- 8) IF CONDITIONS EXIST WHERE 1825 mm WIDTH CAN NOT BE PROVIDED, A MINIMUM WIDTH OF 1550 mm CAN BE USED.

5 mm SEAL WELDED CAP  
STRUCTURAL TUBING  
102x76x6.4

M12 x 220 mm  
ROUND HEAD BOLT

M16 x 330 mm A-325  
ANCHOR BOLTS (EMBEDDED  
250 mm IN CONCRETE)

SIDEWALK SLOPES 2%

NO. 10 @  
160 mm  
CTRS.

6 NO. 15 BARS  
PLACED AS SHOWN

NO. 15 @ 120 mm  
CTRS.

7 NO. 10

NO. 15 @ 240 mm CTRS.

409

610

1070

1800

525

25 RAD.

205 (MIN.)

255

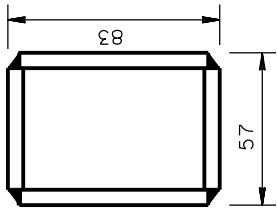
460

5 mm SEAL WELDED CAP

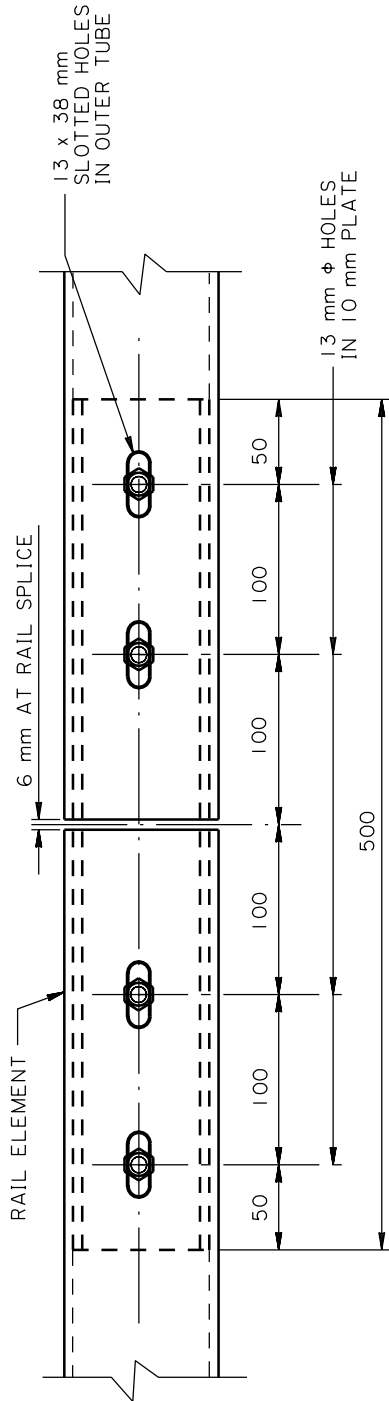
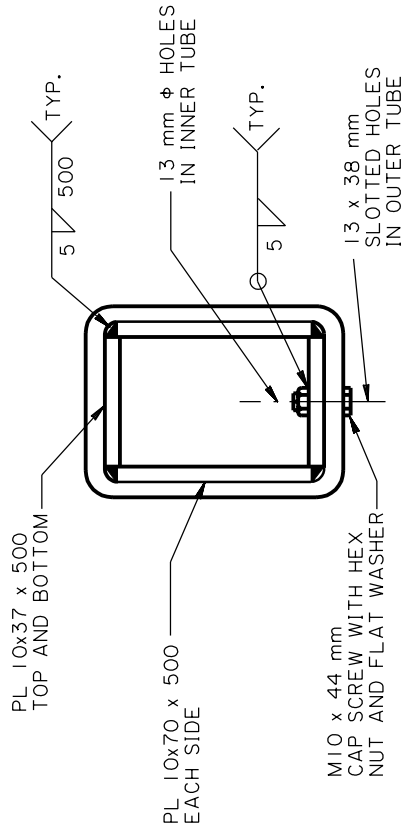
M12 x 220 mm  
ROUND HEAD BOLT

STRUCTURAL TUBING  
102x76x6.4

**RAILING / SIDEWALK  
(PL-2)**



FINISHED DIMENSIONS  
OF INNER SLEEVE

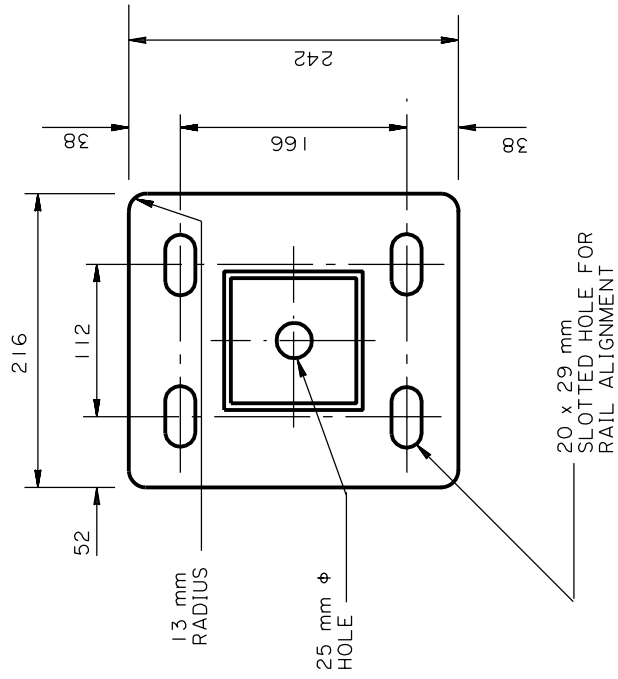


BOTTOM PLATE INTERNAL SPLICE

**RAILING / SIDEWALK**

**(PL-2)**

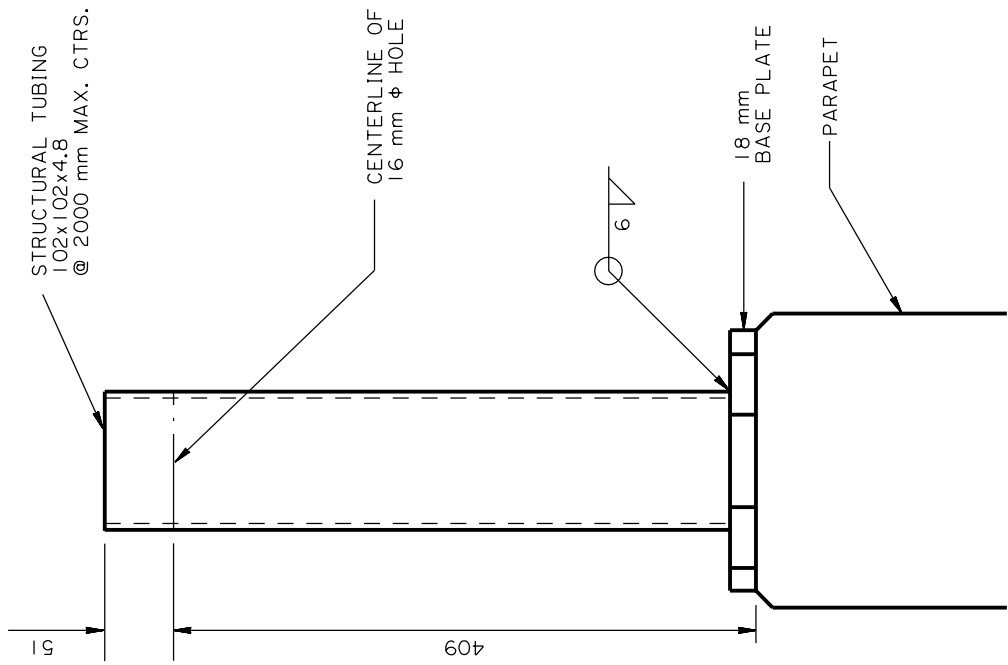
2 OF 3



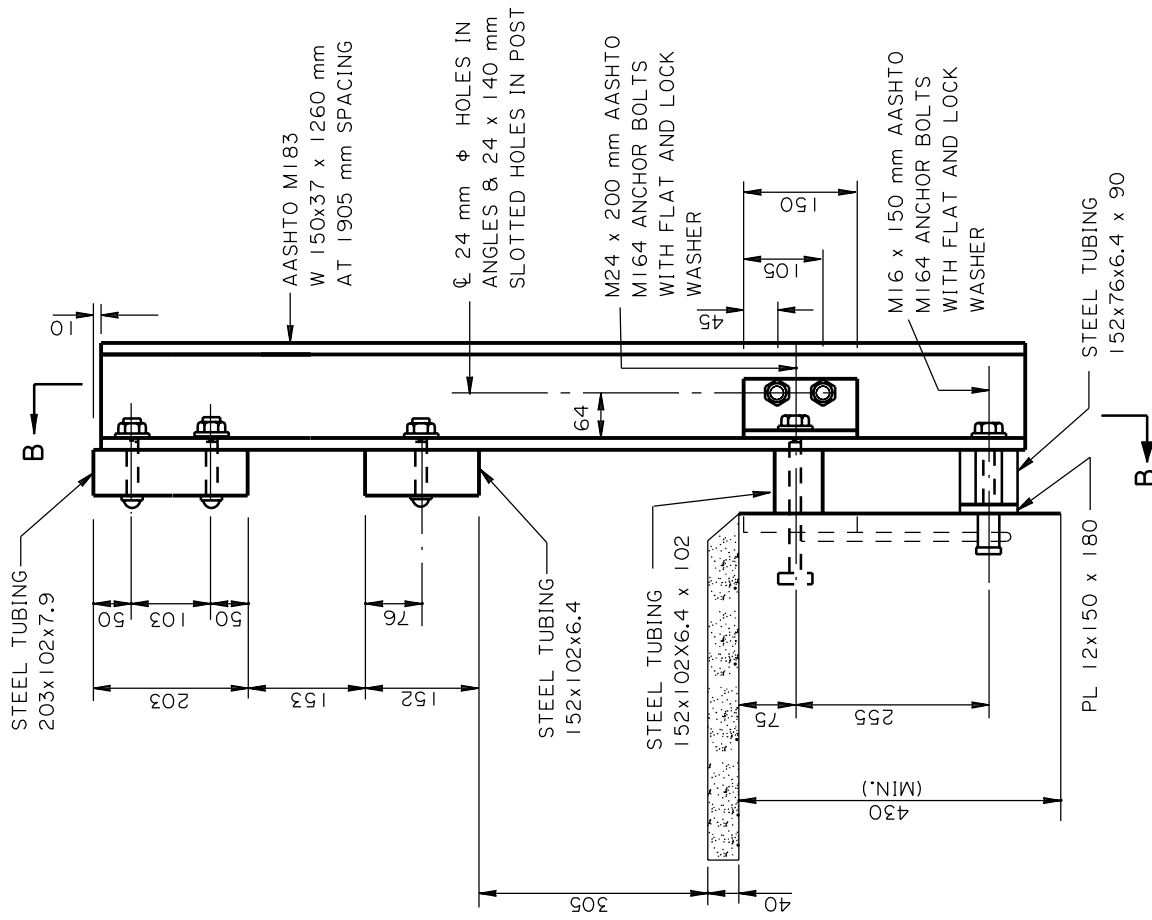
BASE PLATE DETAIL

NOTE:

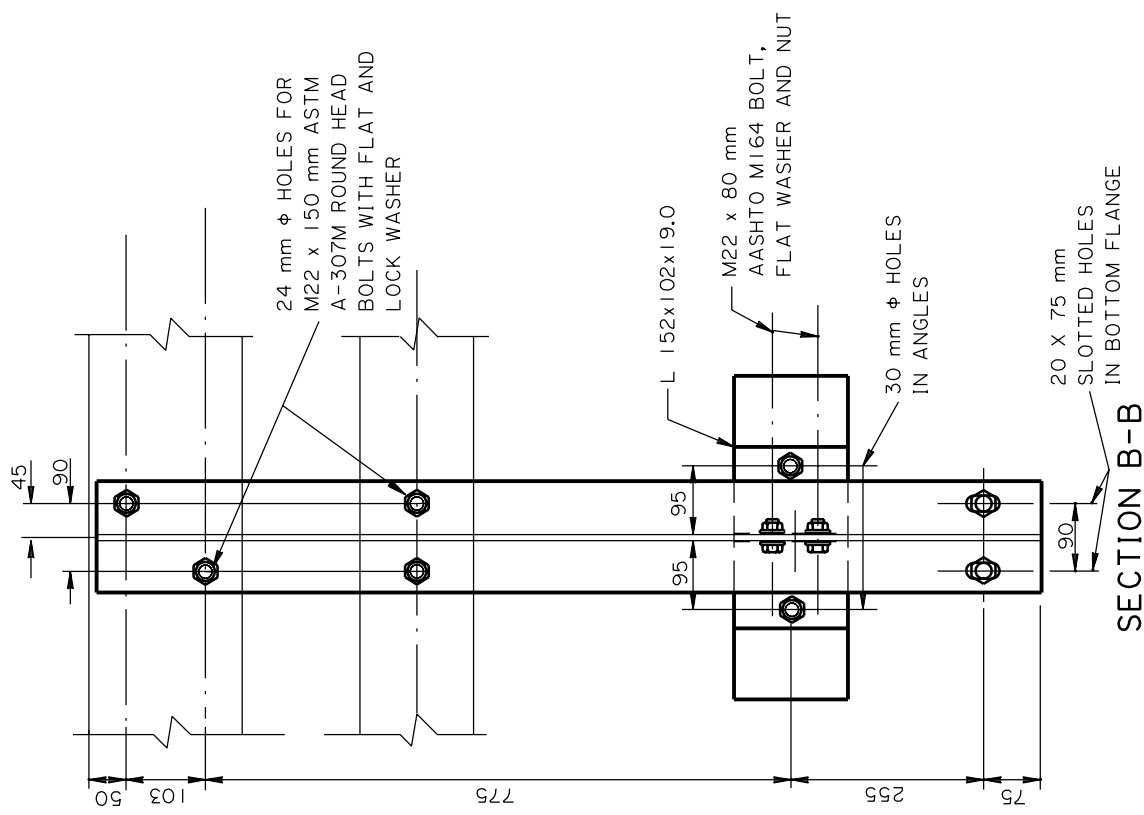
INTERMEDIATE RAIL SPLICES ARE AT EVERY 6000 mm WITH CENTER OF CONNECTION AT SPAN QUARTER POINTS. RAIL SPLICES SHALL NOT BE ALLOWED ON THE LAST TWO SPANS AT THE END OF THE SEGMENTS.



**RAILING / SIDEWALK  
(PL-2)**

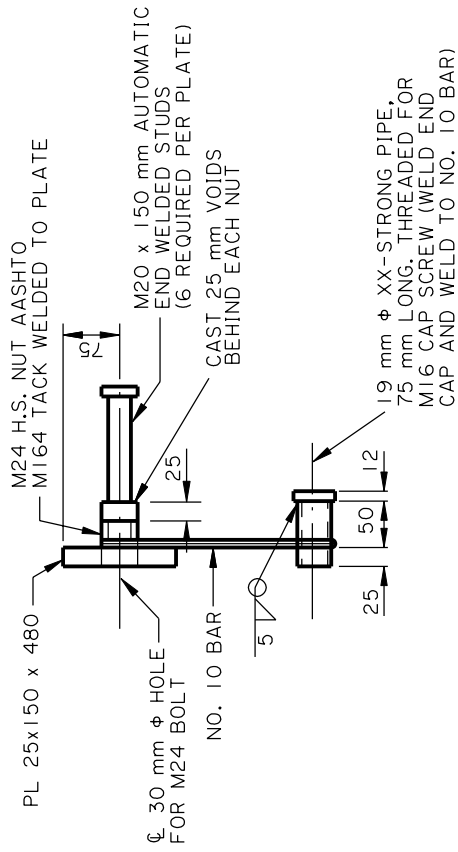
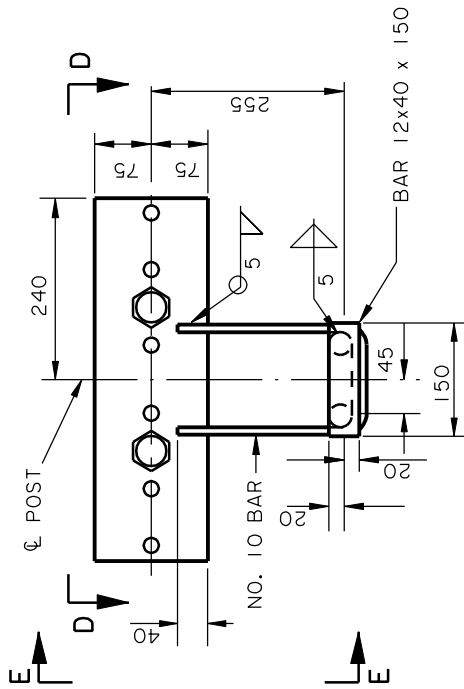


SECTION AT RAIL POST



SECTION B-B

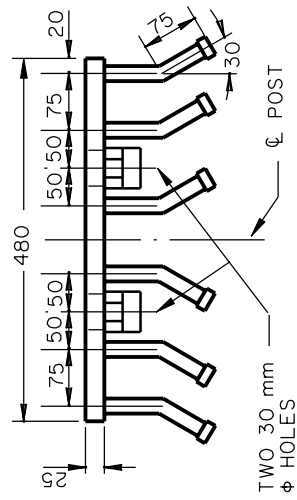
SIDE MOUNTED RAIL  
(PL-2)



VIEW E-E

NOTES:

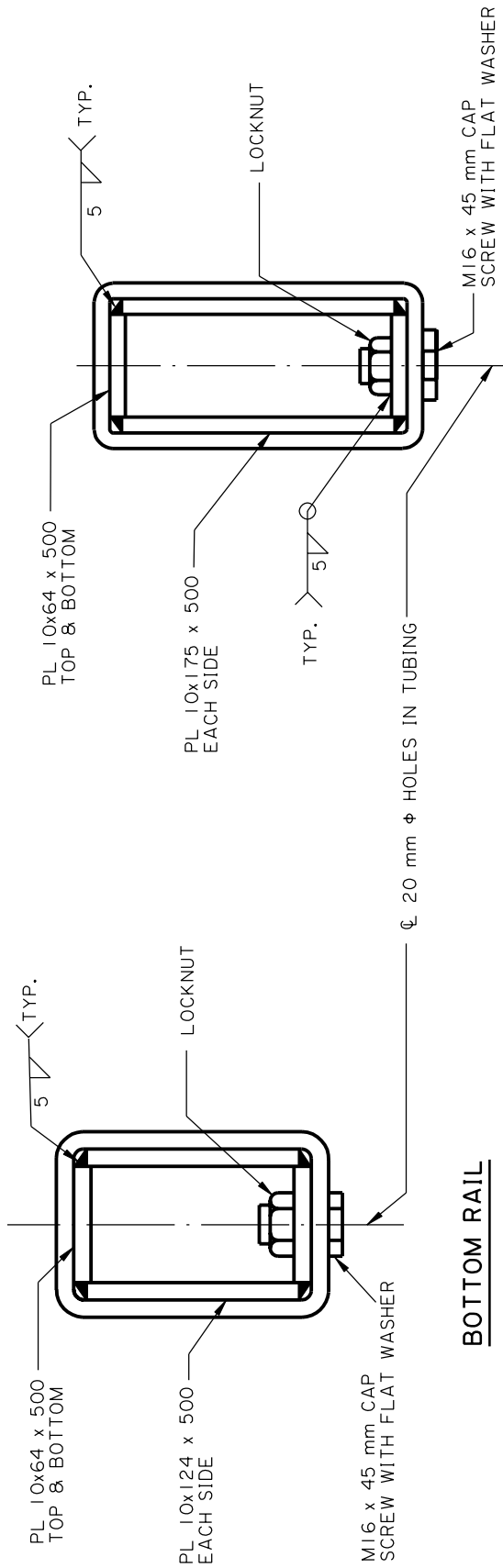
- 1) ALL STRUCTURAL TUBING IS ASTM A-500M, GRADE B.
- 2) STRUCTURAL STEEL TO BE GRADE A-709M
- 3) ALL STRUCTURAL STEEL AND HARDWARE SHALL BE HOT DIPPED GALVANIZED AFTER FABRICATION.



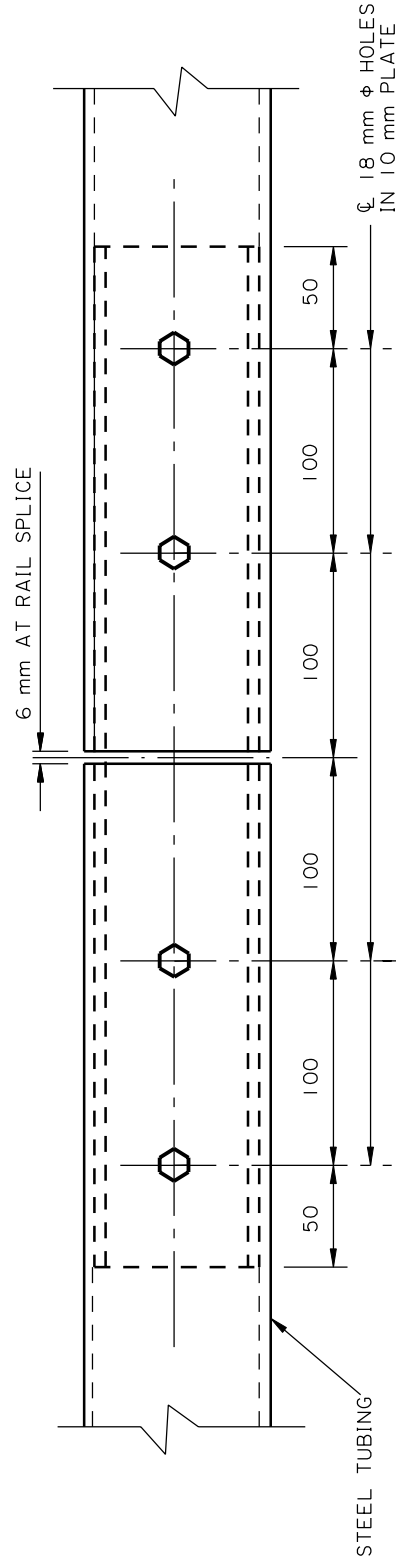
VIEW D-D

ANCHOR DEVICE

**SIDE MOUNTED RAIL  
(PL-2)**

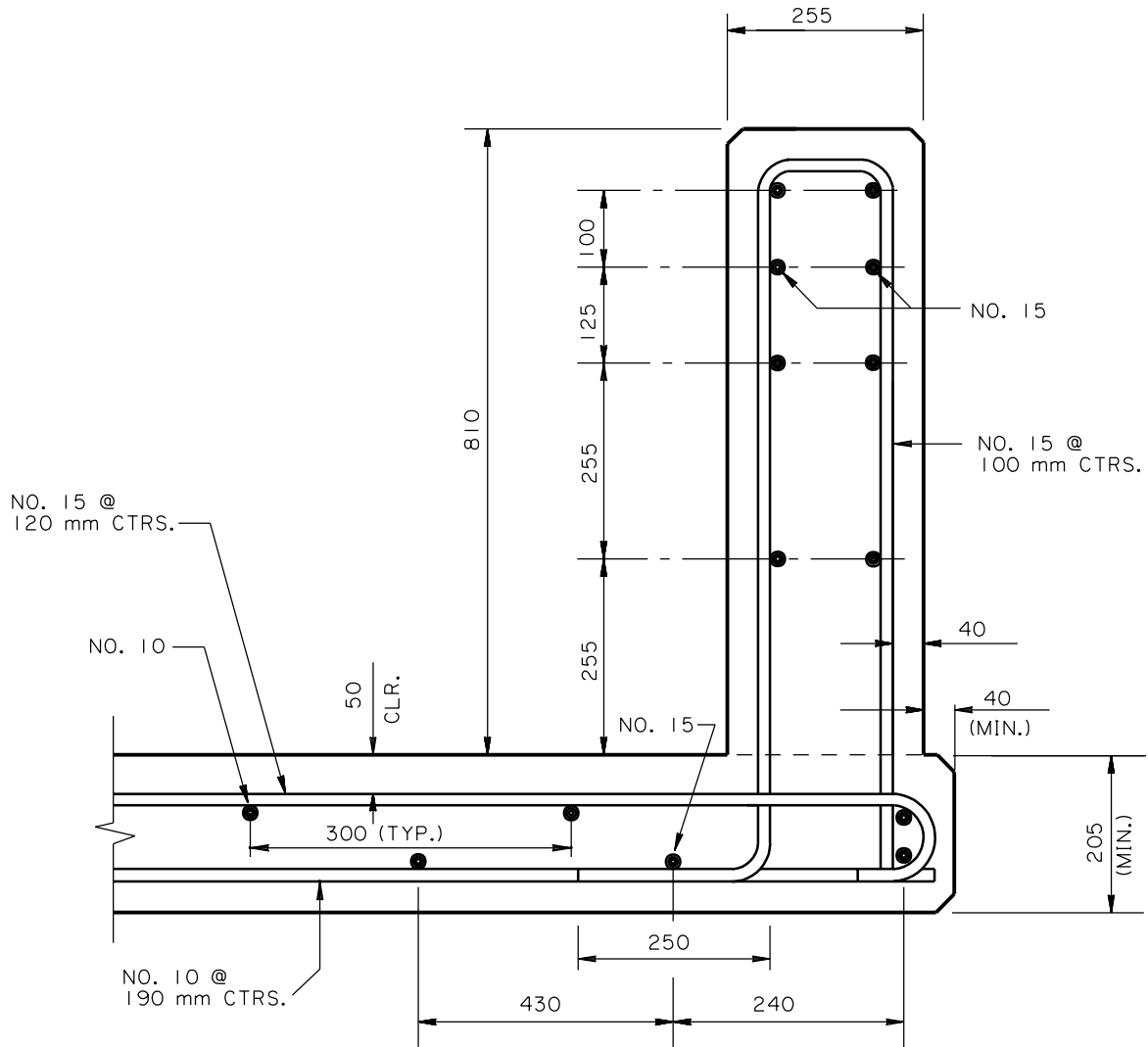


SECTIONS AT RAIL SPLICE



BOTTOM VIEW OF  
RAIL SPLICE DETAIL

**SIDE MOUNTED RAIL  
(PL - 2)**

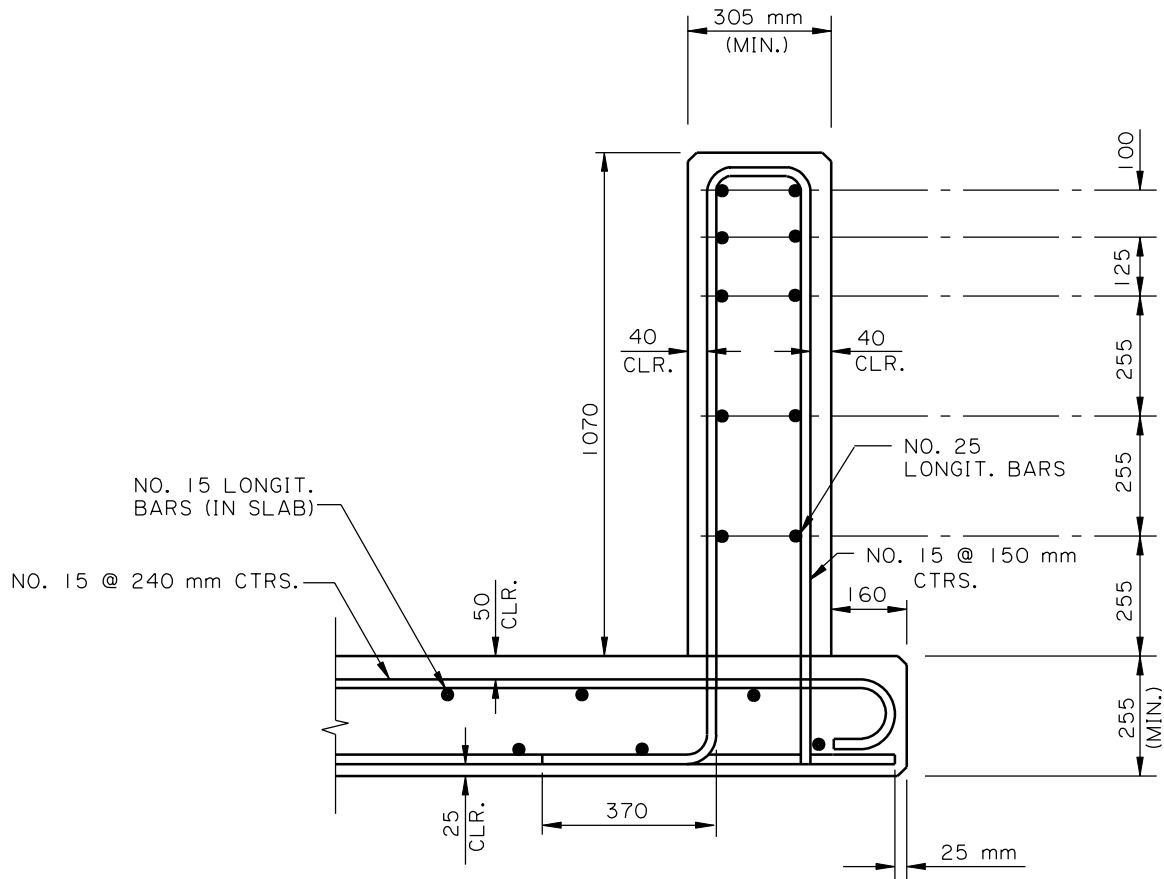


**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420

**VERTICAL WALL  
(PL-2)**





**NOTES:**

- 1) CONCRETE TO BE CLASS AA
- 2) REINFORCING STEEL TO BE GRADE 420

**VERTICAL WALL  
(PL-3)**

## TEMPORARY CONCRETE BARRIERS

### Purpose and Scope

The following sets forth the DOTD's policy with regard to the installation of temporary concrete barriers on highway construction projects. The policy is applicable to all state and federal projects involving the temporary operation of two-way traffic on one side of a multi-lane highway or bridge.

### Policy

Temporary concrete barriers generally shall be required to separate opposing traffic flow on interstate construction projects where shoulders exist on both sides of the lanes on which detour traffic will be directed. Length of detour will be limited to approximately eight (8) kilometers or less. Temporary barriers are also used to provide a positive barrier between workers and traffic.

Temporary barriers in other situations will be considered on a case by case basis and may be used upon written approval of the Chief Engineer.

Temporary barriers normally will not be used on non-control access highways. Barrier placement on multi-lane bridges shall be decided on a project by project basis after evaluation of suitable construction alternatives.

If temporary barriers are used for a bridge application, the Engineer should consider a more rigid anchorage of the temporary barrier to the bridge deck when deemed necessary.

## **BRIDGE DECKS**

There are currently three types of bridge riding surfaces being used by the Department:

1. Full Depth Cast-in-Place (slab span<sup>1</sup> or girder deck<sup>2</sup>)
2. Stay-in-Place Forms with cast-in-place concrete topping
  - a) Slabs - always utilize concrete panels
  - b) Decks
    - 1) Precast Concrete Panels
    - 2) Stay-in-Place Steel Forms
    - 3) Grid Floor

The following standard plans or standard details relating to bridge decks should be included in the bridge plans where applicable:

1. Slab Spans (various roadway widths and skew angles)
2. Miscellaneous Deck and Girder Details
3. Optional Deck Details
4. Grid Floor
5. Strip Seal Joint Details

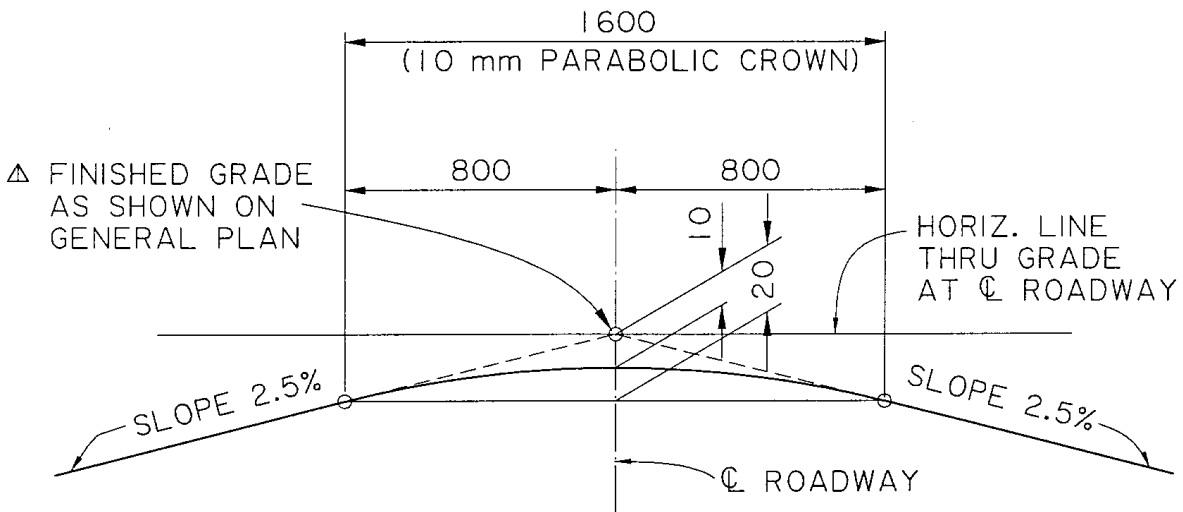
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<sup>1</sup> Slab defined as structural riding surface between substructure members.

<sup>2</sup> Deck defined as structural riding surface between superstructure members.

## ROADWAY CROWNS

1. One-way traffic bridges shall have a single tangent slope of **2.5%**.
2. Two-way traffic bridges shall have two-way tangent slopes of **2.5%** connected by a **1600 mm** parabolic crown section, except for projects utilizing slab span metric standards which presently show a soft conversion of the crown as **1220 mm**.
3. Bridge deck crowns shall match connecting roadway crowns parabolic crown except for special cases.



SKETCH SHOWING PARABOLIC CROWN

△ UNLESS OTHERWISE NOTED IN PLANS

## SUPERELEVATION

### Reasons for Superelevation of Curves

Centrifugal force causes a vehicle moving in a circular path to slide away from the center of the curve. This tendency can be reduced to acceptable levels by increasing the cross slope of the roadway surface away from the curve center sufficiently so that the vehicle weight component parallel to the roadway surface approximates the centrifugal force component parallel to the roadway surface.

The design of superelevation for highway curves will be in accordance with the latest edition of *A Policy on Geometric Design of Highways and Streets*, AASHTO, Washington D.C.

### Definition of Terms

**ACR** is the abbreviation for adverse crown removed. It is where the outside travel lane is rotated to a 0.00% cross slope and the inside travel lane remains at the normal crown cross slope.

$e_{max}$  is the symbol for the maximum superelevation rate of the roadway cross section. Louisiana normally limits this value to 10.0% for rural and 4.0% for urban roadway.

$e$  is the symbol for rate of superelevation for the roadway cross slope and is a function of  $e_{max}$ , design speed, and radius of curve. Values are generally selected from Tables III-7 to 11 in AASHTO.

**MRG** is the acronym for maximum relative gradient between the profile edge of two-lane travel way and the centerline. Its value is a function of design speed. The fractional value, given as a ratio, is **MRS**, or Maximum Relative Slope. MRS values are generally selected from Table III-13 in AASHTO.

**NC** is the abbreviation for normal crown section. In tables it designates curves with radii long enough that elimination of adverse cross slope or use of superelevation is not necessary. AASHTO tables are based on 1.50% cross slope. The designer should be aware that larger curve radii than that shown with NC designation may be required when using cross slopes of 2.50%.

**R** stands for the radius of a horizontal curve.

**RC** is the abbreviation for remove crown cross section. In tables it designates curves with radii long enough that removal of adverse cross slope and superelevating the entire roadway at normal crown inside slope is adequate. AASHTO tables are based on 1.50% cross slope. The designer should be aware that smaller curve radii than that with a RC designation may be satisfactory when using a cross slope of 2.50%.

**Superelevation runoff** is the general term denoting the length of highway needed to accomplish the change in cross slope from a section with adverse crown cross slope removed to a fully superelevated section, or vice versa.

**Tangent runoff** is the general term denoting the length of highway needed to accomplish the change in cross slope from a normal crowned cross section to a section with the adverse crown cross slope removed, or vice versa.

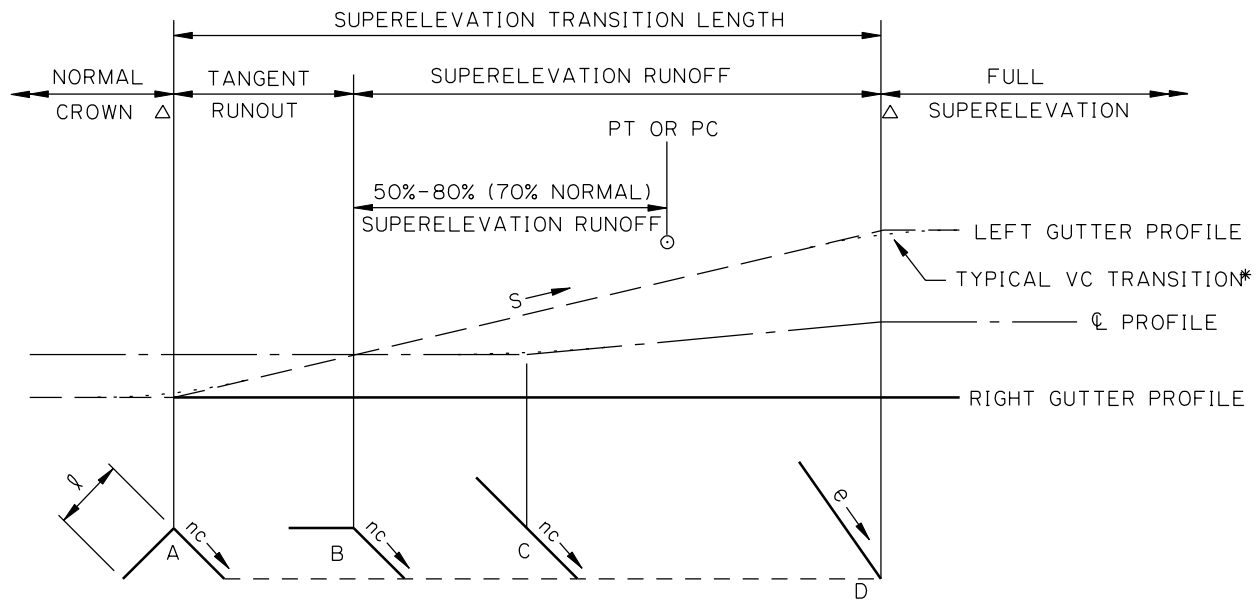
**V** is the assumed design speed.

**Superelevation Rotation:** In order to transition from a normal crown section to a fully superelevated section, a superelevation transition detail must be provided. The two primary methods used in LADOTD Bridge Design for attaining superelevation for curves are: 1) traveled way revolved about the centerline, and 2) traveled way revolved about the low gutter [in bridges with superelevation, it is common practice to profile the gutterline rather than the travel lane profile].

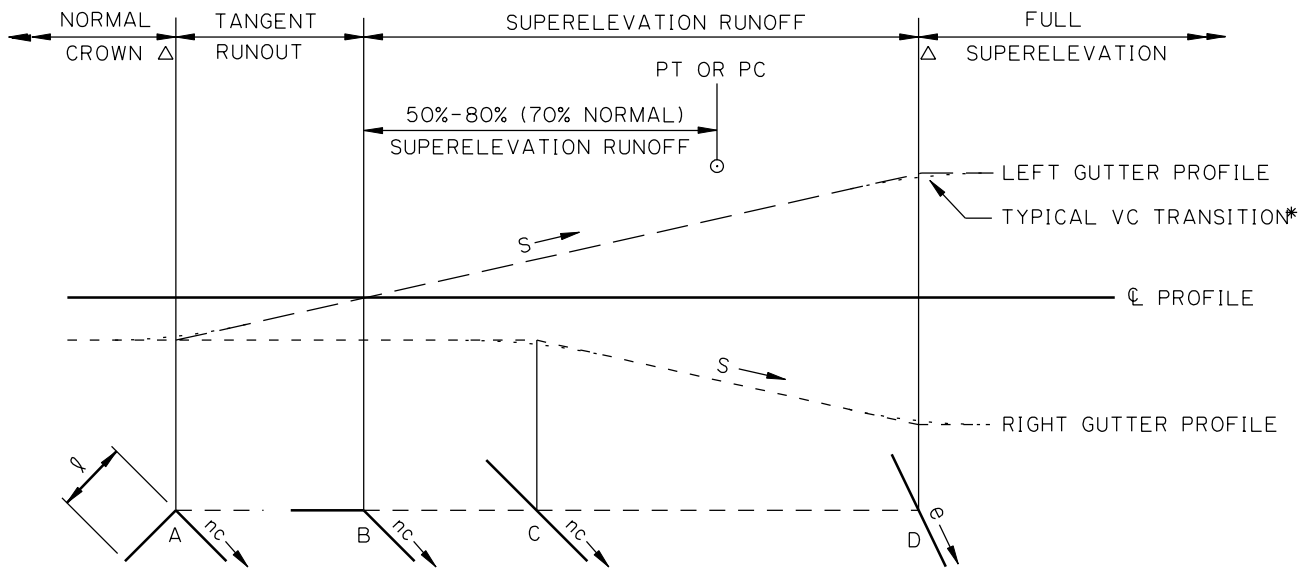
The method of rotating the traveled way about the centerline is widely used in design because the required change in elevation of the gutterlines is made with less distortion and it produces a balance with right-of-way taking. However, with one-half of the required elevation change made at each gutterline, vertical clearance reduction, drainage problems (if low gutter drops below natural ground), and driver apprehension of a dip in the roadway due to lowering of the low gutter of the roadway must be considered.

The method of rotating the traveled way about the low gutter is frequently used and the required change in cross section is accomplished by raising the outside gutter profile. This method is preferable when the low gutter line profile is a major control, as for drainage or vertical clearance above waterways. This method produces the greatest distortion of the high gutterline profile and could result in additional right of way taking due to the increase in fill height associated with the increase in elevation of the high gutter line.

Regardless of which method is used to superelevate the roadway surface for horizontal curves on projects, close coordination should be maintained between the Road and Bridge Design Sections, since the superelevation transitions usually affect both bridge and roadway designs.



PROFILE USING LOW GUTTER ROTATION



PROFILE USING CENTERLINE ROTATION

\* VC LENGTH (METERS) =  $\frac{\text{DESIGN VELOCITY (Km/h)}}{5}$

nc = NORMAL CROWN

5

e = RATE OF ROADWAY SUPERELEVATION

S = MAX. RELATIVE SLOPE BETWEEN THE  
EDGE OF ROADWAY PROFILE AND THE  
REFERENCE PROFILE.

Δ = OUTSIDE EDGE BEGINS TRANSITION VC/2  
BEYOND THIS POINT

**SUPERELEVATION DEVELOPMENT  
OPTIONS**

## Design Considerations

1. As a general rule, 60% to 80% of the superelevation runoff should be achieved on the tangent prior to the PC or after the PT of the curve (70% is normal, 50% is allowed for back to back curves).
2. For traveled ways wider than two lanes, adjustments should be made for lane widths as per AASHTO. In Bridge Design, the width of shoulders is included in the overall traveled way widths for adjustment purposes.
3. Angular breaks in the profile control lines should be rounded in final design by insertion of short vertical curves with minimum lengths (meters) approximately equal to  $V/5$ , with the design speed in kilometers per hour. These short vertical curves should be located so that their PVC and / or PVT are located at bent centerlines, when practical. This may require an elongation of the superelevation diagram.
4. A review by graphical plots of edgelines and centerline should be made to ensure smooth lines and to identify any flat areas. Kinks can be avoided by lengthening curves. Inadequate roadway slope creates potential drainage hazards (one such area is the point of adverse crown removed on a 0.00% grade bridge) that can be reduced by minimizing the superelevation transition lengths or providing additional drains in the area.
5. Bridge length, profile grade line, and superelevation rotation should all be referenced to a common baseline when possible.
6. All plan sheets should be detailed consistent with the examples shown in this manual when possible. It should be noted that the superelevation examples on the following pages are given as a guide; they are but one interpretation of AASHTO. For all projects, but especially the more complex, the engineer is encouraged to apply information contained in *A Policy on Geometric Design of Highways and Streets*, AASHTO, Washington D.C. to develop suitable superelevation transition diagrams.



<b>Lane Factor</b> (adjustment for pavement width ①)	
<b>Length (L)</b> (distance from rotation line to edge of rotated surface) (m)	<b>LF</b>
3.6	1.0
4.5	1.1 ②
5.4	1.2
6.0	1.3 ②
6.6	1.4 ②
7.2	1.5
10.8	2.0
> 10.8	extrapolate
①From page 180, A Policy on Geometric Design of Highways and Streets, 1994 AASHTO.	
②Interpolated value	

<b>Maximum Relative Slope</b> (between longitudinal edges of 3.6 m lane ③)	
<b>Design Speed</b> <b>(V) km/h</b>	<b>MRS</b>
30	1:133
40	1:143
50	1:150
60	1:167
70	1:182
80	1:200
90	1:210
100	1:222
110	1:238
120	1:250
③ Table III-13, A Policy on Geometric Design of Highways and Streets, 1994 AASHTO	

## Examples

Given:  $V = 100 \text{ km/h}$

$$R = 600 \text{ m}$$

$$nc = 0.025 \quad (\text{standard cross-slope})$$

$$e_{\max} = 10\% \quad (\text{DOTD rural standard})$$

$$e = .078 \quad (\text{from AASHTO Table III-10})$$

$$MRS = 1 / 222 \quad (\text{from AASHTO Table III-13})$$

$$\leq \text{rise} / \text{minimum run} \quad (\text{Value based on 2 second min. runoff length, p.177.})$$

$$\leq (\text{lane width} * e) / \text{minimum table runoff} \quad \text{Obtain 2-lane minimum runoff value from}$$

$$\leq (3.6 * 0.078) / 62 = 1:221 \quad \text{Table III-10 and incorporate if geometry permits.})$$

## Rotate about centerline

A) two 3.6 m lanes

no shoulders

$$L = 3.6 \text{ m} \quad (\text{distance from rotation line to edge of rotated surface})$$

$$LF = 1.0 \quad (\text{function of L and page 180, AASHTO})$$

run = rise / slope

$$AB = [\text{lane} * nc / MRS] * LF = 3.6(0.025) / 222 (1.0) = \mathbf{0.09(222)} \cong 20 \text{ m (runout)}$$

$$BD = [\text{lane} * e / MRS] * LF = 3.6(0.078) / 222 (1.0) = \mathbf{0.28(222)} \cong \underline{62 \text{ m}} \quad (\text{matches Table III-10})$$

$$AD = \text{superelevation transition length} \quad \mathbf{82 \text{ m}}$$

$$g = \text{rise} / \text{run} = (nc + e) * L / AD = (.025 + .078)3.6 / 82 = \mathbf{0.004522 \text{ m/m}}$$

Remainder of the superelevation diagram geometry can be determined from the **control values**.

- B) four 3.6 m lanes  
no shoulders

$$L = 3.6 * 2 = 7.2 \text{ m} \quad \text{(distance from rotation line to edge of rotated surface)}$$

$$LF = 1.5 \quad \text{(function of L and page 180, AASHTO)}$$

$$AB = 3.6 (0.025) 222 (1.5) \cong 30 \text{ m}$$

$$BD = 3.6 (0.078) 222 (1.5) \cong 94 \text{ m (matches Table III-10)}$$

$$AD = 124 \text{ m}$$

$$g = (0.025 + 0.078)7.2 / 124 = 0.005981 \text{ m/m}$$

- C) two 3.6 m lanes  
two 3.0 m shoulders

$$L = 3.6 + 3.0 = 6.6 \text{ m}$$

$$LF = 1.4$$

$$AB = 3.6 (0.025) 222 (1.4) \cong 28 \text{ m}$$

$$BD = 3.6 (0.078) 222 (1.4) \cong 88 \text{ m}$$

$$AD = 116 \text{ m}$$

$$g = (0.025 + 0.078)6.6 / 116 = 0.005860 \text{ m/m}$$

### Rotate about low gutter

[Page 187 of *A Policy on Geometric Design of Highways and Streets*, 1994 AASHTO, indicates that when rotation is about roadway edge, runoff lengths are similar to those for a centerline rotation with the same roadway width. This is consistent with page 177 where the MRG between profiles of edges of two-lane traveled ways is allowed to double. One way to account for this is by using a lane factor (LF) based on an adjusted length ( $L' = \frac{1}{2} L$ ) when calculating the required runoff length.]

- D) two 3.6 m lanes  
no shoulders

$$L = \text{lanes} + \text{shoulders} = 2 * 3.6 = 7.2 \text{ m (dist. from rotation line to edge of rotated surface)}$$

$$L' = \frac{1}{2} * L = \frac{1}{2} * 7.2 = 3.6 \text{ m (corrected width for determining LF for low gutter rotation)}$$

$$LF = 1.0 \quad \text{(function of L' and page 180, AASHTO)}$$

$$BC = [\text{lane} * n_c / \text{MRS}] * LF = 3.6 (0.025) 222 (1.0) = \mathbf{0.09(222)} \cong 20 \text{ m}$$

$$CD = [\text{lane} * (e - n_c) / \text{MRS}] * LF = 3.6 (0.078 - 0.025) 222 (1.0) \cong 42 \text{ m}$$

$$BD = [\text{lane} * e / \text{MRS}] * LF = 3.6 (0.078) 222 (1.0) = \mathbf{62 \text{ m}} \quad \text{(matches Table III-10)}$$

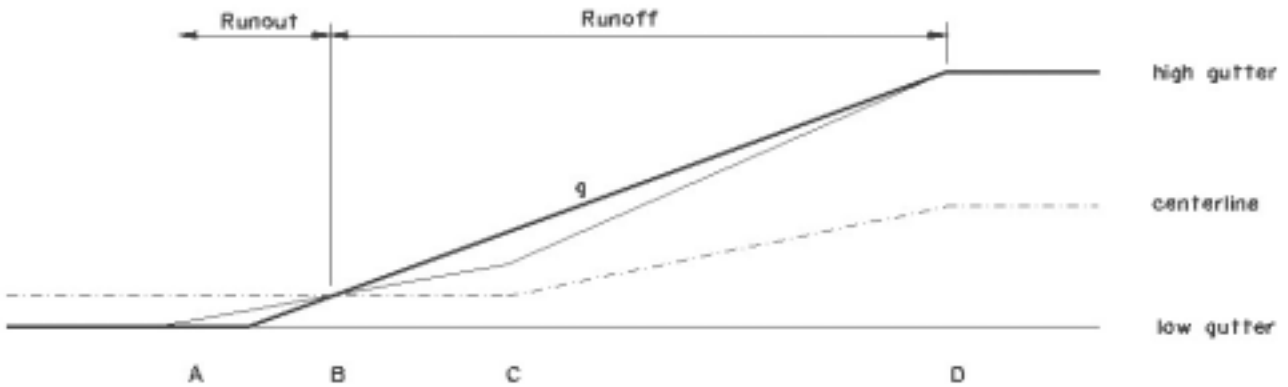
10)

$$g = [(\text{runout width}) * n_c + L(e - n_c)] / BD$$

$$= [(3.6 * 0.025) + 7.2 * (0.078 - 0.025)] / 62 = (.09 + .3816) / 62 = \mathbf{.4716} / 62 = \mathbf{.007606}$$

**m/m**

[Note that runoff length (BD) is independent of initial crown cross slope (we would obtained 62 m in the above example if  $n_c$  had been 0.000 or 0.015 in lieu of 0.025). Also note the “g” calculated is the gradient associated with the allowed runoff from Table III-10 but is dependent on initial crown. When an initial crown exists, the preliminary gradient of BC is one half the value of the preliminary gradient for CD (this is due to the shift in the reference rotation line from centerline to low gutter beyond point C, and the corresponding rise of the initial reference line beyond point C).



Thus “g” (as calculated above) is an average value. Page 184 of AASHTO states that a uniform edge slope is desirable. When the desired relative slopes are not possible, the runout length should be at least equal to those required for a curve with maximum superelevation where the same relative slope for the tangent runoff and runout are retained. With this as a guideline, we can conservatively use the average “g” as calculated above for both runout and runoff. This insures that in all occurrences, a single gradient is used, that the runout is longer than policy minimum, and “g” is less than the maximum.]

In our case:

$$\begin{aligned} \text{runoff} &= [e \cdot \text{lane} / \text{MRS}] \cdot \text{LF} \\ &= [0.078 \cdot 3.6 \cdot 222] \cdot 1.0 = 62 \text{ m} \\ g_{\text{max}} &= (e \cdot L) / \text{runoff} \\ &= 0.078 \cdot 7.2 / 62 = 0.00906 > g (= 0.007606 \text{ m/m}) \end{aligned}$$

If we use a flatter gradient than  $g_{\text{max}}$  to determine runout length, our runout length should always be longer than minimum required. To confirm this assumption, calculate and compare the two lengths one time.

$$\begin{aligned} \text{runout}_{\text{min}} &= (n_c \cdot \text{runout width}) / g_{\text{max}} \\ &= 0.025 \cdot 3.6 / 0.00906 = 9.936 \text{ m} \\ \text{AB} &= (n_c \cdot \text{runout width}) / g \\ &= (.025 \cdot 3.6) / 0.007606 = \mathbf{11.833 \text{ m}} > \text{runout}_{\text{min}} \end{aligned}$$

The remainder of the superelevation diagram geometry can be determined from the **control values**.

With our assumptions confirmed, we can reduce the steps necessary to find control values in subsequent problems.

E) two 3.6 m lanes

two 3.0 m shoulders

$$L = \text{lanes} + \text{shoulders} = 2 * (3.6 + 3.0) = 13.2 \text{ m}$$

$$L' = \frac{1}{2} * L = \frac{1}{2} * 13.2 = 6.6 \text{ m (corrected width for determining LF for low gutter rotation)}$$

$$LF = 1.4 \quad \text{(function of } L' \text{ and page 180, AASHTO)}$$

$$BD = [e * \text{lane} / \text{MRS}] * LF = 0.078(3.6) 222(1.4) = \mathbf{88 \text{ m}}$$

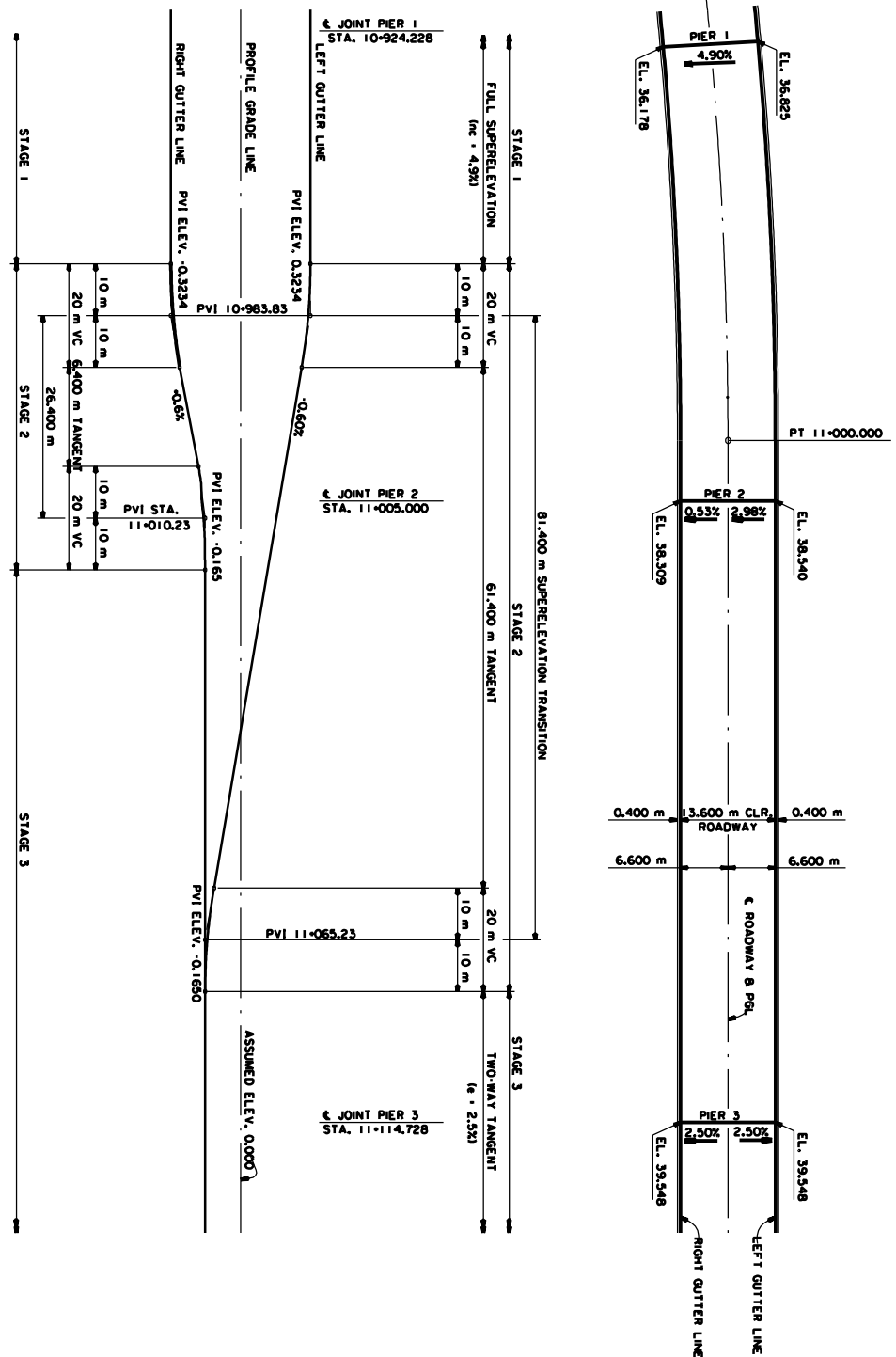
$$g = [(\text{runout width}) * nc + L(e - nc)] / BD$$

$$= [(3.6 + 3.0) * 0.025 + 13.2 * (0.078 - 0.025)] / 88$$

$$= (\mathbf{0.165} + .6996) / 88 = \mathbf{0.8646} / 88 = \mathbf{0.009825 \text{ m/m}}$$

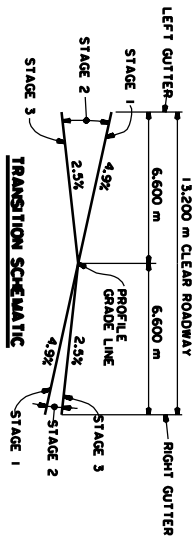
$$\leq e * L / BD = (0.078 * 13.2) / 88 = .0117 \quad \text{okay}$$

$$AB = BC = [(nc * \text{runout width}) / g] = [0.025 * (3.6 + 3.0) / 0.009825] = 0.165 / 0.009825 = \mathbf{16.79 \text{ m}}$$



CORRECTION TABLE				
LOCATION	% JOINT STATION	PROFILE GRADE ELEV.	CORRECTION LEFT GUTTER	CORRECTION RIGHT GUTTER
PIER 1	10+984.228	36.5015	-0.3234	-0.3234
PIER 2	11+005.000	36.3439	-0.1964	-0.0348
PIER 3	11+114.728	39.7132	-0.1650	-0.1650

**NOTE:**  
 SUPERELEVATION DIAGRAM SHOWN IS USED FOR THE CALCULATION OF VERTICAL CORRECTIONS ONLY. ACTUAL ELEVATIONS ARE COMPUTED BY ADDING THE CORRECTION TO THE PROFILE GRADE ELEVATION BASED ON VERTICAL CURVE DATA SHOWN ON THE GENERAL PLAN.

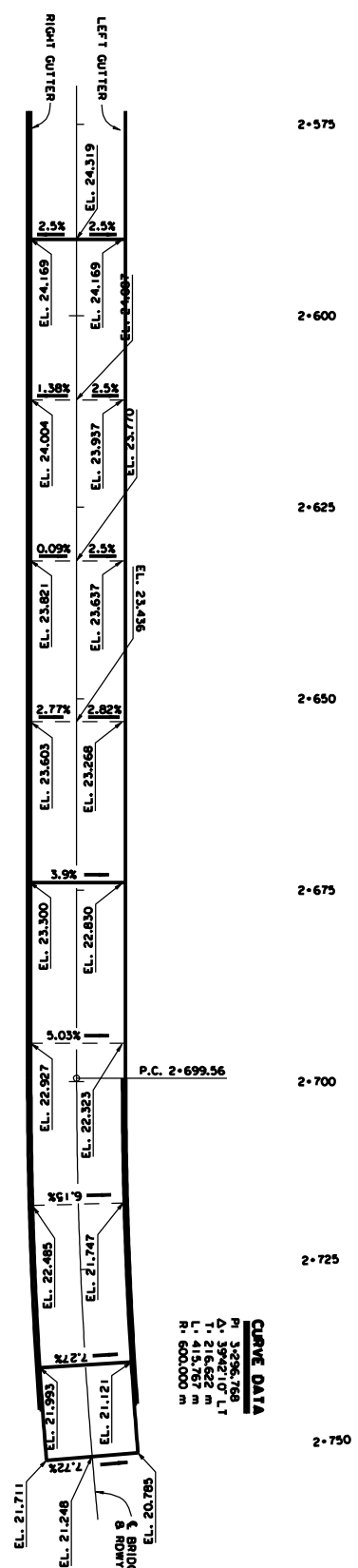
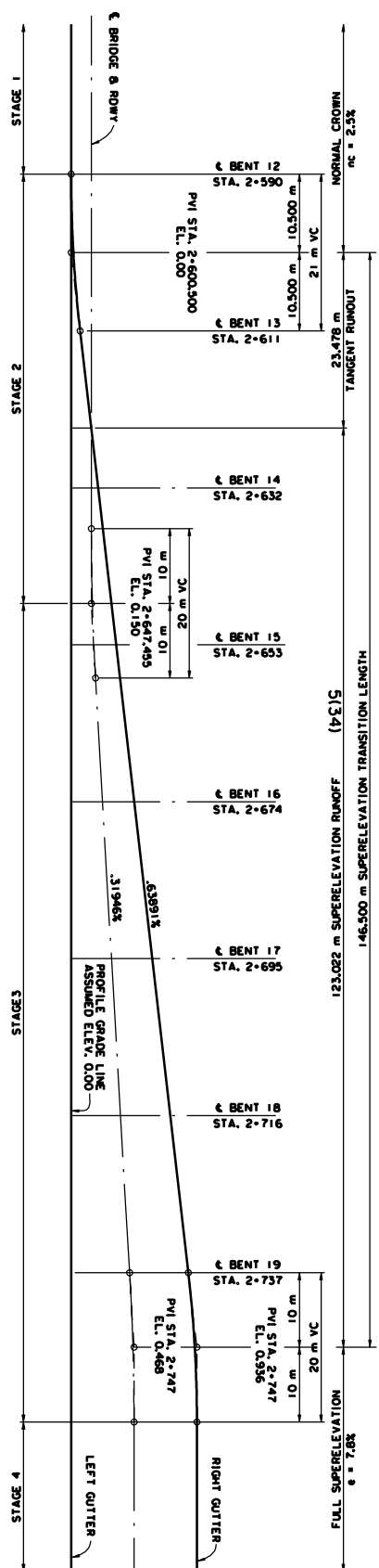
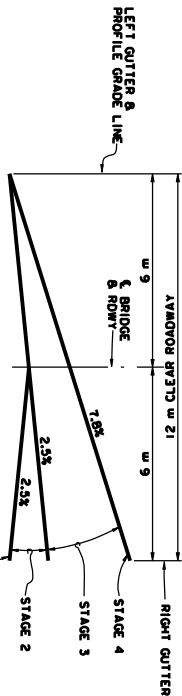


NO.	DATE	REVISION DESCRIPTION	BY	DESIGNED	CHECKED	DATE	SHEET		PARISH PROJECT FEDERAL PROJECT STATE PROJECT	SHEET NUMBER TOTAL SHEETS
				Detailed						

LOCATION	STATION	PROFILE GRADE ELEV.	CORRECTION	CORRECTION RIGHT GUTTER
BENT 12	2-590	24.169	0.130	0.0
BENT 13	2-611	23.937	0.130	0.067
BENT 14	2-632	23.637	0.130	0.201
BENT 15	2-653	23.268	0.169	0.335
BENT 16	2-674	22.830	0.234	0.470
BENT 17	2-695	22.323	0.302	0.604
BENT 18	2-716	21.747	0.369	0.738
BENT 19	2-737	21.121	0.436	0.872
END APPR.	2-749	20.785	0.463	0.926

NOTE:  
 1. PROFILE GRADE ELEVATION QUASARAL SHOWN IS USED FOR  
 THE COMPUTATION OF THE VERTICAL CURVE. THE  
 ACTUAL ELEVATIONS ON THE PROFILE GRADE ELEVATION BASED  
 ON VERTICAL CURVE SHOWN ON THE GENERAL PLAN.

**TRANSITION SCHEMATIC**



**CURVE DATA**

PI	3-236.768
PT	3-394.107
LT	1-415.785
R	600.000

DESIGNED	CHECKED	DATE	SHEET	BY

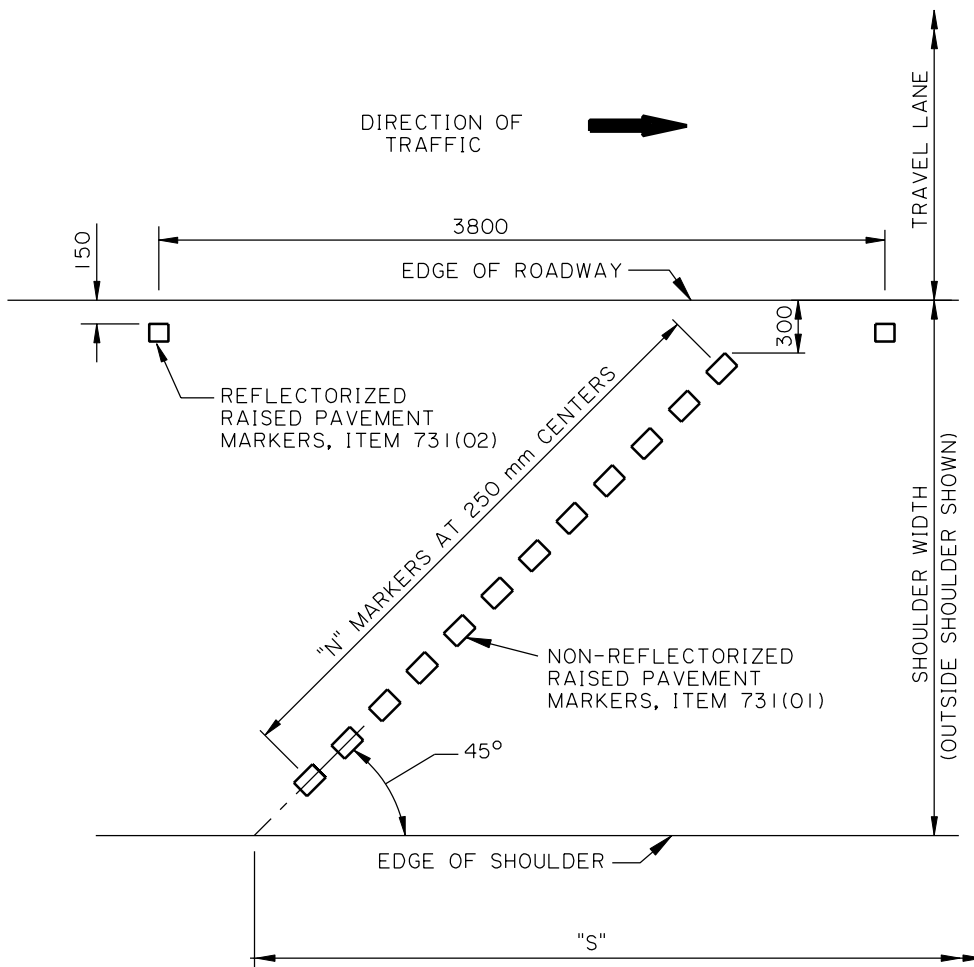
BRIDGE AND  
ROADWAY  
DESIGN

PARISH  
PROJECT  
STATE  
PROJECT

## BRIDGE DECK DRAINAGE

1. On concrete slab span and precast-prestressed concrete girder span bridges, 150 mm diameter deck drains are typically provided along low gutter lines on 3000 mm centers. Spans directly over railroads, roadways, or embankments do not have these drains. On steel bridges, the need for drains is investigated, and when required, drains, which extend their outlet to below the low steel, are used. Design of drains such as scuppers may be found in the Bridge Deck Drainage References, November 1989, DOTD Hydraulics Section and the *Hydraulic Engineering Circular No. 21*, May 1993, Publication No. FHWA-SA-92-010.
2. Structures with significant vertical curves or which incorporate higher embankments ( $\geq 3000$  mm above natural ground elevation) and have large deck drainage areas ( $\geq 250$  m<sup>2</sup>) are susceptible to embankment erosion and should incorporate bridge end drains where needed.





\* THE DIAGONAL MARKINGS ARE INTENDED FOR TWO-LANE BRIDGES AS WELL AS DIVIDED MULTI-LANE FACILITIES. SEE STANDARD PLAN PM-01-M FOR MORE DETAILS.

SHOULDER WIDTH (METERS)	NUMBER OF MARKERS PER DIAGONAL (N)
3.6	18
3.0	15
2.4	11
1.8	7
1.2	3
< 1.2	NOT REQUIRED

BRIDGE LENGTH (METERS)	REQUIRED SPACING (S) (METERS)
> 150	30
60-150	15
< 60	NOT REQUIRED

THE LAYOUT SHOWN BELOW CANNOT BE USED WHERE THE BRIDGE WIDTH IS LESS THAN THE APPROACH WIDTH. SEE PM-01-M FOR DETAILS.

**TYPICAL TRAFFIC MARKER  
PLACEMENT ALONG BRIDGE SHOULDER**

## DESIGN CRITERIA FOR CONCRETE SLAB SPANS

1. Live load moment shall be based on AASHTO 3.24.3.2 for "E". Both truck and approximate moment shall be calculated. The concrete slab shall be designed for whichever moment is greater.
2. All concrete slab spans with the clear roadway width  $\geq 12$  m shall be designed for military live load.
3. Load Factor design shall be used in determining the reinforcing steel in the slab to resist the barrier rail design load only when a crash tested model can not be used.
4. Wearing surface, 600 N/m<sup>2</sup>

## DESIGN CRITERIA FOR CONCRETE BRIDGE DECKS

For the vast majority of girder bridges, the decks are designed and built as reinforced concrete. An alternate, incorporating the use of precast stay-in-place concrete panels, which become composite with a cast-in-place portion of deck, is allowed under some circumstances. Steel stay-in-place forms may be allowed on a case for case basis for use on steel girders only. Loads and stress analysis are as specified by AASHTO and as modified herein.

### Analysis

1. The deck is designed as a continuous span over the girders.
2. The Department has chosen to satisfy both working stress and load factor requirements. For working stress design the slab will be designed as doubly reinforced concrete slab with the main reinforcement perpendicular to traffic.
3. The ultimate 28 day compressive strength for the deck concrete (Class AA) shall be **24 MPa** minimum. An allowable stress of **9.0 MPa** shall be used for the working stress method.
4. All steel shall be 420 grade bars.
5. Since the primary stress in the deck is due to live load+impact, the creep factor applied to compression reinforcement shall be neglected.
6. A **600 N/m<sup>2</sup>** dead load will be assumed for future wearing surface.
7. Modular Ratio:  $n = 9$  will be used for the design.

8. Reinforcement shall meet the development requirements as stated in AASHTO.
9. The distribution reinforcement indicated in the charts shall be placed in the bottom of the deck.
10. Design section shall equal slab thickness less **15 mm** for section loss due to tire wear.

## Deck Design Details

1. Deck thickness shall vary from a minimum of **180 mm** to a maximum of **220 mm** in **20 mm** increments. Optional deck panels will not be allowed as an alternate for **180 mm** decks. Any deck thickness other than 200 and 220 mm, shall be considered a special case, and will have to be approved by the Bridge Design Engineer.
2. A suggested pouring sequence for continuous spans is to be provided for spans over **25 m** in length, giving the minimum rate of pour in cubic meters per hour. The necessary information should be added to the "Miscellaneous Span and Girder Details" sheet 1 of 3. The pouring sequence is based on a 4 hour set time and attempts to minimize cracks in the top of the deck. Try to break the deck into segments at contraflexure points and pour positive moment areas first unless a continuous pour across the support is possible. See Louisiana Standard Specifications article 805.03(d) and limit rate to 45 m<sup>3</sup> per hour.
3. Reinforcing steel shall have **50 mm** cover at the top of the slab, and **25 mm** cover at the bottom of the slab.
4. Main reinforcing bars shall be **#15, or #20** and be placed as near perpendicular to the girders as possible.
5. Longitudinal reinforcing bars shall be **#10**, unless a larger size is needed for continuity over the bents. The top plane of longitudinal steel shall have a maximum spacing of **300 mm** center to center.
6. All bars greater than **#10** will have a detailed maximum length of 18.0 m unless spliced. **#10** bars shall be limited to 12.2 m in length for handling purposes.
7. Main reinforcing steel shall have a minimum spacing of **120 mm** and not greater than the gross deck thickness plus 5 mm.
8. Interpolation of reinforcing steel in deck design table will be allowed only between two sets of identical bar size.
9. 150 mm diameter drains should not be used directly above lower travel lanes, R.R. tracks or abutment slopes, even if revetment is present.
10. Optional deck panels are restricted from use in areas with severely skewed joints (see optional deck panel sheets for geometric limits). On bridges in curves or variable width roadways, the contractor may be allowed to use panels if he provides an independent check of his design and review of all shop drawings at no additional cost.

11. When the use of stay-in-place concrete panels will be allowed, the standard detail sheets will be incorporated into the plans and the general note sheet shall include the item "Optional Deck Details: Precast-prestressed concrete panels conforming to the optional deck detail sheets may be used at the contractor's option."
12. Stay-in-place steel forms will be allowed as an option to the contractor for deep widely spaced plate girders or box girders. The steel panels shall be galvanized in accordance to ASTM A 653M, Z 900 (450 g/m<sup>2</sup> coverage or 64 μm thick each face) and not increase the dead load from the deck concrete.
13. In order to combat the corrosive effects of salting on primary routes in Districts 04 and 05, as listed below, epoxy coated reinforcing steel shall be required as follows:
  - a) All superstructure reinforcing steel, top and bottom mattes.
  - b) All reinforcing steel used in bridge barrier rails and bridge sidewalks.

In addition, the engineer should contact District 04 or 05 to verify if deicing is practiced on a particular structure in an unlisted control section. Galvanized reinforcing steel may be substituted wherever epoxy coated reinforcing steel is required.

Control Sections in Districts 04 and 05 requiring epoxy coated concrete reinforcing steel:

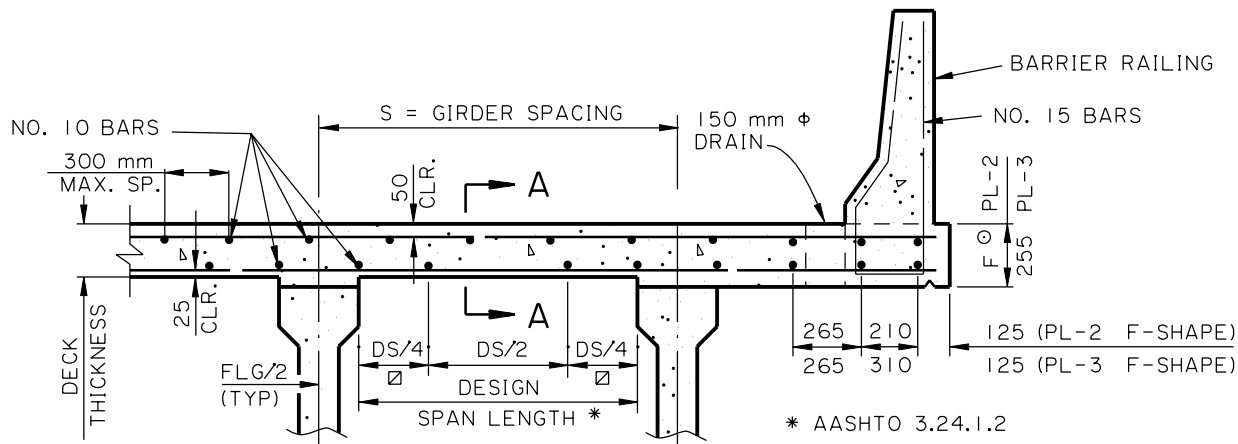
1-01 to 1-09	37-01 to 37-04	83-01 to 83-06
2-01 to 2-06	38-03 & 38-04 & 38-30	85-07
10-02 to 10-03	43-01 to 43-06	86-01 & 86-02
10-05, 10-06 & 10-33	44-01 to 44-03	87-02
11-01 to 11-04	45-01 & 45-03 & 45-30	98-02
15-08 & 15-31	48-01	124-03
16-01 to 16-05	49-01	156-01 to 156-03
20-06 to 20-09	51-04 to 51-08	420-01
21-01 to 21-05 & 21-30	53-06 to 53-09	427-01
23-06 & 23-09 to 23-11	67-07 to 67-09	451-01 to 451-08
25-05 to 25-08	69-02 to 69-04	451-30 & 451-31
26-08 to 26-10	70-01 to 70-07	455-07 & 455-08
27-01 to 27-06	72-01 to 72-02	809-08

The term control section refers to a section of highway and is designated by the first two digit groupings of a construction project number, for example:

Project No. 156-02-0053 -----Control Section 156-02

14. Tension development length modification factors for epoxy reinforcing steel must be used. See AASHTO 8.25.2.3

15. When epoxy reinforcing steel is specified, separate quantities will be computed for the epoxy and non-epoxy reinforcing steel, and a separate bid item shall be included in the plans for the epoxy coated reinforcing steel.

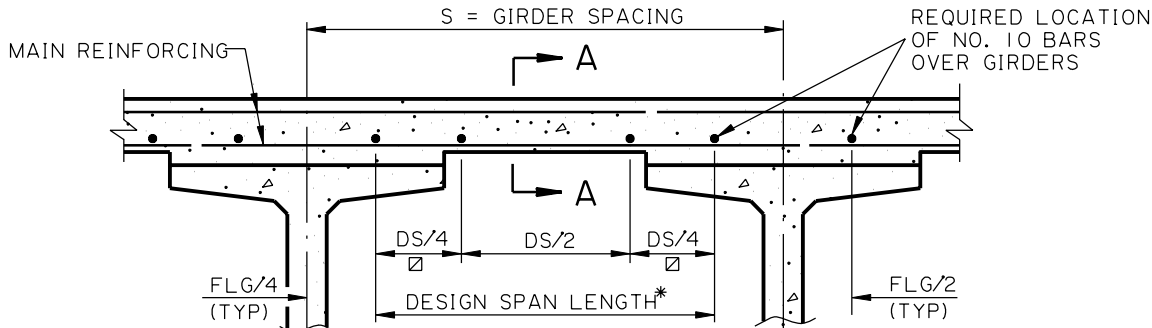


**TYPICAL DECK SECTION**

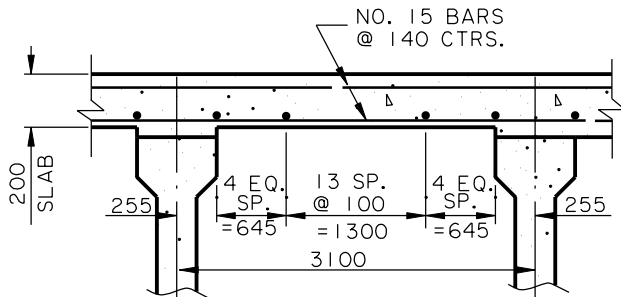
(PRECAST PRESTRESSED BEAM)

Ø NUMBER OF BARS WITHIN DS/4 SHALL BE EQUAL TO 1/4 THE NUMBER OF BARS REQUIRED WITHIN DS/2 FROM THE TABLE

- \* AASHTO 3.24.1.2
- MINIMUM "F" (PL-2) EQUALS DECK THICKNESS PLUS 20 mm (PLUS 25 mm FOR 180 mm DECK THICKNESS). WHERE DECK THICKNESS VARIES FROM SPAN TO SPAN, SET DIMENSION "F" TO BE CONSISTANT THROUGHOUT THE BRIDGE.



**TYPE BT DECK SECTION**

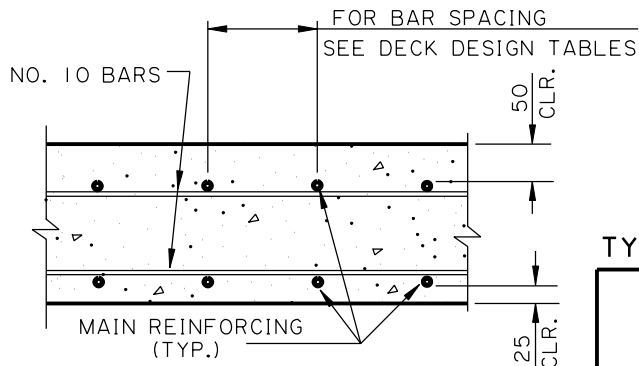


**EXAMPLE SOLUTION**

**EXAMPLE:**

GIVEN:  
GIRDER SPACING=3100; TYPE IV ( $t_f = 510$  mm)  
DESIGN SPAN=2590

SOLUTION:  
FROM DECK DESIGN TABLES, THE MOST ECONOMICAL THICKNESS AND REINFORCEMENT COMBINATION IS A 200 mm DECK WITH STRAIGHT NO. 15 BARS AT 140 mm BAR SPACING. USE 13 NO. 10 BARS IN BOTTOM MIDDLE HALF OF SPAN AND THEREFORE 4 NO. 10 BARS IN EACH OUTER QUARTER.



**SECTION A-A**

**TYPICAL SECTIONS**

**DECK DESIGN**

Deck Design Table (hard metric conversion)				
Straight reinforcing steel (400 MPa), AA concrete (24MPa)				
Slab thickness (mm)	Maximum Design Span (mm)	Main Reinforcement		No. of #10 bars in bottom mid half of span
		Bar No.	Bar spacing (mm)	
180 mm <sup>♦</sup>	2663	20	140	20
	2465	20	160	16
	<b>2426</b>	<b>15</b>	<b>120</b>	<b>14</b>
	2304	20	180	13
	2219	15	140	11
	1938	15	160	9
	1706	15	180	7
200 mm	3813	20	120	30
	3505	20	140	25
	<b>3261</b>	<b>20</b>	<b>160</b>	<b>21</b>
	3034	15	120	17
	2708	20	200	14
	2621	15	140	13
	2297	15	160	10
	2035	15	180	8
	1818	15	200	7
220 mm	4675	20	120	33
	4224	20	140	27
	3768	20	160	23
	3397	20	180	19
	3088	20	200	16
	2989	15	140	15
	2826	20	220	13

1. Slab thickness shown above includes 15 mm of wearing surface
2. Bar spacing is measured center to center
3. Minimum main bar spacing shall be 120 mm.
4. Design Load includes a future wearing surface of 600 N/m<sup>2</sup> ≈ [12 psf]
5. Design spans that are bold type are preferred for a given slab thickness and should provide the most economical design. Others may be used by the designer if special conditions warrant such use.
6. Bars in the bottom outer fourth of span = bars in mid half/4.

<sup>♦</sup> Requires approval from the Bridge Design Engineer, see item 1 under Deck Design Details.



<u>Deck Design Table (soft metric conversion)</u>				
Straight reinforcing steel (420 MPa), AA concrete (24MPa)				
Slab thickness (mm)	Maximum Design Span (mm)	Main Reinforcement		No. of #13 bars in bottom mid half of span
		Bar No.	Bar spacing (mm)	
180 mm <sup>3</sup>	2552	19	145	14
	<b>2369</b>	<b>19</b>	<b>165</b>	<b>11</b>
	2218	19	185	9
	2167	16	145	8
	1931	16	165	7
	1705	16	185	5
200 mm	3649	19	125	21
	3366	19	145	17
	<b>3138</b>	<b>19</b>	<b>165</b>	<b>15</b>
	2881	19	185	12
	2613	19	205	10
	<b>2600</b>	<b>16</b>	<b>145</b>	<b>10</b>
	2288	16	165	8
	2033	16	185	6
220 mm	1822	16	205	5
	<b>4482</b>	<b>19</b>	<b>125</b>	<b>23</b>
	<b>4057</b>	<b>19</b>	<b>145</b>	<b>19</b>
	<b>3628</b>	<b>19</b>	<b>165</b>	<b>16</b>
	<b>3276</b>	<b>19</b>	<b>185</b>	<b>14</b>
	2982	19	205	11
	2966	16	145	11
2733	19	225	9	

1. Slab thickness shown above includes 15 mm of wearing surface
2. Bar spacing is measured center to center
3. Minimum main bar spacing shall be 120 mm.
4. Design Load includes a future wearing surface of 600 N/m<sup>2</sup> ≈ [12 psf]
5. Design spans that are shaded are preferred for a given slab thickness and should provide the most economical design. Others may be used by the designer if special conditions warrant such use.
6. Bars in the bottom outer fourth of span = bars in mid half/4.

<sup>3</sup> Requires approval from the Bridge Design Engineer, see item 1 under Deck Design Details.

## DESIGN CRITERIA FOR DECKS OF MOVABLE BRIDGES

### Vertical Lift Spans

1. Span  $\leq$  30 m: Use 165 mm concrete deck
2. Span  $>$  30 m: An economic determination shall be made between a grid floor half filled and a 165 mm solid concrete deck. This study shall include the additional machinery and hardware requirements necessary to lift the bridge.
3. Spans, in which ADT requires an extra heavy grid floor, the economic investigation shall be made with a regular steel grid half filled with concrete above.

### Swing Spans

1. In general an open steel grid floor shall be used, however, half filled with concrete and a larger counterweight must be investigated.
2. Pivot castings shall be standardized for short, medium, and long spans such that the molds can be reused.

## STEEL GRID FLOORS

Steel grid floors are made up of steel plates (bars) or special rolled shapes welded together to form an open grid. The plates subject to main flexural stresses are referred to as bearing bars. The plates perpendicular to the bearing bars provide lateral support and distribution of the load to the bearing bars and the shallower bars between and parallel to the bearing bars provide more uniform surface respectively. Loads and stress analysis are as specified by *AASHTO*.

### Commentary

Steel grid floors are generally used in movable bridges to minimize the weight of the movable span's deck. This in turn reduces the load requirements on the machinery required to perform the movement operations.

Commercial types of open grid flooring are fabricated from plates or special rolled shapes, and should conform to Standard Plan GF-1 or GF-2. One of these open grid standards shall be used on all grid-flooring applications.

### Analysis

1. 1. Grid flooring shall be designed as continuous over stringers or girders parallel to the centerline of the roadway.
2. Use heavy-duty grid floor when ADT is high ( $ADT > 7000$ ).

3. Use half-filled grid floor in the first bay on the long cantilever of swing span bridges to protect machinery below if weight is critical.
4. Grid floors are available in ASTM A 709 Grade 250, 345, and 345 W steels. The design span will determine the type used.

### Design Details

1. The merits of alternate open grid floor systems should be investigated in terms of the basic AASHTO Specifications.
2. Bearing bars shall be perpendicular to the stringers or girders and welded to the top flange of the same at each juncture.
3. If two or more coats of paint are required on the grid floor, the cost to galvanize is more economical and should be specified.
4. For 165 mm concrete decks, incorporate 38 mm clear cover for reinforcing steel, top and bottom

### **DECK JOINT**

The discussion herein will pertain to deck joints for girder span bridges, as slab span joints are in accordance with the standard plans for slab span bridges.

For prestressed girder spans there are two types of joints currently being used; open joints and strip seal joints. Open joints are used at intermediate bents in rural areas and for stream crossings in urban areas where aesthetics is not as critical. For urban overpasses and interchanges exposed to the public view, strip seal joints are used to prevent unsightly staining and debris accumulation from drainage effluent. Strip seals are used at all end bents to prevent erosion. Both strip seal and open joints are capable of handling the expansion of up to **80 m** of prestressed girder span (**75 mm** maximum opening). For a single continuous span unit in which all of the expansion occurs at the abutments, the distance between joints could theoretically be doubled, however, bent restraint must be taken into account at continuity bents with span fixity.

All steel girder spans will have sealed joints. Strip seal joints are capable of handling the expansion of up to **56 m** of steel girder span. (A 112 m continuous unit can be handled if abutments are at each end with the unit fixed at mid-point.) For longer spans, finger joints will generally be employed with a trough (at 8% minimum slope) provided to divert the drainage away from the steel superstructure. Generally thick finger plates without stiffeners are more desirable than thinner plates with stiffeners, as the thick plates add more

inertia to the joint as well as provide a better detail for fatigue resistance. For finger joints on curved girder spans, the designer is advised to refer to the AASHTO's "Tentative Design Specifications for Horizontally Curved Highway Bridges" regarding the orientation of the fingers and the bearings. Joints shall be furnished in one piece without butt welds unless it is impractical due to plate length availability, in which case only one shop butt weld will be permitted.

The Bridge Design Engineer must approve the use of prefabricated or modular expansion joints in lieu of finger joints.

The use of steel reinforced elastomeric joint seals is prohibited.

In gore areas of new construction or in severely skewed spans, portions of the joint may have severe kinks and the designer is advised to confer with the joint manufacturer to insure a proper fit of the strip seal.

Open joints shall be in accordance with the "Miscellaneous Span and Girder Details", and strip seals shall be in accordance with the "Strip Seal Joint Details". The design of the gap setting of open joints is similar to strip seals.

Assume the normal installation temperature for finger joints is 20°C. The project engineer should adjust the opening when the temperature in the structure differs from normal by more than 8°C. The design should use a factor of safety of 2 for overlap and for opening.

Design Criteria for Strip Seals

- Span length "L" equals the expansion distance. In some instances it will equal the length of the particular continuous span unit in question. In other cases it will equal the distance between the assumed points of fixity of two consecutive continuous span units.

2.	TEMPERATURE RANGE (°C)	<u>RISE</u>	<u>FALL</u>
	Concrete Girders	17°	22°
	Steel Girders	34°	34°

COEFFICIENT OF THERMAL EXPANSION (°C)

CONCRETE	= 0.0000108
STEEL	= 0.0000117

- SHRINKAGE AND PRESTRESS CREEP

**20.833 mm per 100 m for PRESTRESSED GIRDERS**  
**10.417 mm per 100 m for STEEL GIRDERS**



$$= 74.9 \text{ mm} < 75 \text{ mm}$$

∴ O.k.

#### EQUATION FOR CHECKING THE MAXIMUM JOINT OPENING

$$\begin{aligned}\Delta_{(\max)} &= (0.00018 \times L) + [(0.00024 \times L) + (0.00021 \times L)] < [75 \text{ mm} - 25 \text{ mm}] \\ &= 0.00063 \times L < 50 \text{ mm} \\ L &< 80 \text{ m concrete}\end{aligned}$$

#### Design Example: Steel Girder Spans

A series of 50 m simple spans

1.  $L = 50 \text{ m}$
2. Thermal movement  
34°C rise (expansion)  
 $= 34 * (0.0000117) \times L$   
 $= 0.0003978 \times L$   
 $= 19.9 \text{ mm}$   
34°C fall (contraction)  
 $= 19.9 \text{ mm}$
3. Installation dimension  
25 mm (min.) + thermal expansion  
 $= 25 \text{ mm} + 19.9 \text{ mm}$   
 $= 45.0 \text{ mm}$
4. Deck shrinkage  
 $= (10.417 \text{ mm} \div 100\text{m}) \times (50 \text{ m} \div 1000\text{mm}) \times L$   
 $= 0.0001042 \times L$   
 $= 5.2 \text{ mm}$
5. Max opening  $\leq 75 \text{ mm}$   
 $= \text{installed dimension} + [\text{deck shrinkage} + \text{thermal contraction}]$   
 $= 45.0 \text{ mm} + 5.2 \text{ mm} + 19.9 \text{ mm}$   
 $= 70.1 \text{ mm} < 75 \text{ mm}$   
∴ O.k.

#### EQUATION FOR CHECKING THE MAXIMUM JOINT OPENING

$$\begin{aligned}\Delta_{(\max)} &= 0.0003978 \times L + [(0.0003978 \times L) + (0.0001042 \times L)] < [75 - 25 \text{ mm}] \\ &= 0.0009 \times L < 50 \text{ mm} \\ L &< 56 \text{ m}\end{aligned}$$

## **PRESTRESSED GIRDERS**

### Introduction

The precast, pretensioned girders covered herein are used in unshored, composite action with the concrete deck. They are most commonly used in the **12 to 40 m** span ranges. The prestressed girders in present use are the standard AASHTO Types I, II, III, IV, IV modified, and the bulb tee (1830 BT).

### Scope

This article is to supplement and amend the design presented in the AASHTO Specifications to conform to the design policy of the Department.

### Commentary

The deck used is constructed exclusively of normal weight aggregate with normal strength structural concrete. The girder concrete is an early high strength concrete.

The girders are precast and pretensioned in manufacturing plants usually away from the job site. The girders are mass produced elements that are subject to a variety of different methods of fabrication depending on the individual manufacturers.

It is desirable to minimize the number of strand patterns in a project. Frequently, girders of similar length or loads can be grouped into a particular strand pattern.

Prestressed girders shall be made continuous for the maximum practical length, to eliminate expansion joints. The prestress girders shall be designed as simple span girders for positive moment, without regard to live load continuity. The prestress girders shall be designed to account for live load continuity for shear and negative moment design. The girders are assumed to be continuous because they are embedded into the continuity diaphragm that is poured in-place with the deck slab. Additional reinforcing steel shall be placed in the cast-in-place deck slab to resist the continuous live load negative moments developed as a result of the continuity.

## Analysis

1. In the design analysis the initial camber (deflection at release due to prestress and self-weight) can be assumed to be the final camber (deflection after all dead loads and applied prestress). For construction purposes the initial camber and expected dead load deflection are calculated and given.
2. To relieve the stress at the ends of the girders, prestress girders will be designed utilizing either the debond or draped strand design. The preferred debond design must follow AASHTO LRFD limits on total percent debonded and percent debonded per row. If the debond design results in a more costly design (four or more additional strands per girder, additional girder line, etc.), then a draped pattern should be utilized.
3. The sidewalk and traffic railing dead and live load shall be assumed to be carried by the exterior girder. If in the judgement of the designer, the sidewalk and the parapet places an excessive load on the exterior girder, he may distribute a percentage of the load to the adjacent interior girder(s) as directed by the Bridge Design Engineer. Exterior girders shall not have less capacity than interior girders and will almost always be designed to carry the full weight of the barrier rail.
4. For design purposes, the haunch shall be taken as 15 mm less than the actual haunch dimension used at the centerline bearing to account for loss of structural depth due to camber.
5. It is desirable that the temporary tension stress in the top fiber near the ends of prestressed girders be reduced as much as possible by debonding (see #2 above and LRFD 5.11.4.2). If the tensile stress still exceeds the allowable after maximum debond, bonded non-prestressed reinforcing steel shall be supplied in an amount to resist the total tension force developed in the uncracked girder section at a working stress of  $0.4 F_y$ . (See example, page 4-21 PCI Handbook, 4th edition).
6. A future wearing surface of  $600 \text{ N/m}^2$  in dead load shall be added to the clear roadway width. However, no section loss or gain is assumed due to the wearing surface in the composite section.
7. Raised medians shall have required construction joints between the raised portion and the regular roadway slab. Girders affected by raised medians shall be designed to carry full live load & impact and dead load, exclusive of the weight at the raised portion, at 100% of the allowable stress. These girders affected shall also be checked with the previous loads plus the raised median superimposed for 150% of the Group I stress.
8. The design shall be made with 12.70 mm diameter 1860 MPa low relaxation (lo-lax) strands in accordance with ASTM A 416.



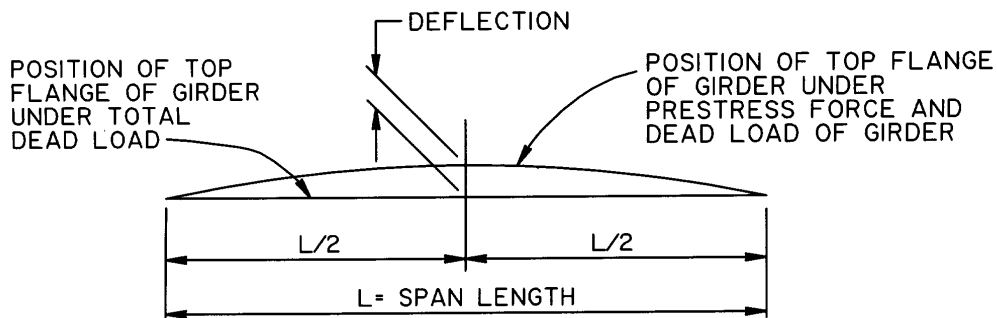
9. The actual camber ( $\Delta$ ) due to prestressing forces plus girder dead load may vary by  $\pm 10 \text{ mm}$  from the predicted value, but the actual minimum camber should not be less than the predicted deflection due to composite and non-composite superimposed dead load (excluding future wearing surface). If the final deflection is negative, (i.e. sagging) then adding more strands or reducing the dead load to reduce the undesirable deflection will be required.

Let  $c$  = camber due to prestress force and girder weight  
 $\Delta$  = deflection due to diaphragms, deck, haunch, and barrier rail

Then at release:  $C_{\max} = c + 10 \text{ mm}$   
 $C_{\min} \geq (c - 10 \text{ mm}) \geq \Delta$

	EXT. GIRDER		INT. GIRDER	
DEAD LOAD REACTION	○		○	
DEFLECTION				
ALLOWABLE CAMBER	MIN	MAX	MIN	MAX

○ INCLUDES  $600 \text{ N/m}^2$  FUTURE WEARING SURFACE.



DEFLECTION OF PRESTRESSED GIRDER UNDER DEAD LOAD OF CAST- IN- PLACE CONCRETE

10. Release and final strengths of concrete shall be **30 MPa** and **40 MPa** for **Class P**, and **35 MPa** and **45 MPa** for **Class P(M)**, respectively. **Class P(M)** concrete is to be used only with permission of the Bridge Design Section. The actual required design strength to the nearest 1 MPa, shall be the one shown on the plans.
11. Spans continuous for live load shall have additional reinforcing steel placed in the cast-in-place slab to carry the negative moment caused by live load plus impact at the continuous supports. Shrinkage and distribution reinforcing steel is to be included in the computation for determining the total amount of negative moment reinforcing required.
12. The shear requirements for prestressed girders shall be in accordance with the current AASHTO Specifications.
13. Girders subject to corrosion (road salt, gulf spray, etc..) shall incorporate means to reduce the potential of steel corrosion, such as calcium nitrite, microsilica, and fly ash.
14. Development length for fully bonded strands =  $1.6 \times$  [AASHTO Equation 9-32]  
Development length for debonded strands =  $2 \times$  [AASHTO Equation 9-32]
15. Prestressed girders that have a deck placed on them within a month or two of manufacture do not experience much camber or deflection growth. Therefore, a camber/deflection multiplier = 1.0 should be used on all standard projects.
16. Prior to final release of a project with prestressed girders, a final set of shop drawings (showing the strand type and pattern actually used in the bridge) shall be requested from the fabricator and transmitted to general files for microfilming.
17. Where PPCG are being used in an inefficient location (such as under a trapezoidal deck in a skewed span), it may be difficult to meet the  $M_{cr}$  requirement near the end ( $1/10$  span point and outward) of the girder. Engineering judgment should be exercised in evaluating the specifications versus possible conditions.

## Design Details

1. Girder spacing shall be equal where practical.
2. Generally, only exterior girders shall be anchored to the bent unless additional anchorage is required to meet seismic loading criteria. Spans subject to collision over navigable channels or subject to possible inundation by flooding shall be anchored at each girder.
3. The minimum haunch above the centerline bearing of the girder shall be **40 mm** for Type I, II and III girders and **50 mm** for Type IV, Type IV(mod), and **75 mm** for Type BT girders. For cases with high superelevation or a sag vertical curve, these may need to be increased so that there is no encroachment by the top girder flanges into the deck.
4. Girders with draped strands shall have tie-down points located symmetrically about the centerline of the span. The distance between the tie-down points shall be approximately  $\frac{1}{5}$  to  $\frac{1}{4}$  of the design span.
5. Diaphragm Policy:

**Spans  $\leq 15$  m** requires no intermediate diaphragm.

**15 m < spans  $\leq 30$  m** require one (1) intermediate diaphragm

**Spans > 30 m** require two (2) intermediate diaphragms

When no intermediate diaphragms are used, a note shall be placed in the plans requiring the contractor to provide temporary bracing during the deck pour.

Intermediate diaphragms for skewed spans are usually constructed perpendicular to the girder webs by use of partial span width or stepping the diaphragms. For flared or skewed spans less than about  $20^\circ$ , diaphragms may be constructed at a skew to the web.

6. See details for standard end block for each girder type.
7. Neoprene bearing pads shall be in accordance with the miscellaneous span and girder details.
8. Precast-prestressed girder details shall be in accordance with the Miscellaneous Span and Girder Details sheets.

9. The maximum spacing of tie reinforcement shall meet AASHTO 9.20.4.5 as given in the table below.

AASHTO TYPE PPCG	MAXIMUM TIE SPACING(mm)	
	#10	#15
II	600	600
III	550	600
IV	450	600
BT	210	425

$$S \leq A \times F_y \div 0.345 \times b_v$$

10. For prestressed girder projects in which the contractor elects to fabricate all the girders at the same time but girder placement will extend more than 4 months after casting (such as for phased construction or very large projects), the contractor will be required to account for camber growth. Camber for each girder shall be measured prior to erection and project engineer acceptable adjustments (such as lowering riser elevations) shall be made such that the top girder flange does not enter the bottom of the deck (maintain a positive haunch).

#### Applicable Standard Drawings

1. Miscellaneous Span and Girder Details (4 sheets).

## PRESTRESSED GIRDERS WITH DEBONDED STRANDS

### Introduction

The prestressed girders with debonded strands covered herein are intended to be used in lieu of girders with draped strands. This article is intended as a guide to the design of prestressed girders with debonded strands, and reflects current bridge design policy.

### Commentary

Strands that are placed in a straight configuration near the bottom of a prestressed girder tend to cause overstress near the end of the girder at detensioning when the flexural capacity of the girder at midspan is efficiently utilized. To avoid this overstress, several strands centered in the web area are usually deflected or draped upward near each end to reduce the eccentricity of the force they cause about the centroid of the girder causing the overstress. The fabrication effort required getting the draped strands stressed and in position is time consuming, labor intensive, difficult and dangerous. It also requires the use of heavy equipment. This procedure contributes significantly to the fabrication cost of prestressed girders.

A less costly procedure is to place and stress the strands required for flexure at midspan in a straight configuration over the full length of the girder. The overstress near the ends of the girder at detensioning is avoided by debonding several strands from the ends of the girder towards midspan over a length which would otherwise be overstressed. This eliminates the eccentric forces the debonded strands would otherwise cause about the centroid of the girder and thus reduces the stresses.

The debonding of a strand is accomplished with a plastic tube shielding the strand from contact with the concrete mortar that bonds the strands to the concrete mass. This tube may be split with overlapping sides to facilitate installation along the strand as required and yet remain mortar tight. It must also have a thick and rigid enough wall to prevent collapsing on the strands. The end of the tube terminating in the concrete is taped closed to avoid concrete mortar seeping through. When the tube is successfully installed, none of the pretensioned force from the strand is transferred to the girder from its end to the point where the tube is terminated within the girder.

Since the unbonded prestressing steel and shielding material will remain in the girder, it is appropriate to minimize the use of debonding material and simultaneously attain the required flexural capacity of the girder to minimize cost. The strategy is to debond the strand from the ends only enough to eliminate overstress at detensioning and then check for adequate development lengths of the strands required to resist the factored moments at critical points.

The strands shall generally be debonded in a sequence beginning in the row nearest the bottom flange and progressing upward as required to satisfy design conditions.

### Analysis

1. Determine the number of strands required at the midspan of the girder based on conventional procedures for service load and load factor analysis. Stresses and moments shall be determined at increments of 1/10 of the design span length or less.
2. Determine the number and location of the strands required to be debonded to avoid overstress at the ends of the girder at detensioning (initial conditions). The allowable tension shall be  $0.249(f'_{ci})^2$  and the allowable compression shall be  $0.6f'_{ci}$ . For calculation purposes, the strands are assumed to introduce prestress force to the girder as follows:
  - a) Transfer length for service load (initial and final conditions): Linearly from no contribution at the debond point to full effect over a distance of fifty times the strand diameter<sup>4</sup>.
  - b) Development length for ultimate strength: Linearly from no contribution at the debond point to full effect over a distance of two times the development length specified in the AASHTO Specifications subsection 9.28.1.
3. Establish the number and sequence of each set of strands to be debonded at intermediate points along the girder based on stresses at detensioning. Preferably, a 2 m distance between debond lengths will be utilized. Limit debond to 25% of total, 40% of any row (LRFD 5.11.4.2).
4. Exterior strands in each horizontal row should be fully bonded.
5. Locate the point that the strand pattern required at midspan will produce the maximum allowable stress in the girder at detensioning. Debond the first set of strands from this point to the end of the girder.
6. Locate the point that the remaining strand pattern will produce the maximum allowable stress in the girder at detensioning. Debond the second set of strands from this point to the end of the girder. Repeat this step for the third and additional sets of strands to be debonded at intermediate points along the girder.
7. Check stresses at final conditions at the centerline of the girder, at debond points and along the transfer lengths.
8. To satisfy the ultimate strength requirements, check that the strands bonded to the end of the girder are capable of resisting the factored moment at one development

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<sup>4</sup> Standard Specifications For Highway Bridges, Sixteenth Edition-1996, subsection 9.20.2.4

length from the ends of the girder. Then, check the capacity at all critical points, debond points and midspan, to insure that the ultimate moment capacity is greater than the factored moment. The ultimate moment capacity shall be the sum of the capacities of all fully developed strands plus the capacity of partially developed strands. At two development lengths from debond points, strands are fully developed. At points less than two development lengths from the debond point, the partial capacity of debonded strands shall be calculated based on a linear proportion from zero at the debond point to full capacity at two development lengths.

9. In the event that the number of strands required for the factored moment at a critical point cannot be bonded for two development lengths, determine the service load stress in the bottom fibers for Group I loads. If no tension stress occurs along the beam, one development length can be used in lieu of two development lengths.

### Design Details

1. The use of debonding material and the number of debonding termination points should be minimized.

**ASSUMPTIONS**

1. 200 mm SLAB @ 24 MPa
2. 230 mm BEARING DISTANCE
3. HS 20-44(M) AND HST-18(M) LIVE LOAD
4. INTERIOR GIRDER SHOWN
5. BARRIER CARRIED BY EXTERIOR GIRDER EXCEPT FOR BT-72
6. 12.7 mm 1860 MPa STRANDS

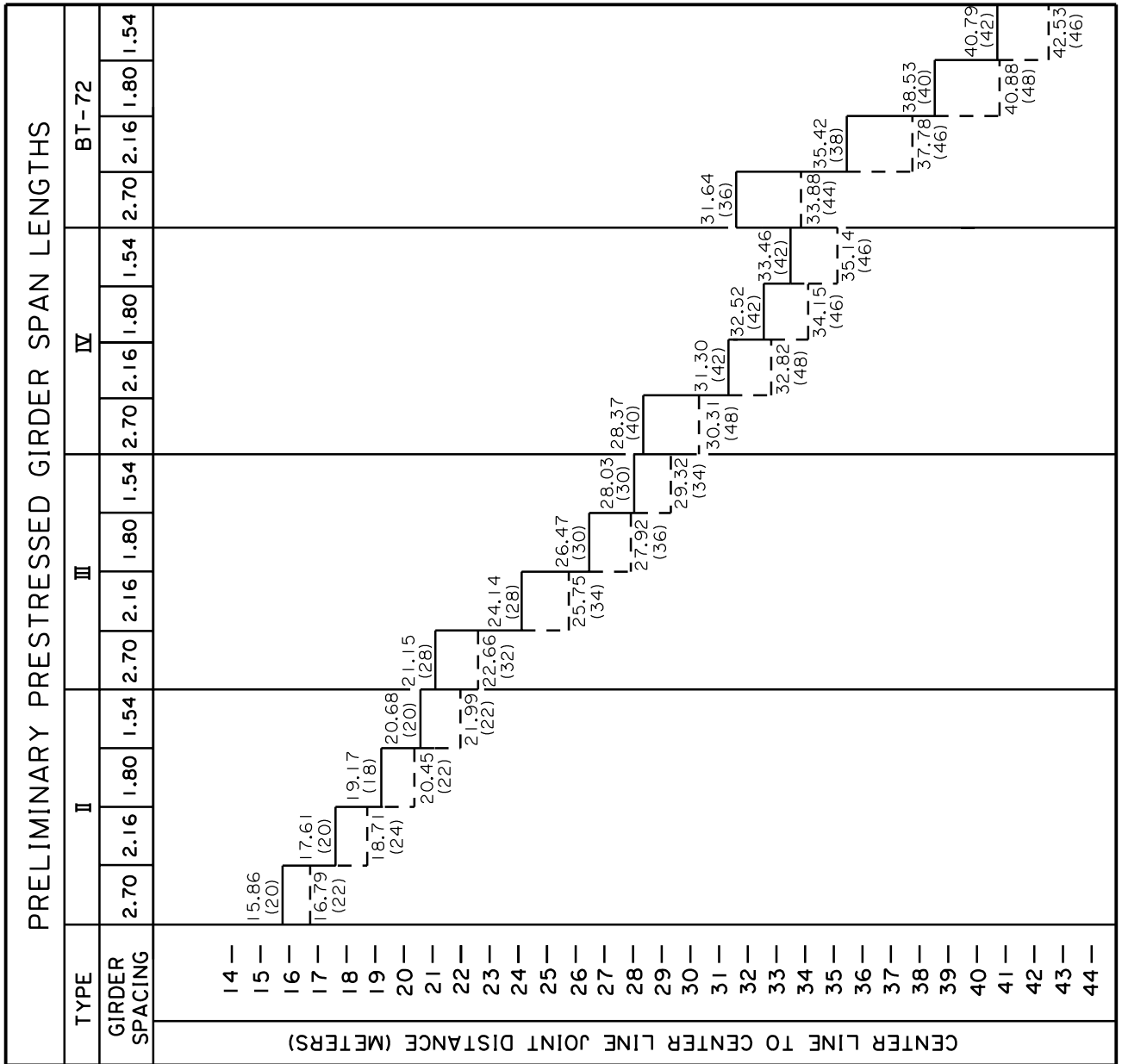
—  $f'_c = 40 \text{ MPa}$

- - -  $f'_c = 45 \text{ MPa}$

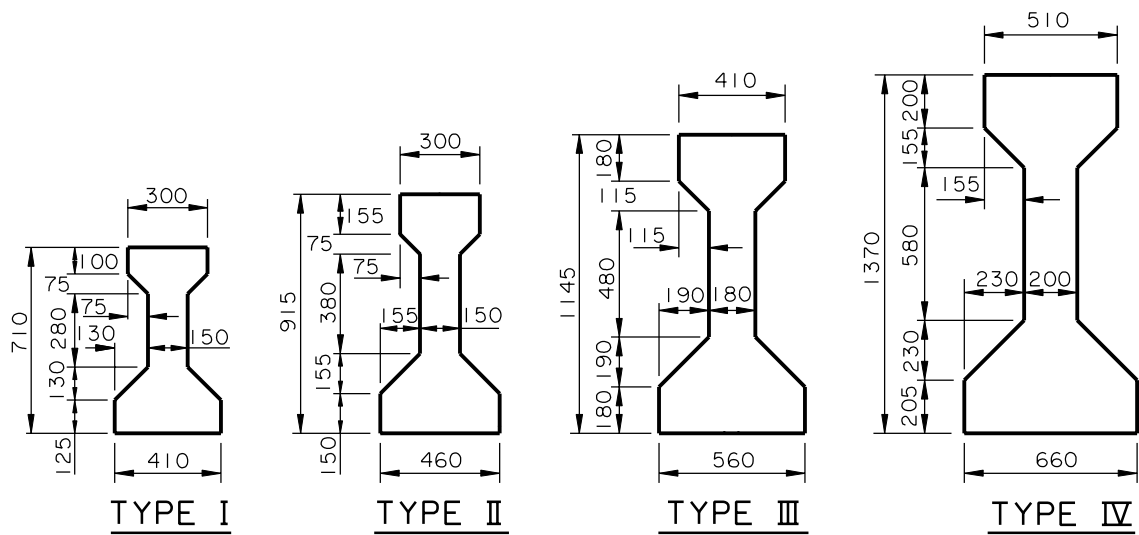
(xx) NUMBER OF STRANDS

**APPROXIMATE SPAN LIMITS**

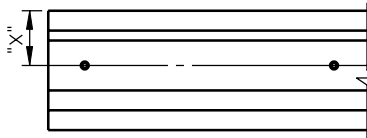
**CHART OF SPAN RANGE LIMIT FOR PRECAST-PRESTRESSED GIRDERS**



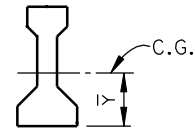




### BEAM PROPERTIES



⊕ 50 mm DIA. OPEN HOLE AT  
⊕ END AND INTERMEDIATE  
DIAPHRAGMS ⊗



BEAM TYPE	AREA (mm <sup>2</sup> )	"X" * (mm)	$\bar{Y}$ (mm)	MOMENT OF INERTIA (mm <sup>4</sup> x 10 <sup>4</sup> )	WEIGHT (kg/m)⊕	BOTTOM SECT. MOD. (mm <sup>3</sup> x 10 <sup>3</sup> )	TOP SECT. MOD. (mm <sup>3</sup> x 10 <sup>3</sup> )
I	176 525	315	316.52	934 754	423.66	29 532	23 756
II	236 650	420	400.30	2 113 520	567.96	52 798	41 063
III	365 225	535	517.12	5 290 770	876.54	102 312	84 264
IV	507 225	645	626.67	10 818 620	1217.0	172 636	145 543

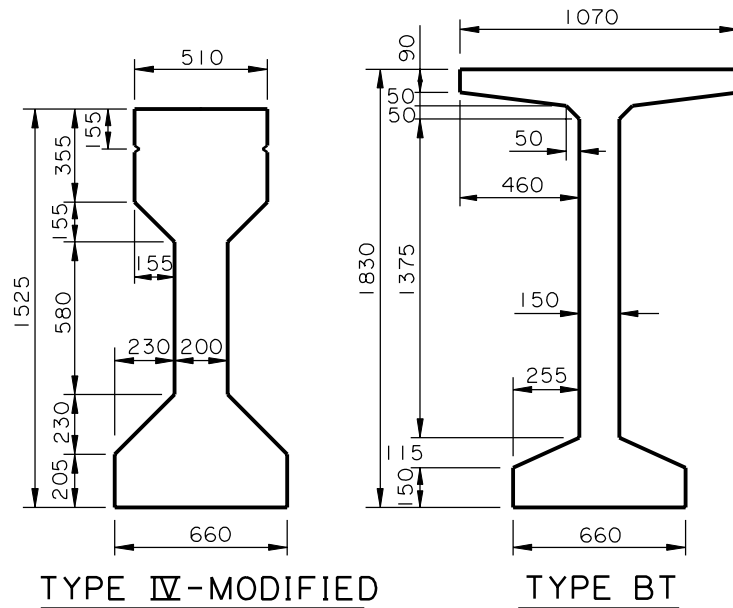
\* THIS DIMENSION MAY BE ADJUSTED TO CLEAR DRAPED STRANDS WHEN NECESSARY.  
THIS DIMENSION IS TYPICAL FOR ALL GIRDERS REGARDLESS OF ROADWAY CROWN.

⊕ BASED ON CONCRETE DENSITY OF 2400 kg/m<sup>3</sup>

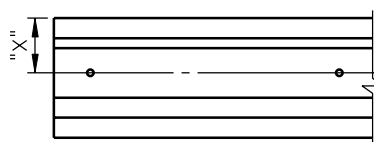
⊗ INTERIOR GIRDERS ONLY

### DIMENSIONS AND PROPERTIES

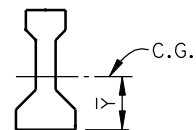
## PRESTRESSED GIRDERS



### BEAM PROPERTIES



⊕ 50 mm DIA. OPEN HOLE AT  
⊕ END AND INTERMEDIATE  
DIAPHRAGMS ⊗



BEAM TYPE	AREA (mm <sup>2</sup> )	"X" * (mm)	$\bar{Y}$ (mm)	MOMENT OF INERTIA (mm <sup>4</sup> x 10 <sup>4</sup> )	WEIGHT (kg/m)⊕	BOTTOM SECT. MOD. (mm <sup>3</sup> x 10 <sup>3</sup> )	TOP SECT. MOD. (mm <sup>3</sup> x 10 <sup>3</sup> )
IV-MOD.	586 275	800	737.35	15 442 370	1408	209 431	196 056
BT	491 125	880	933.19	22 683 580	1179	243 076	252 936

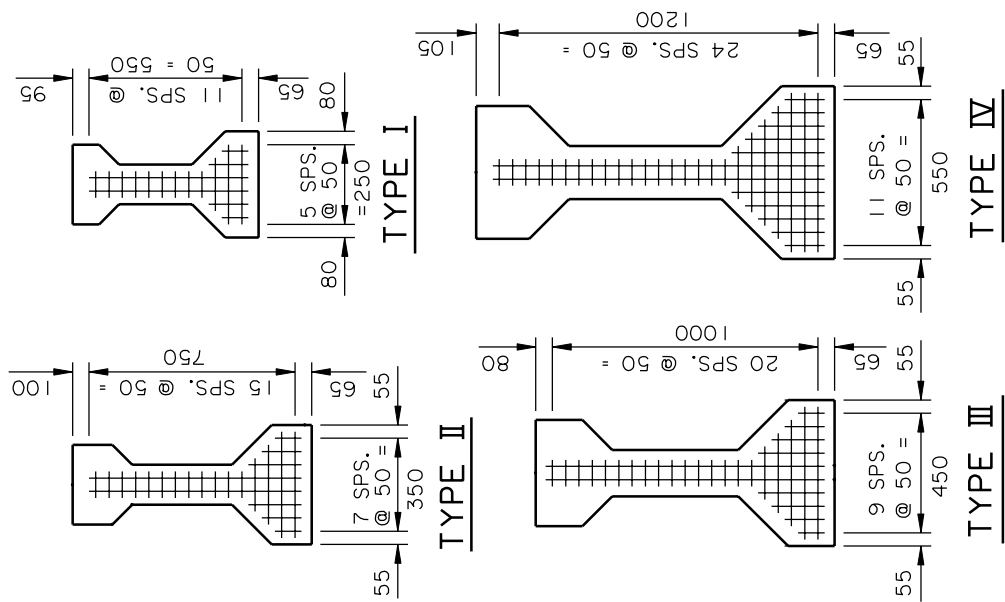
⊕ BASED ON CONCRETE DENSITY OF 2400 kg/m<sup>3</sup>

\* THIS DIMENSION MAY BE ADJUSTED TO CLEAR DRAPED STRANDS WHEN NECESSARY.  
THIS DIMENSION IS TYPICAL FOR ALL GIRDERS REGARDLESS OF ROADWAY CROWN.

⊗ INTERIOR GIRDERS ONLY

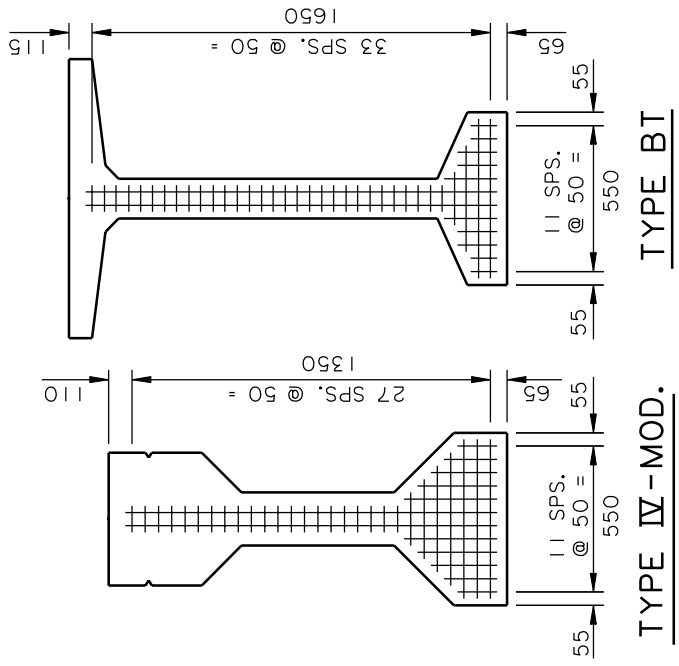
### DIMENSIONS AND PROPERTIES

## PRESTRESSED GIRDERS



**NOTE:**

STRANDS ARE LOCATED ON A GRID  
 50 mm BY 50 mm STARTING 65 mm  
 FROM THE BOTTOM FOR ALL GIRDERS.



STRAND PATTERN TEMPLATES

**PRESTRESSED GIRDERS**

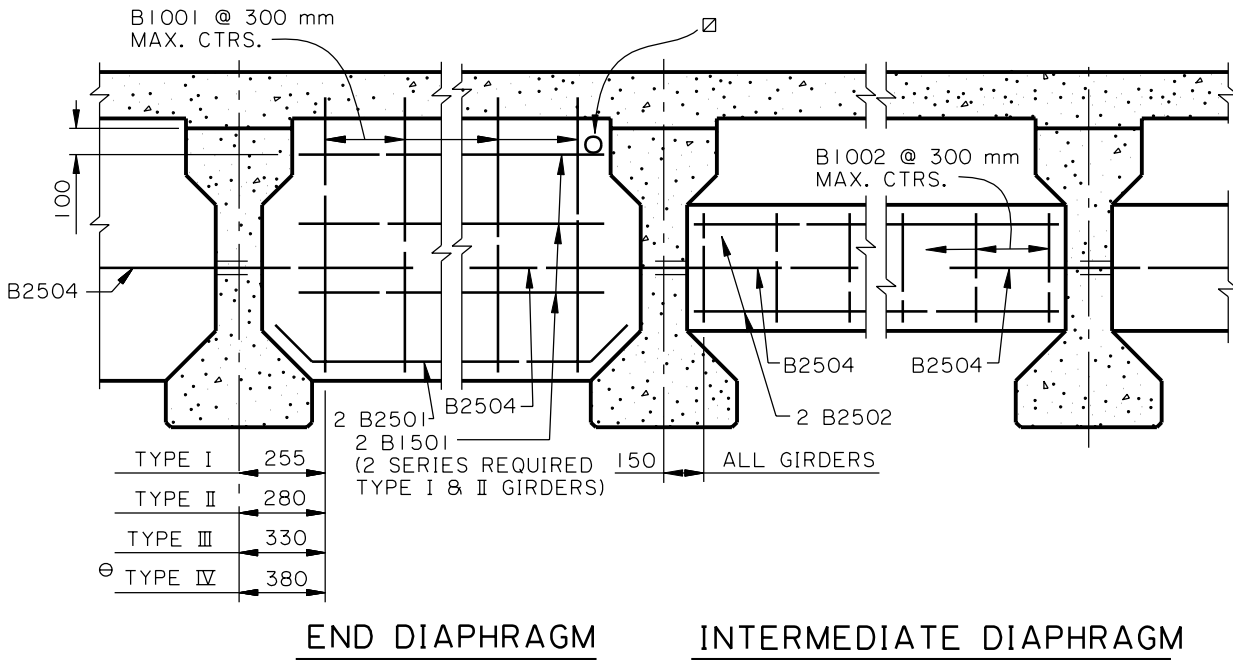
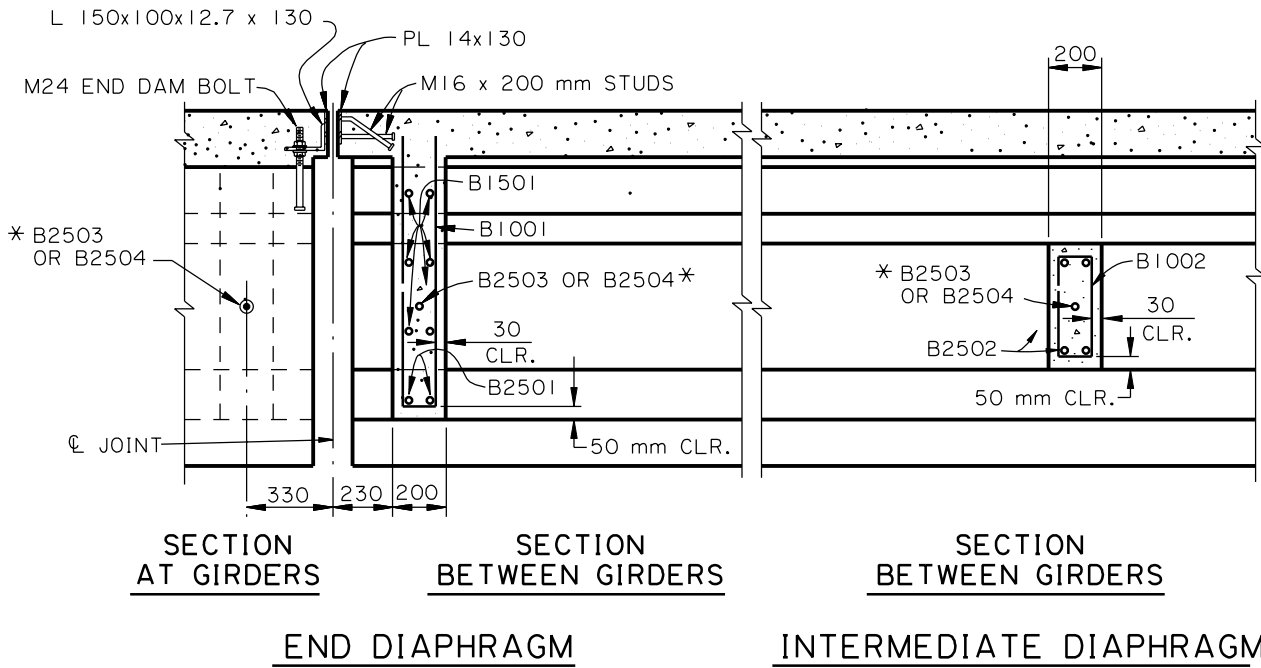
Strand Properties Table

ASTM DESIGNATION A 416 UNCOATED 7-WIRE STRANDS FOR PRESTRESSED GIRDERS								
Strand Size (Dia)	Strand Grade (MPa)	Breaking Strength (kN)	Nominal Area (mm <sup>2</sup> )	Weight (kg/1000 m)	Initial Load (kN) ⊙	Load @ 1% Extension (kN)	Initial Tension (70% Breaking Strength) (kN)	Initial Tension (75% Breaking Strength) (kN)
9.5 mm	1725	89.0	51.61	405	8.9	75.6	62.3	-----
	1860 S.R.	102.3	54.84	432	8.9	87.0	71.6	-----
	1860 L.R.	102.3	54.84	432	8.9	92.1	-----	76.7
11.1 mm	1725	120.1	69.68	548	12.0	102.3	84.1	-----
	1860 S.R.	137.9	74.19	582	13.8	117.2	96.5	-----
	1860 L.R.	137.9	74.19	582	13.8	124.1	-----	103.4
12.7 mm	1725	160.1	92.90	730	16.0	136.2	112.1	-----
	1860 S.R.	183.7	98.71	775	18.4	156.1	128.6	-----
	1860 L.R.	183.7	98.71	775	18.4	165.3	-----	137.8

S.R. DENOTES STRESS-RELIEVED.  
L.R. DENOTES LOW-RELAXATION.

⊙ INITIAL TENSION PRIOR TO RELEASE OF STRANDS.

\*B2503 (EXTERIOR GIRDERS ONLY)  
ONE END THREADED 75 mm



**NOTES:**

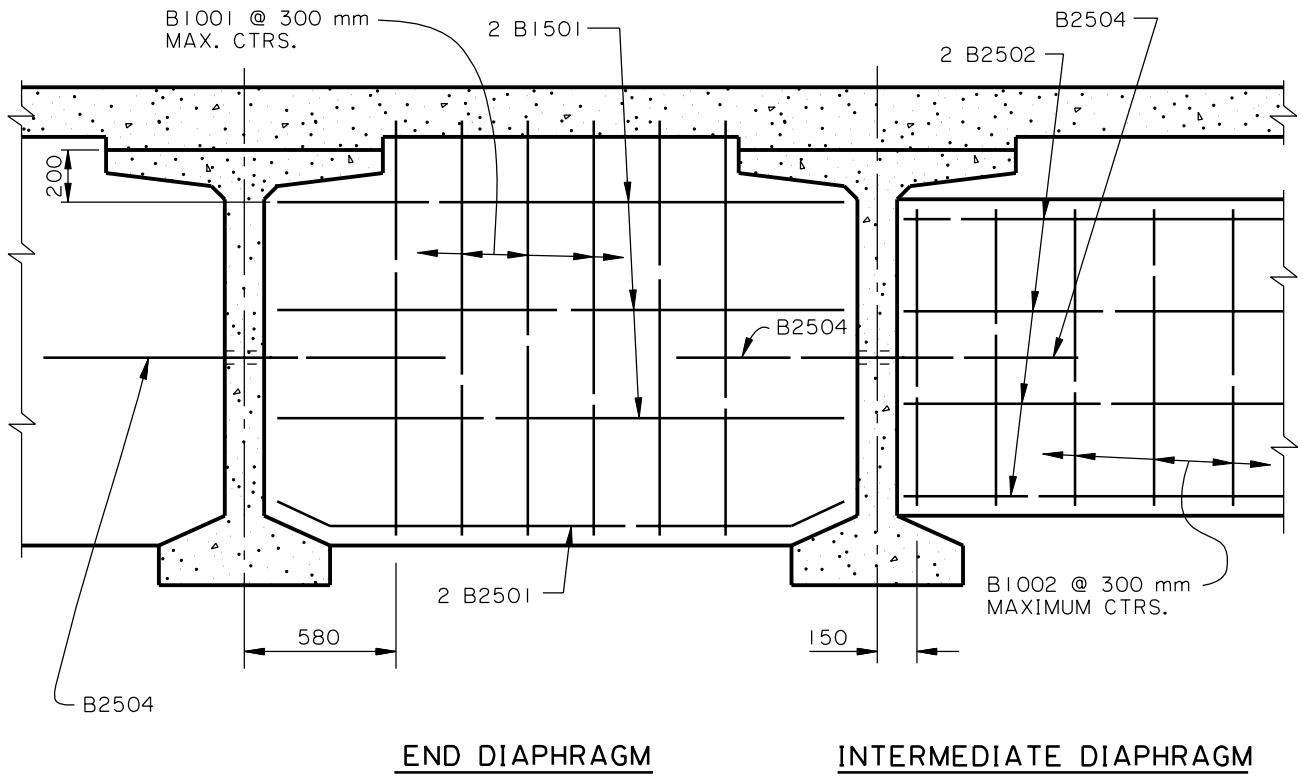
SPANS >15 m REQUIRE ONE INTERMEDIATE DIAPHRAGM.  
SPANS >30 m REQUIRE TWO INTERMEDIATE DIAPHRAGMS.

⊠ 75 mm  $\phi$  VENT HOLE IN EACH END DIAPHRAGM WHERE INUNDATION BY FLOOD IS POSSIBLE.

⊖ INCLUDES TYPE IV-MODIFIED

TYPE I-IV (END & INTERMEDIATE DIAPHRAGMS)

DIAPHRAGM DETAILS



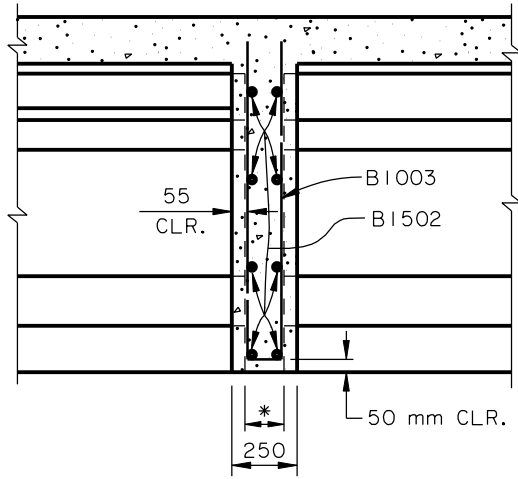
**TYPICAL DIAPHRAGM DETAILS**  
(TYPE BT)

**NOTE:**  
DETAILS NOT SHOWN ARE SIMILAR TO  
DETAILS SHOWN ON SHEET 1 OF 8.

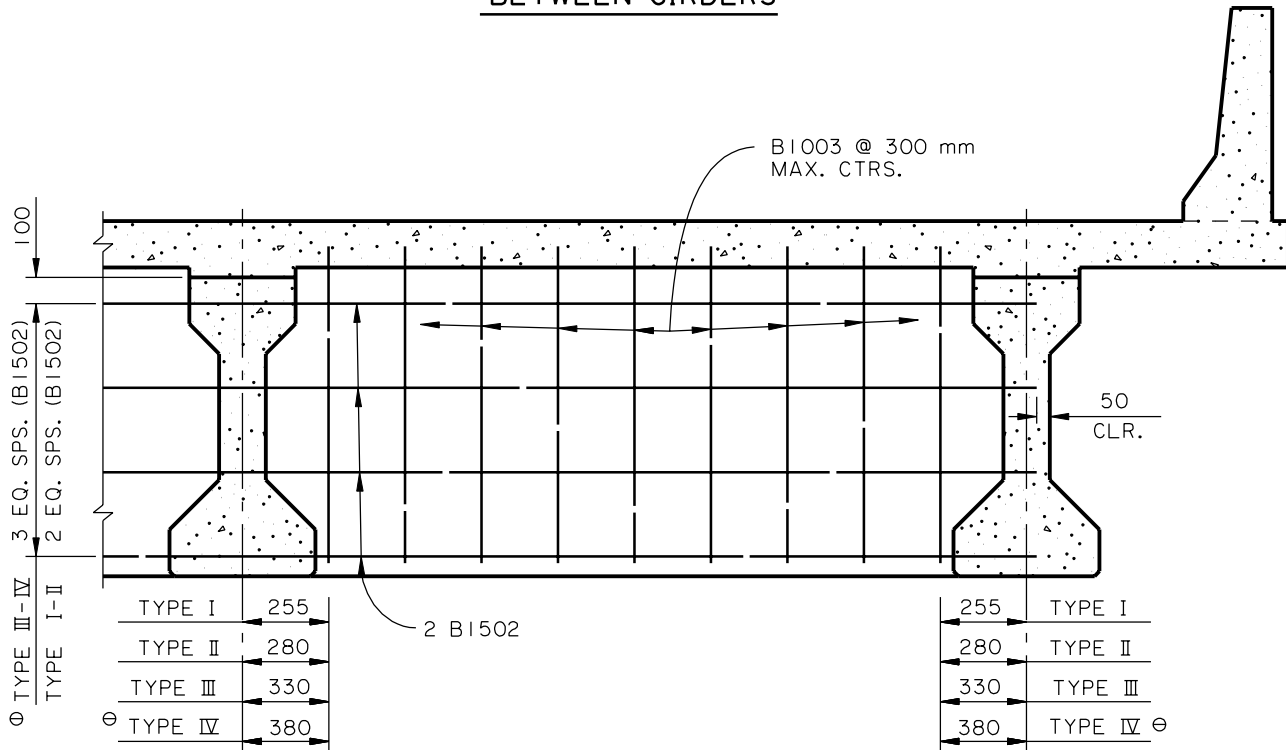
TYPE BT (END & INTERMEDIATE DIAPHRAGMS)

**DIAPHRAGM DETAILS**

\* 150 mm BETWEEN GIRDER ENDS



**SECTION  
BETWEEN GIRDERS**



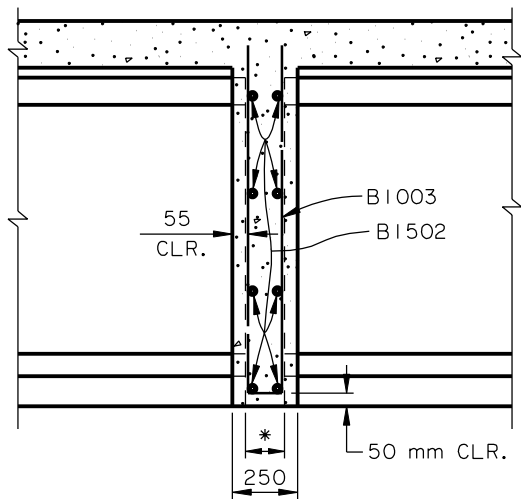
⊖ INCLUDES TYPE IV-MODIFIED

**CONTINUITY DIAPHRAGM**

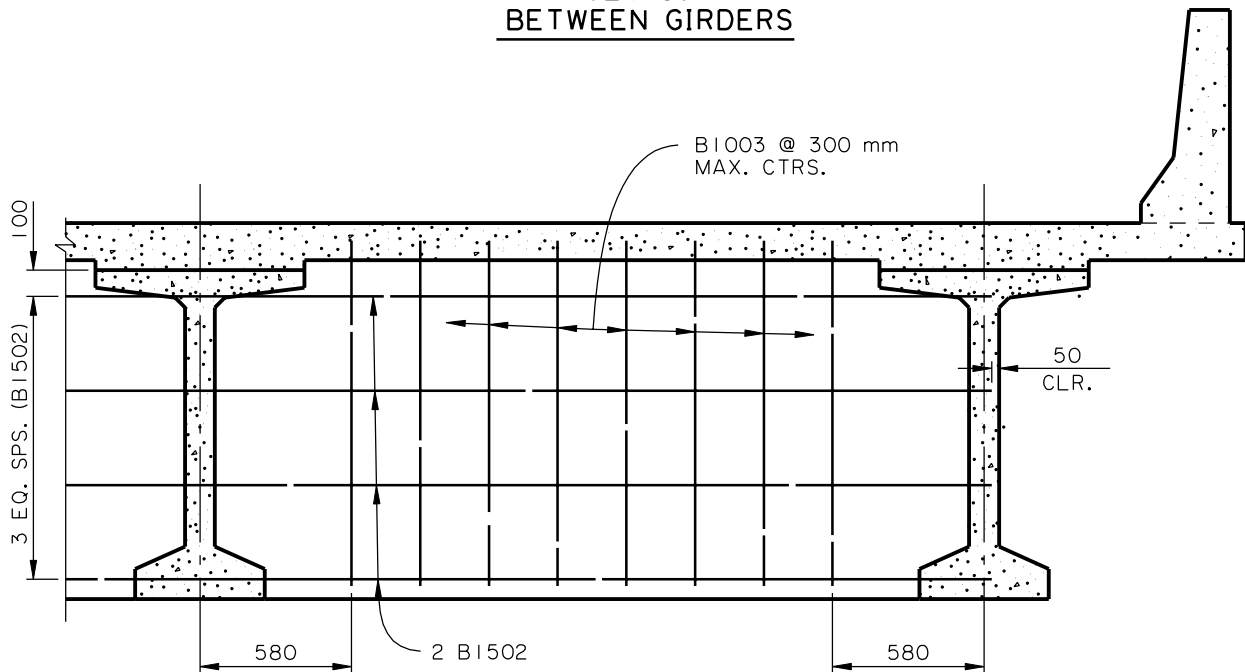
TYPE I-IV (CONTINUITY DIAPHRAGMS)

DIAPHRAGM DETAILS

\* 150 mm BETWEEN GIRDER ENDS



SECTION  
BETWEEN GIRDERS



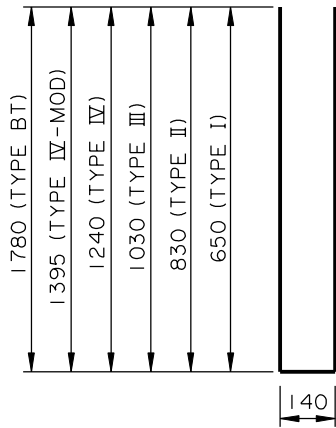
CONTINUITY DIAPHRAGM  
(TYPE BT)

TYPE BT (CONTINUITY DIAPHRAGMS)

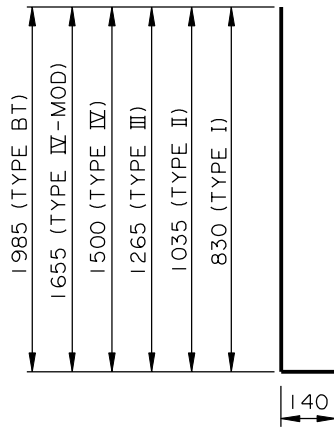
**DIAPHRAGM DETAILS**



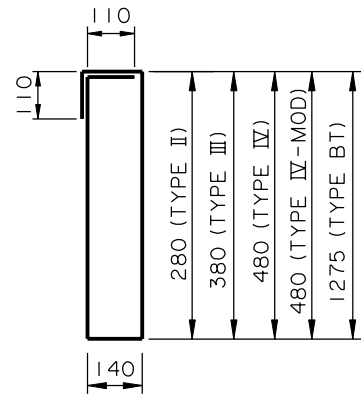
TOTAL LENGTH OF BARS						
BAR	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE IV-MOD.	TYPE BT
B1001	1440	1800	2200	2620	2930	3700
B1002	N/A	1060	1260	1460	1460	3050
B1003	1800	2210	2670	3140	3450	4110
B1501	"Z"	"Z"	"Z"	"Z"	"Z"	"Y"
B2501	"X"+220	"X"+280	"X"+380	"X"+500	"X"+500	"X"+440
B2502	"Y"	"Y"	"Y"	"Y"	"Y"	"Y"
B2503	960	960	960	960	960	960
B2504	1980	1980	1980	1980	1980	1980



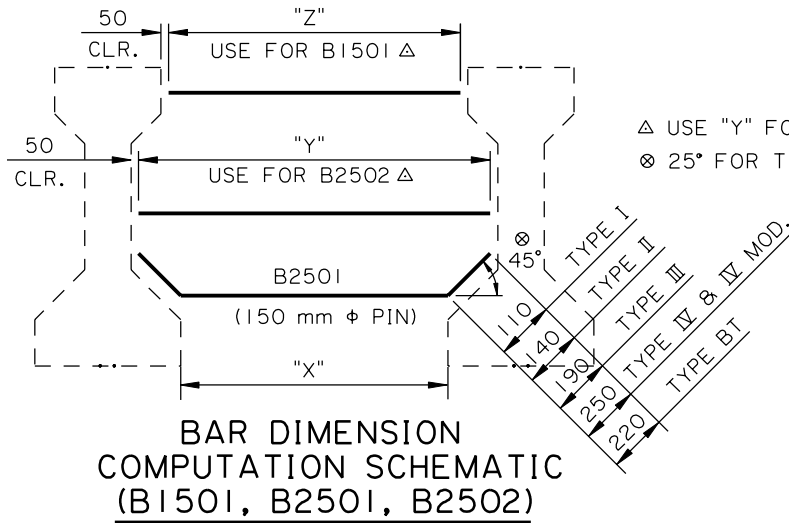
**B1001**  
(45 mm  $\phi$  PIN)



**B1003**  
(45 mm  $\phi$  PIN)

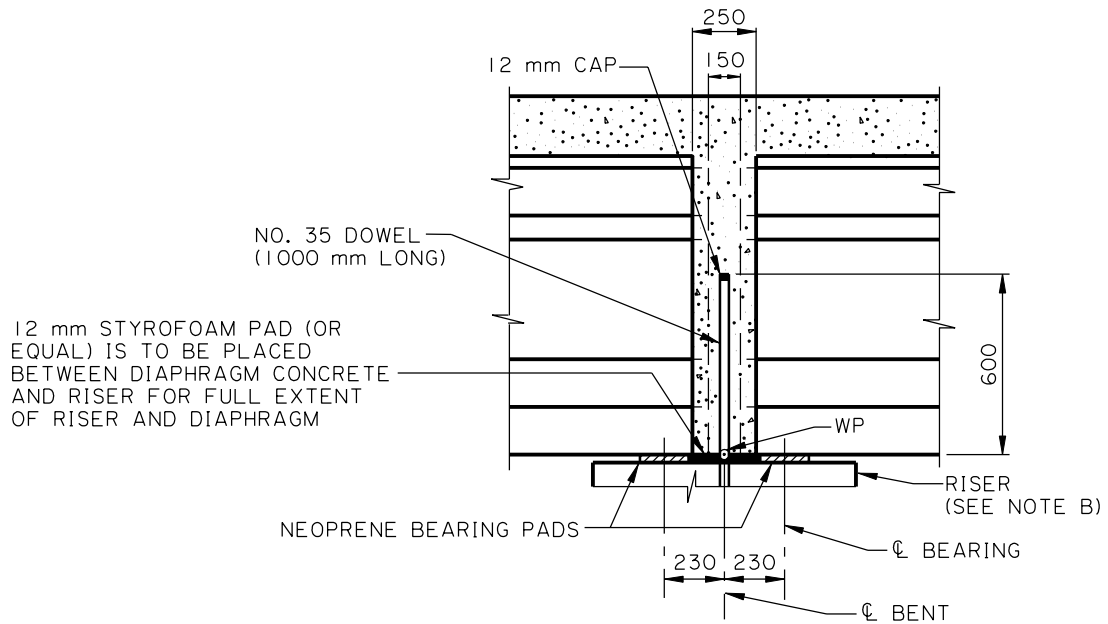


**B1002**  
(45 mm  $\phi$  PIN)



TYPE I-IV AND BT (REINFORCING STEEL)

**DIAPHRAGM DETAILS**



## CONNECTION DETAIL AT CONTINUITY DIAPHRAGM

### NOTE A

DOWELS IN THE CAP SHALL BE GALVANIZED NO. 35 DEFORMED REINFORCING STEEL. PRIOR TO POURING THE CONTINUITY DIAPHRAGM, EACH DOWEL SHALL BE SHEATHED BY 45 mm I.D. RIGID SLEEVE WITH A 12 mm THICK COMPRESSIBLE CAP ABOVE THE TOP OF THE DOWEL TO ALLOW THE GIRDERS TO DEFLECT ON THEIR BEARING PADS UNDER FUTURE LOADS.

TO FACILITATE PLACEMENT OF GIRDERS, THE CONTRACTOR MAY SET THE NO. 35 DOWELS BY ONE OF THE FOLLOWING METHODS:

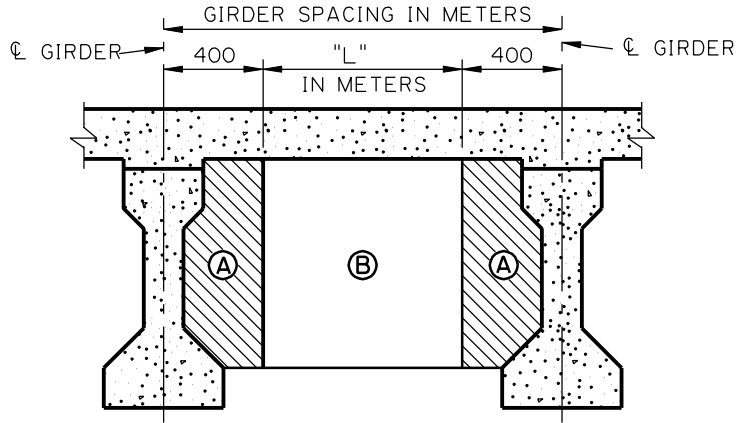
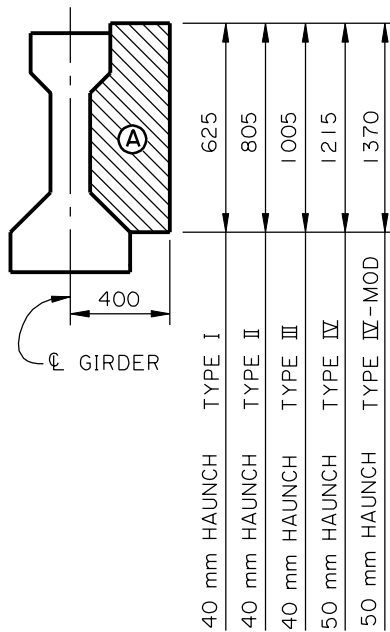
- 1) SETTING DOWELS IN APPROVED NON-SHRINK GROUT IN PREFORMED HOLES HAVING A MINIMUM DIAMETER OF 75 mm.
- 2) SETTING DOWELS AT INITIAL CASTING OF CAP.

### NOTE B

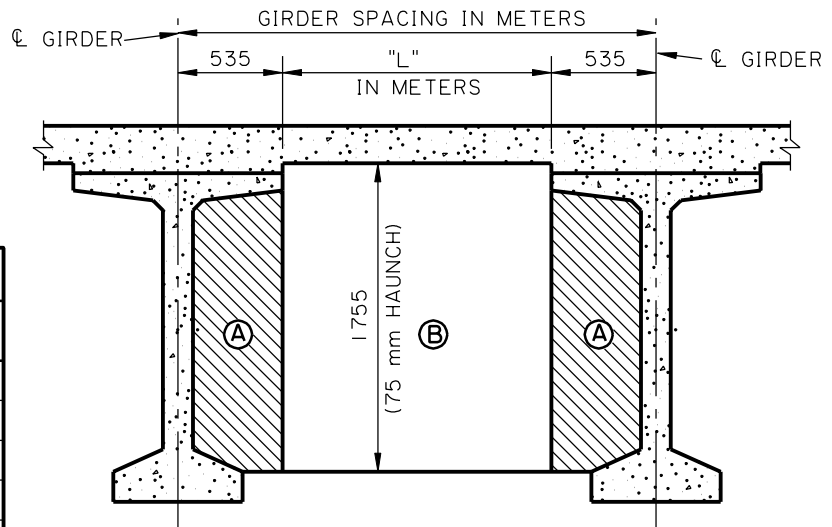
RISERS AT FIXED BENTS SHALL BE SLOPED TO APPROXIMATE TANGENT GRADE AT CL BENT. ELEVATIONS SHOWN FOR THESE RISERS ARE AT CL BENT.

CONNECTION DETAIL AT CONTINUITY DIAPHRAGM

## DIAPHRAGM DETAILS



**TYPICAL END DIAPHRAGM**  
(EXCEPT TYPE BT)



**TYPICAL END DIAPHRAGM**  
(TYPE BT)

CONCRETE VOLUMES		
BEAM TYPE	VOLUME (A) m <sup>3</sup>	VOLUME (B) m <sup>3</sup>
I	0.0363	0.125 x "L"
II	0.0464	0.161 x "L"
III	0.0523	0.201 x "L"
IV	0.0575	0.243 x "L"
IV-MOD.	0.0620	0.274 x "L"
BT	0.1405	0.351 x "L"

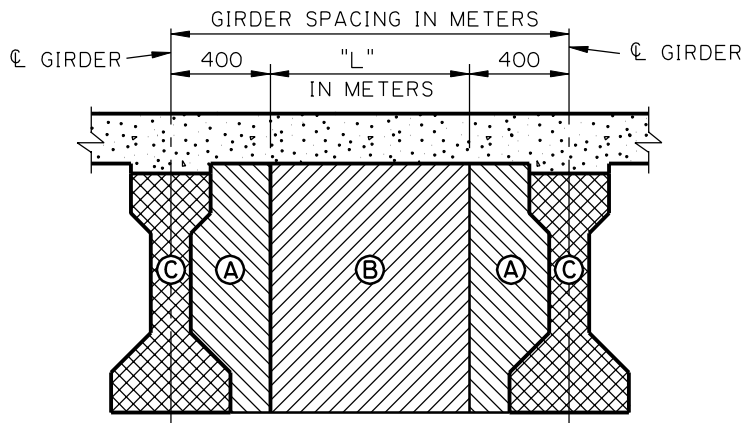
TOTAL VOLUME = 2 (A) + (B)

**NOTE:**

ALL DIMENSIONS AND QUANTITIES ARE FOR 90° CROSSINGS.

TYPE I-IV AND BT (CONCRETE COMPUTATIONS)

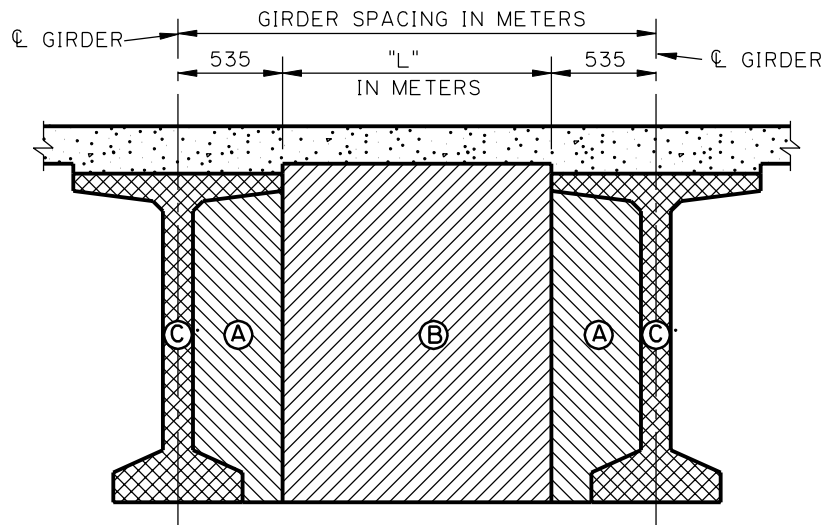
**DIAPHRAGM DETAILS**



**TYPICAL CONTINUITY DIAPHRAGM**  
(EXCEPT TYPE BT)

CONCRETE VOLUMES			
BEAM TYPE	VOLUME (A) m <sup>3</sup>	VOLUME (B) m <sup>3</sup>	VOLUME (C) m <sup>3</sup>
I	0.0514	0.1875 x "L"	0.0265
II	0.0644	0.2388 x "L"	0.0355
III	0.0708	0.2963 x "L"	0.0548
IV	0.0754	0.3550 x "L"	0.0761
IV-MOD.	0.0810	0.3938 x "L"	0.0879
BT	0.1834	0.4763 x "L"	0.0737

TOTAL VOLUME AT BENT = (2(A) + (B)) \* NO. OF BAYS + ((C) \* NO. OF GIRDERS)



**TYPICAL CONTINUITY DIAPHRAGM**  
(TYPE BT)

TYPE I-IV AND BT (CONCRETE COMPUTATIONS)

**DIAPHRAGM DETAILS**

## GENERAL GUIDELINES FOR STEEL SPANS

### ANALYSIS

1. Load factor design shall generally be used except when horizontally curved girders are involved.
2. Horizontally curved girders will be designed in accordance with the latest edition and interim of the "AASHTO Guide Specifications for Horizontally Curved Highway Bridges". Where diaphragms are connected to the bottom flange, they shall be bolted only. Cross frames will be primary members. A note shall be placed in the plans referencing the additional camber requirements for heat curving as noted in the supplemental specifications.
3. When less than **three (3)** longitudinal girders (plate or box girders) are used in a structure, the members shall be designated as fracture critical. The portions of the girder to be designated as fracture critical are the top and bottom flanges in tension and webs. Also, the longitudinal stiffeners, gusset plates and all connections welded longitudinally to the web in the tension area of the web are considered fracture critical. The limits of all fracture critical plates shall be designated on the plans.
4. In general, simple and continuous steel spans shall be designed for composite action. The exception would be in a main girder-floor beam-stringer system when the stringers are non-composite because of incompatibility with main girder.
5. Continuous girders designed as composite will generally be assumed non-composite in the negative moment regions, i.e., the reinforcing steel will not be assumed to act composite with the girder. No shear connectors will be placed in these regions; however, the **1%** minimum longitudinal reinforcing requirements of the 1996 LFD AASHTO Specifications sub sections 10.38.4.3 and 10.50.2.3 are still applicable.
6. A **600 N/m<sup>2</sup>** dead load will be assumed for a future wearing course to be placed on the composite section.
7. Although different classes of steel have been used in steel girders (a typical hybrid would use higher strength steel in the flanges than in the web) for economy in the past, we have been moving away from this practice due to steel pricing and design considerations. Hybrid girders should be used only with the approval of the Bridge Design Engineer.
8. For projects that are designed for HST truck loading, it shall not be used for fatigue computations.

9. The curb and railing dead load will be placed on the composite section of the exterior girder only.
10. The steel section of exterior girders shall have at least the same structural capacity as the interior girders for future widening purposes.
11. For the design of friction type connections surface condition "A", (clean mill scale) will be assumed.
12. Structural steel may be A 709 Grades 250, 345 or 345W. Gusset plates, stiffeners, bracing and other secondary members are generally designed using Grade 250.

## DETAILING

1. The haunch shall be set so there is no encroachment by cover splice plates and their connectors into the deck.
2. Cantilevered deck slabs shall have their bottom surface aligned with the bottom of the girder flange.
3. The flange widths shall preferably be specified in multiples of **50 mm**. Flange thickness will be specified in multiples of **5 mm** for  $t < 60 \text{ mm}$  and **10 mm** multiples for  $t \geq 60 \text{ mm}$ .
4. The web plate heights shall be specified in multiples of **50 mm**. Web thickness will be designed as follows:

$$\begin{array}{ll}
 10 \text{ mm} \leq t \leq 22 \text{ mm} & 2 \text{ mm increments from } 10 \text{ mm} \\
 t > 22 \text{ mm} & 5 \text{ mm increments from } 25 \text{ mm}
 \end{array}$$

5. The location of "permissible welded shop splices" in girder web and flange plates shall be shown on the girder sheets. Generally, the limit of plate lengths without splices is **15 m**.
6. Full penetration groove welded connections at transitions in thickness or in width shall have slopes no steeper than 1 to 5.
7. When applicable, the following note shall be added to the plans:

THE CONTRACTOR MAY PROPOSE ALTERNATE SPLICE LOCATIONS FROM THOSE SHOWN IN THE PLANS, OR BOLTED FIELD SPLICES IN LIEU OF WELDED SPLICES, ALL AT NO ADDITIONAL COST TO THE DEPARTMENT AND SUBJECT TO THE APPROVAL OF THE ENGINEER PRIOR TO INCLUSION IN THE SHOP DRAWINGS.

8. Field splice locations are generally in low moment areas or where a section change is planned. Member lengths  $\leq 35$  m or weigh  $\leq 40\ 000$  kg are two approximate maximums for pieces that can be handled efficiently either in the shop or at the site. When the girder is erected over a road open to traffic, consider locating the field splice outside of the traveled lane to minimize disruption of traffic.
9. A minimum plate thickness of **10 mm** shall govern for both primary and secondary structural members. Unstiffened webs are generally more economical for webs approximately **1250 mm** deep or less; above that, consider a partially stiffened web.
10. When required, transverse stiffeners shall generally be placed on one (1) side of the web except at cross-frames, and shall be preferably on the inside of exterior girders normal to flanges.
11. The longitudinal stiffener shall normally be placed on the opposite side of the web from transverse stiffeners, and cut  **$4t_w$  to  $6t_w$  (50 mm)** short of any transverse stiffeners it would intersect with.
12. Special attention must be paid to welding details to avoid critical fatigue condition. For longitudinal stiffeners, fillet weld in the compression zone, but bolting may be required in the transition compression-tension zone.
13. Transverse stiffeners shall be cut  **$4t_w$  to  $6t_w$**  short of the tension flange, and seal welded to the compression flange. In areas where both flanges are subject to tension stress, welding to both flanges will generally be acceptable if the appropriate fatigue category is used in the design of the flange. Stiffeners at cross-frames and floorbeams shall be full depth and fillet welded to both the top and bottom flange, and the proper fatigue category shall be used.
14. Bearing stiffeners shall be groove welded or milled to bear and fillet welded, and shall be seal welded on the top. They shall be set vertical over the bearing device.
15. For structural steel welding, the minimum weld sizes shall be in accordance with the AWS Specifications. All items relating to welding shall be in accordance with the latest ANSI/AASHTO/AWS Bridge Welding Code.

16. The following information shall be included for steel spans:
  - a) Moments, shears, and reactions values should be provided at critical points for each loading stage.
  - b) The vertical curve ordinates, dead load deflections for the various load stages, and cambers should be shown either on a diagram or in tabular form.
  - c) Cambers for composite girders shall take into account creep by calculating long term deflection based on 3n section properties.
  - d) The above deflection information shall be shown at the span  $1/10$  points for continuous spans and  $1/4$  points for simple spans.
17. In general, bolted connections shall be made with **ASTM A 325M** bolts. **ASTM A 490M** bolts will not be used.
18. Shear connectors shall normally include an alternate for both **19 mm** and **22 mm** diameter studs, and the height shall be such that there is a minimum of **50 mm** penetration in the slab.
19. On long girders, deflections cause excessive longitudinal movements at the bottom of the girder ends. The designer must account for these movements when designing the girder bearings.
20. Seismic loading must be accounted for. Since Louisiana has an acceleration coefficient of **4.0%** and both importance classification result in a seismic performance category equal to "A", minimum analysis is required. Structures must meet minimum seat width and the connection requirements between the superstructure and substructure.
21. Inspection Details: All projects involving steel spans with more than **9 m** of vertical clearance above the ground shall provide details for inspection access. For grade separation structures with web depths  $\geq$  **1800 mm** this will normally consist of a Class A galvanized wire rope **12.7 mm** in diameter (1 x 7 with breaking strength  $\geq$ 111 kN) run through holes in the transverse stiffeners or clip angles and fastened at each span end. Wire ropes shall be located on both sides of the interior girders webs and the inside of the exterior girders. The rope should be placed about 1.2 m from the bottom flange. On major river crossings, inspection cables will be required on both sides of all girders on the main spans. More elaborate details will be required and will be handled on an individual basis. Minimum items to provide would include an enclosed access ladder at every pier and a walkway along the face of the cap.



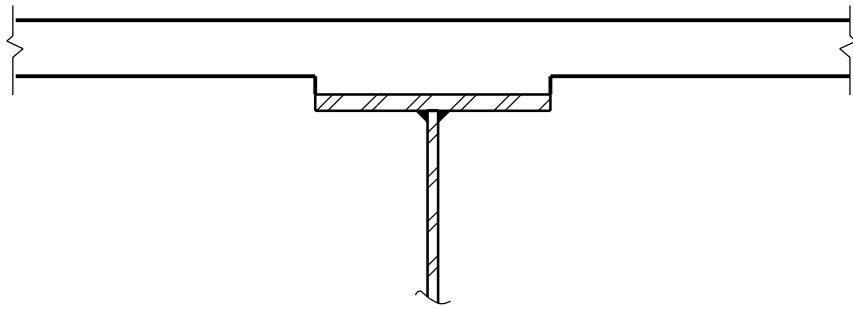
22. Shop Assembly of Structural Steel: All construction plans for bridges involving structural steel shall have a general note as follows: "Shop assembly shall be by the Progressive Truss or Girder Assembly Method in accordance with Subsection 807.18 except that for structures less than **50 m** long or less than four contiguous panels, assembly shall be by the Full Truss or Girder Assembly Method.
23. Tack welds, which are not remelted, by welding required on design drawings, will not be allowed.
24. Stress relieving may be necessary for those applications where weldments must retain dimensional stability during machining (such as bearings). Contract drawings or specifications shall indicate welded assemblies to be stress-relieved by heat-treating. Finish machining shall be done after stress relieving<sup>5</sup>.
25. All main load carrying steel members require Charpy V-Notch Impact Test (CVN), as per 1013.01 of the Standard Specifications. In order to comply with this requirement, the plans are to show the location and length of those members or portions of members subject to tension and which require CVN testing. Fracture critical members are a more critical subset of load carrying members. See the FCM section later in this chapter.
26. Use lateral bracing only if required.
27. The end of the girder and the bearing stiffeners shall be vertical. Intermediate transverse web stiffeners may be either all normal to flange or all vertical.
28. A pouring sequence will be shown dividing the deck into segments which minimizes deck cracking by allowing construction joints near contraflexure points and by loading positive moment areas first. Each pour must be completed in 4 hours with a maximum rate of 45 m<sup>3</sup> per hour. (Unless a higher rate is approved by the Bridge Design Engineer for special cases.)
29. The camber diagram shall include a note, which states: Cambers shown are for pouring sequence shown. If the contractor wishes to use a different sequence which meets the requirements of minimizing deck cracking and 4 hour set times, he shall submit his sequence with its associated camber diagram to the bridge design engineer for approval prior to the first shop drawing submittal.
30. Unless otherwise specified, an approved three-coat waterborne paint system shall be used for coating all new metal surfaces requiring painting. See special provisions, such as E-85 (9/94 p. 494) from the contracts section and QPL 68 for further information.

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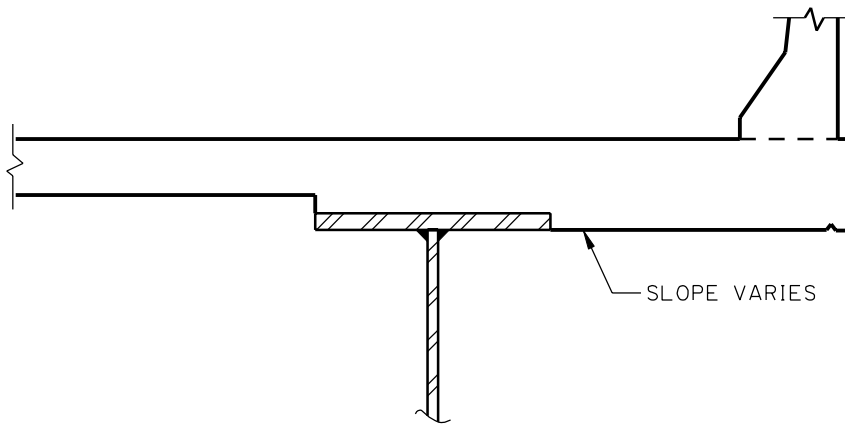
<sup>5</sup> see 1988 AWS D 1.5, section 4.4

31. Swing Spans are not considered to be fracture critical by the bridge design section. Load case II for swing spans shall use temperature difference between top and bottom chords of **15°C** and a short span uplift equal to **25 mm**. *Dead load plus impact* shall be added to case II worst wedge reaction for total case II design loads.
32. All bolting for structural steel bridge members shall utilize Direct Tension Indicator (DTI) washers during installation. When DTI s are used, the bolts are tightened until the bolt tension collapses the washer protrusions to the specified 127 µm. gap. This will ensure proper bolt tension. Inspection is accomplished by means of a 127 µm. Feeler gage inserted to the washer gap.

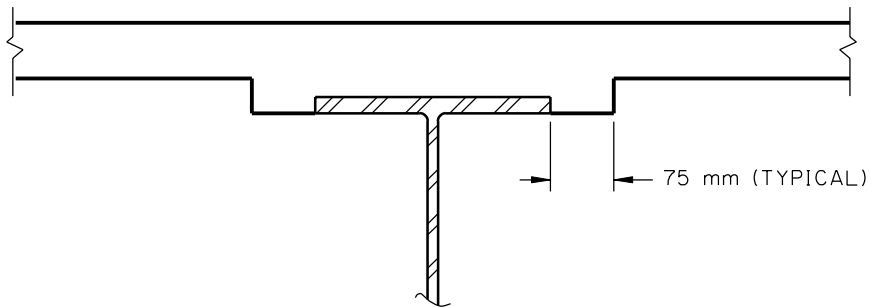
The DTIs will always be galvanized with the additional requirement that for use on unpainted weathering steel, DTI shall be epoxy coated to prevent accelerated sacrificial galvanized coating loss.



INTERIOR PLATE GIRDER (COMPOSITE DESIGN)

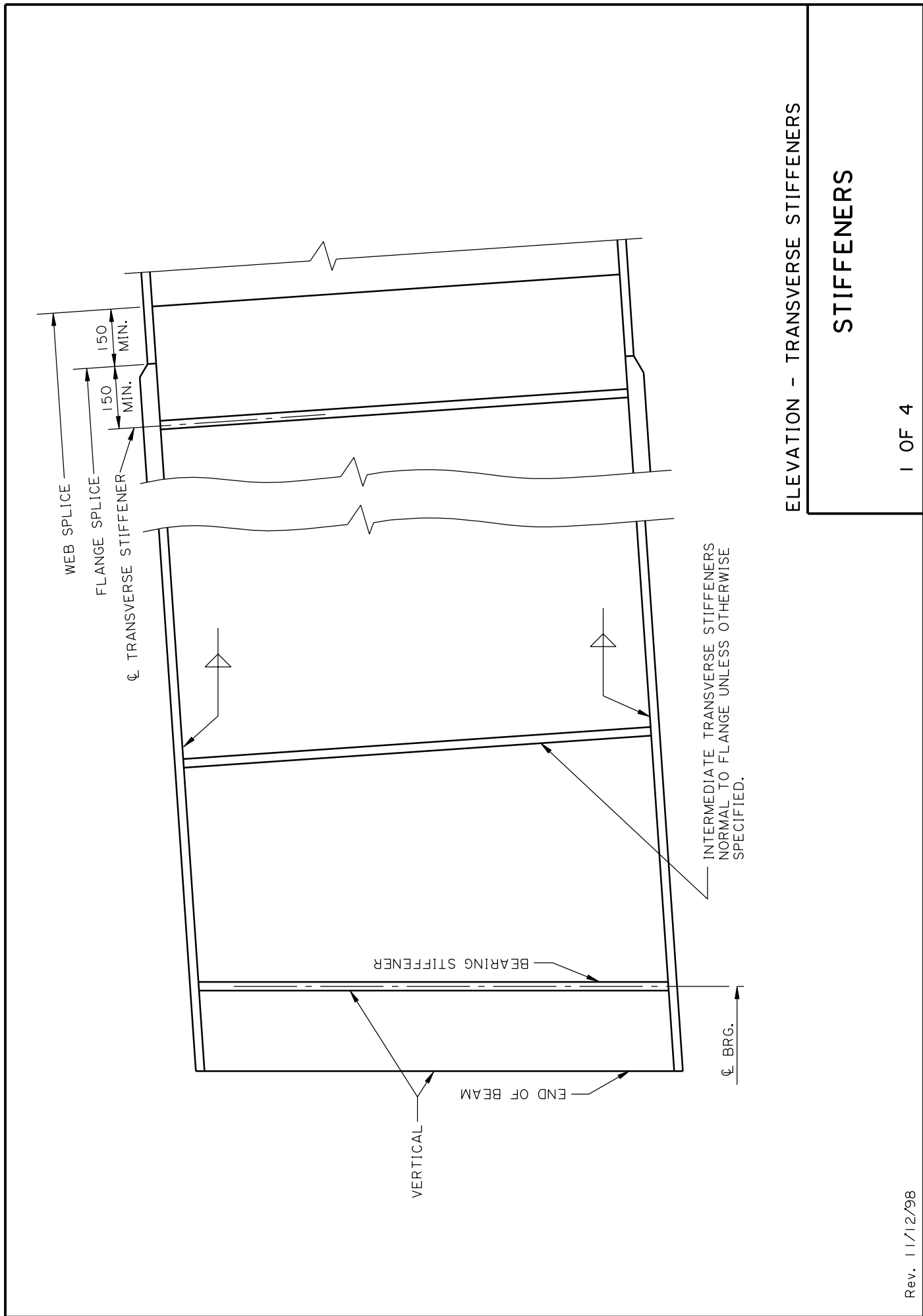


EXTERIOR PLATE GIRDER (COMPOSITE DESIGN)



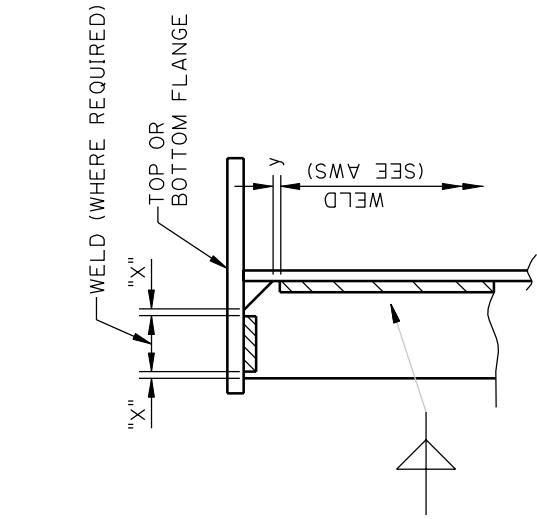
INTERIOR STRINGER (NON-COMPOSITE)

TREATMENT OF SLAB AND HAUNCH  
ON STEEL GIRDER STRUCTURES

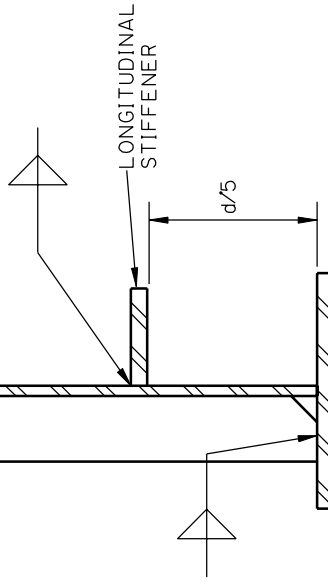
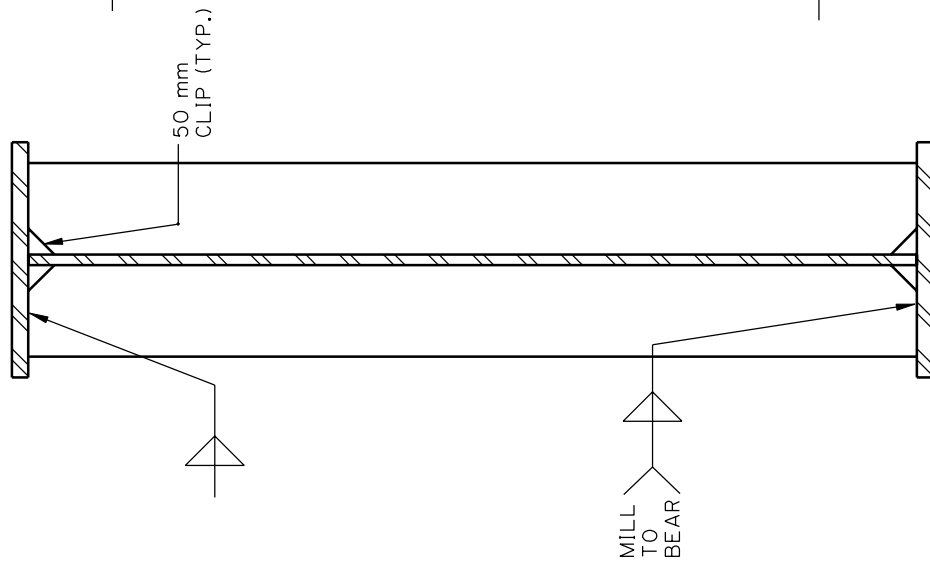
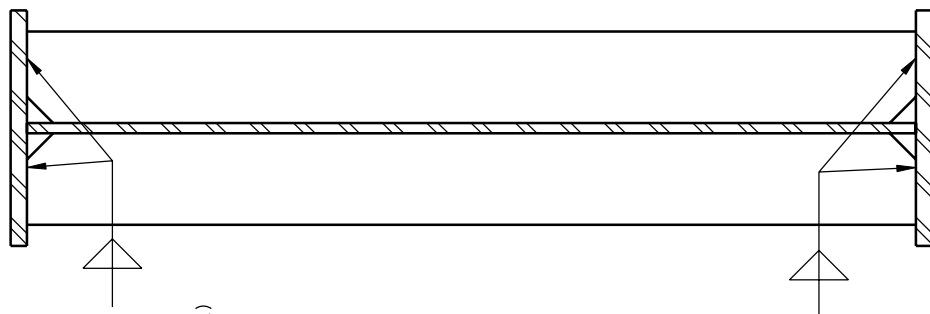
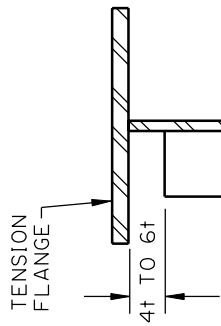


ELEVATION - TRANSVERSE STIFFENERS

STIFFENERS



TYPICAL WELDING DETAIL



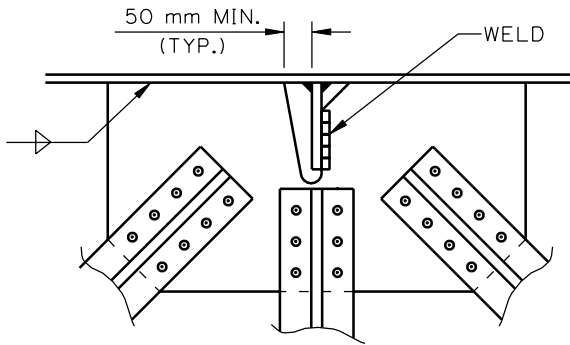
TRANSVERSE STIFFENERS

CROSS-FRAME STIFFENERS

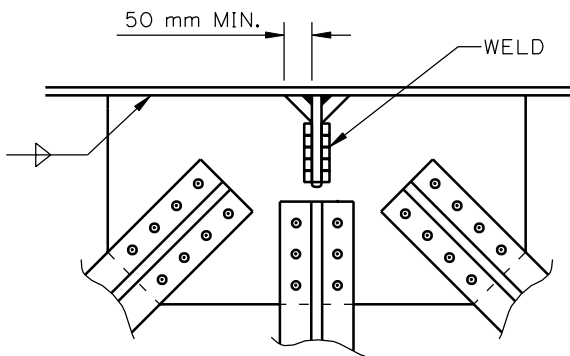
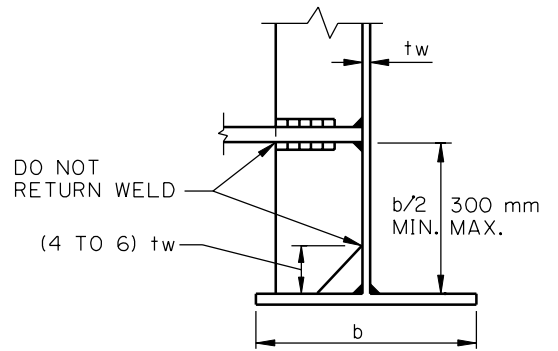
BEARING STIFFENERS

TYPICAL SECTIONS THRU GIRDER

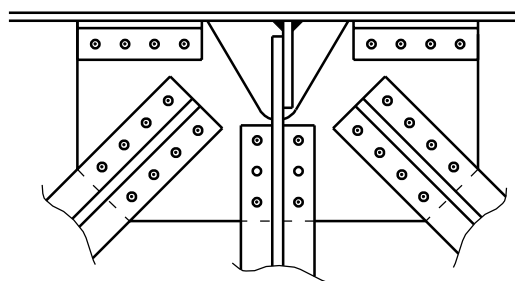
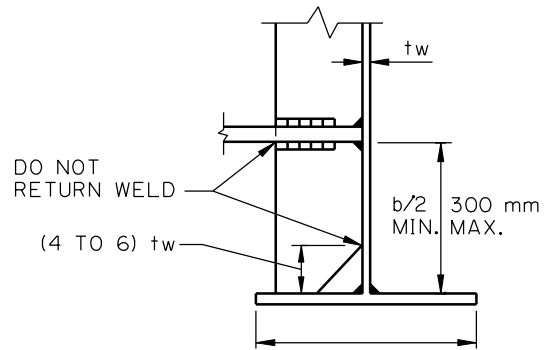
**STIFFENERS**



**LOW LATERAL  
LOAD DETAIL**

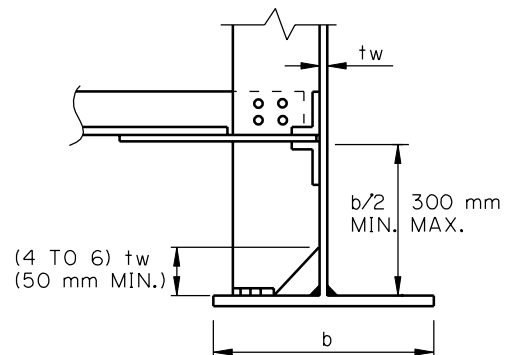


**WELDED HIGH LATERAL  
LOAD DETAIL**



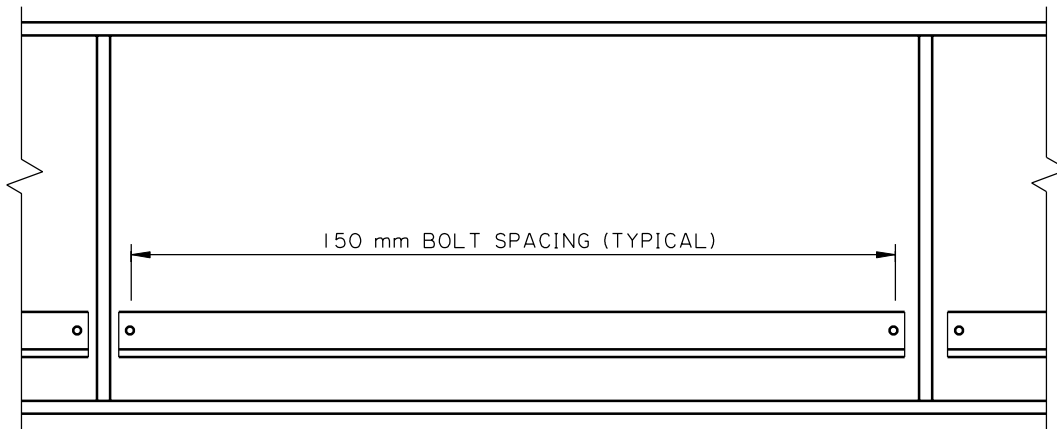
**BOLTED HIGH LATERAL  
LOAD DETAIL**

(PARTICULARLY TO BE USED WITH  
SKEWED SPANS OR CURVED GIRDERS)

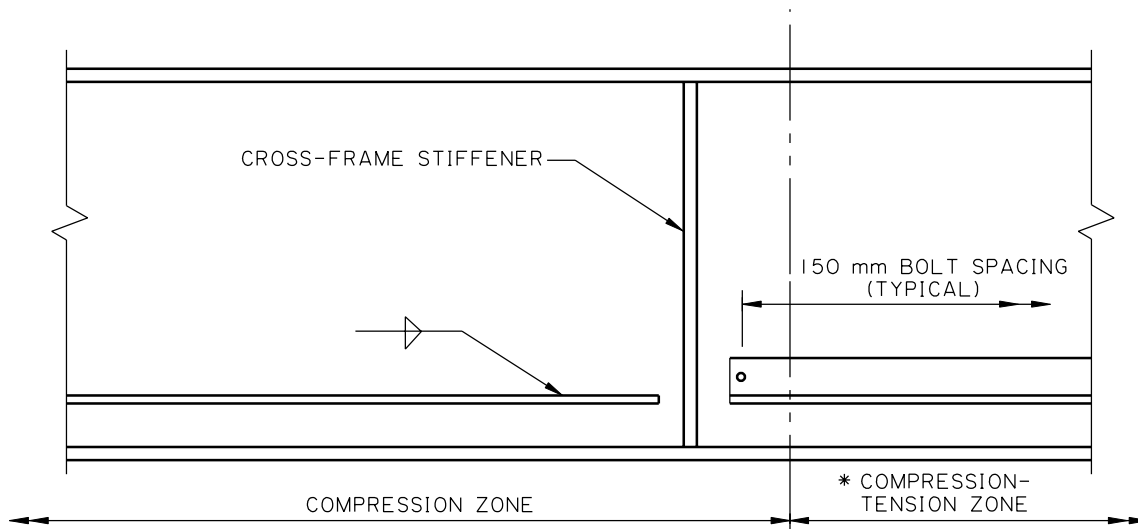


LATERAL CONNECTION PLATE

**STIFFENERS**



DETAIL SHOWING LONGITUDINAL STIFFENER IN COMPRESSION-TENSION ZONE



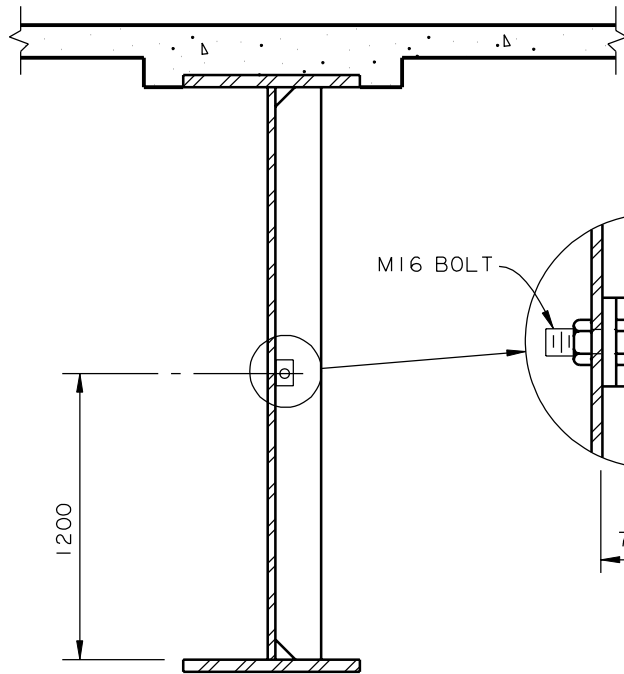
DETAIL SHOWING TRANSITION FROM WELDED TO BOLTED LONGITUDINAL STIFFENER

**NOTE:**

IF ANY PORTION OF THE LONGITUDINAL STIFFENER BETWEEN CROSS-FRAME STIFFENERS WILL BE IN TENSION, THAT SECTION SHOULD BE BOLTED.

ELEVATION - LONGITUDINAL STIFFENERS

**STIFFENERS**



**NOTE:**

INSPECTION HANDRAIL IS REQUIRED ON BOTH SIDES OF INTERIOR BAYS. DO NOT USE ON EXPOSED SIDE OF EXTERIOR GIRDERS.

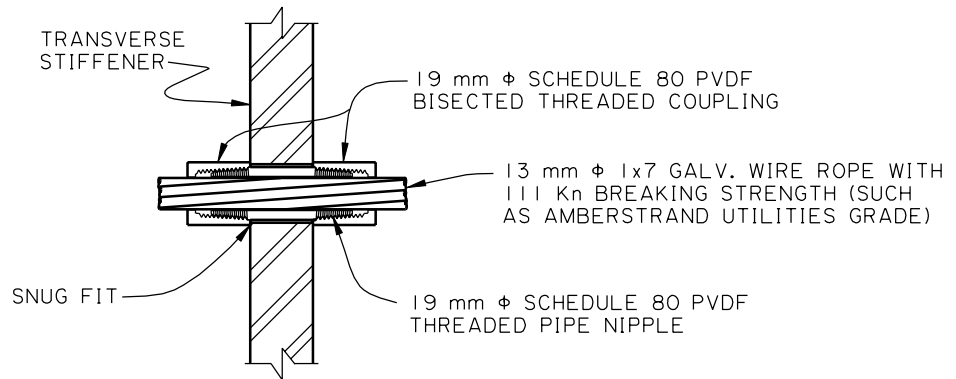
M16 BOLT

27 mm  $\phi$  HOLE FOR PVDF NIPPLE AND 13 mm  $\phi$  GALVANIZED WIRE ROPE

L 127x89x9.5 x 100 mm PLACED BETWEEN STIFFENERS EXCEEDING 2500 mm SPACING

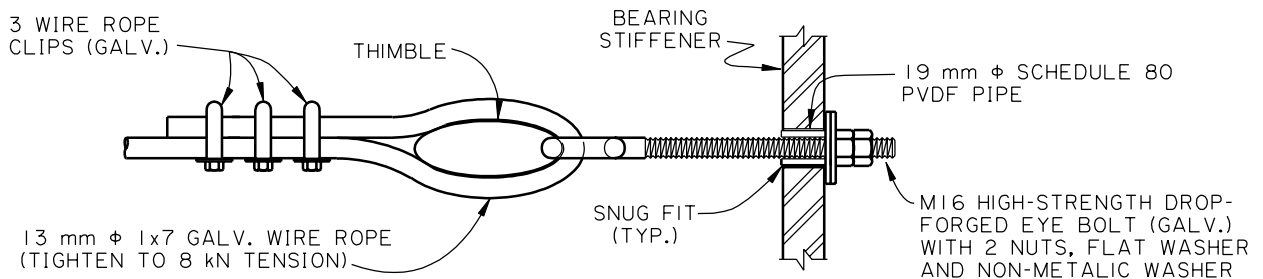
**TYPICAL GIRDER SECTION**

(SHOWING WIRE ROPE LOCATION)



**DETAIL OF SAFETY CABLE BUSHING**

(SHOWING WIRE ROPE PASSING THROUGH STIFFENER)



**DETAIL OF SAFETY CABLE TERMINATION**

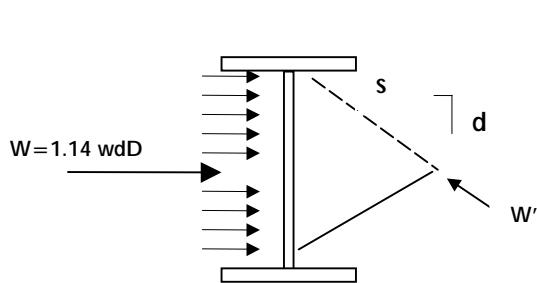
(OPPOSITE END MAY UTILIZE PIN ANCHOR SOCKET)

**INSPECTION HANDRAIL**



## Cross Frames Diaphragms

1. Cross frames have a high price per kilogram but are given less attention by the designer than primary members.
2. Cross frame spacing is based on stability requirements during erection, lateral torsional buckling of compression flange and 1996 AASHTO LFD 10.20.1. However, 1996 AASHTO LRFD 6.7.4 allows the engineer to determine the need for permanent cross frame based on engineering analysis rather than arbitrary specified requirements. It may be economical to increase dimensions of the flange and reduce the number of cross frames to be fabricated to achieve a cost-effective design. The Bridge Design Engineer must approve the spacing greater than 7.6 m.
3. Unless required due to horizontal curve, treat elements of a cross frame as secondary members (AASHTO 10.20.1) to reduce undesirable load paths and design according to articles 10.7.1, 10.19.1.2 and 10.20 . Once the deck is placed, cross frames provide little resistance to wind loads but still may be required in negative moment regions.



$W$  = wind load (Newtons) on cross frame

$w = 2400 \text{ N/m}^2$

$d$  = beam depth (meters)

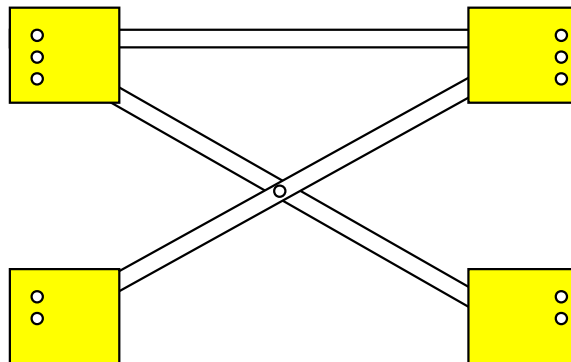
$D$  = cross frame spacing

$s$  = girder spacing (meters)

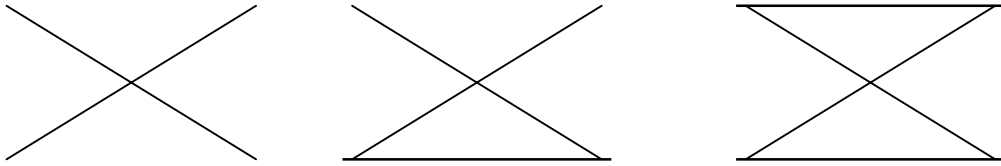
$W'$  = axial load in cross frame member in Newtons

$$= \frac{1.14 \times w \times (d) \times D \times (s^2 + d^2)^{1/2}}{2s}$$

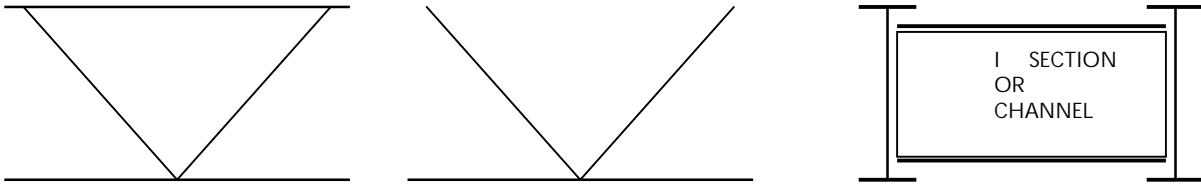
4. Reduce the cost by not mixing connections within a cross frame. Construction requires welded joints to be welded all around unless otherwise noted, then painted. In a bolted joint, faying surfaces receive two coats of paint before assembly. If a bolted joint is used in the middle, with welded ends, construction requires all surfaces to be painted before welding, then painted again. Avoid this mix.



**DIAPHRAGM CONFIGURATIONS**

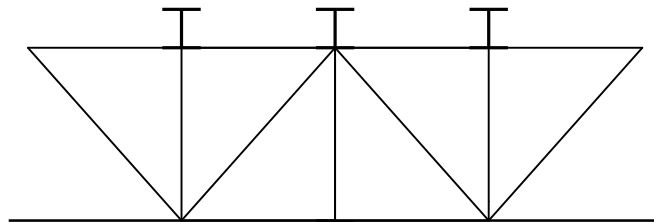


**"X" FRAMES ANGLES OR TEES**

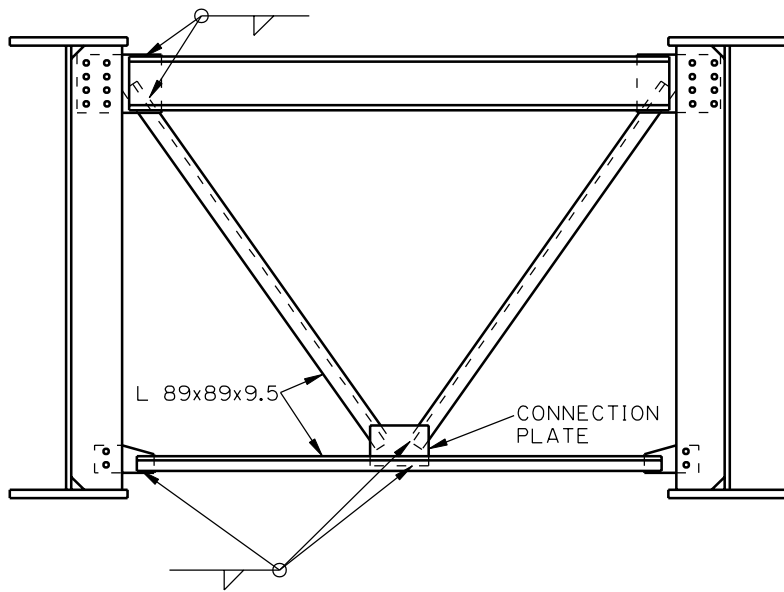
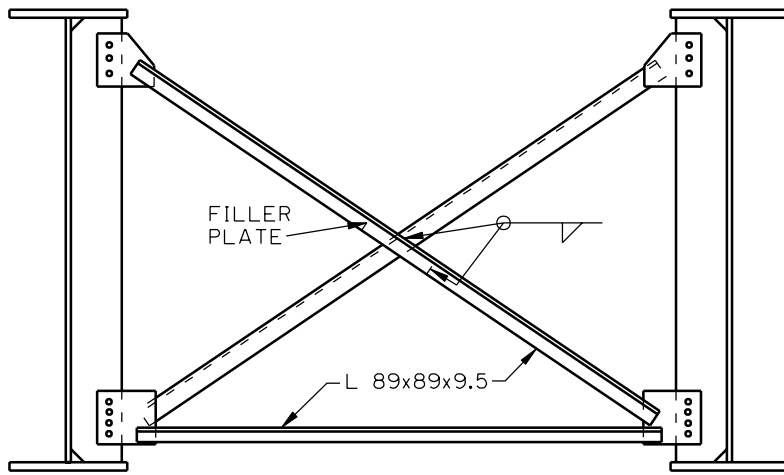


**"K" FRAMES ANGLES OR TEES**

**SOLID**

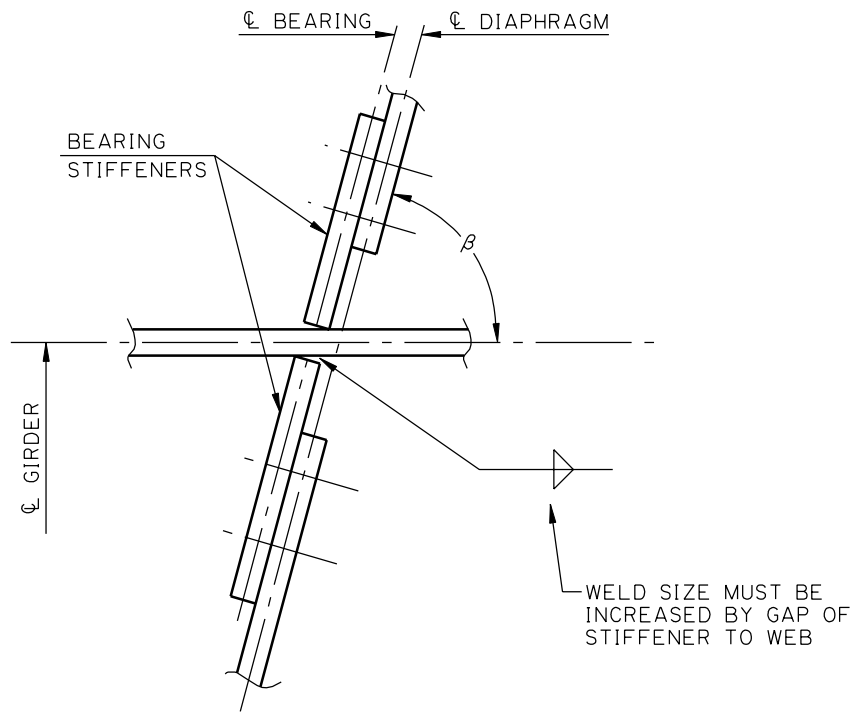


**STEEL SUBSYSTEM ANGLES OR TEES**

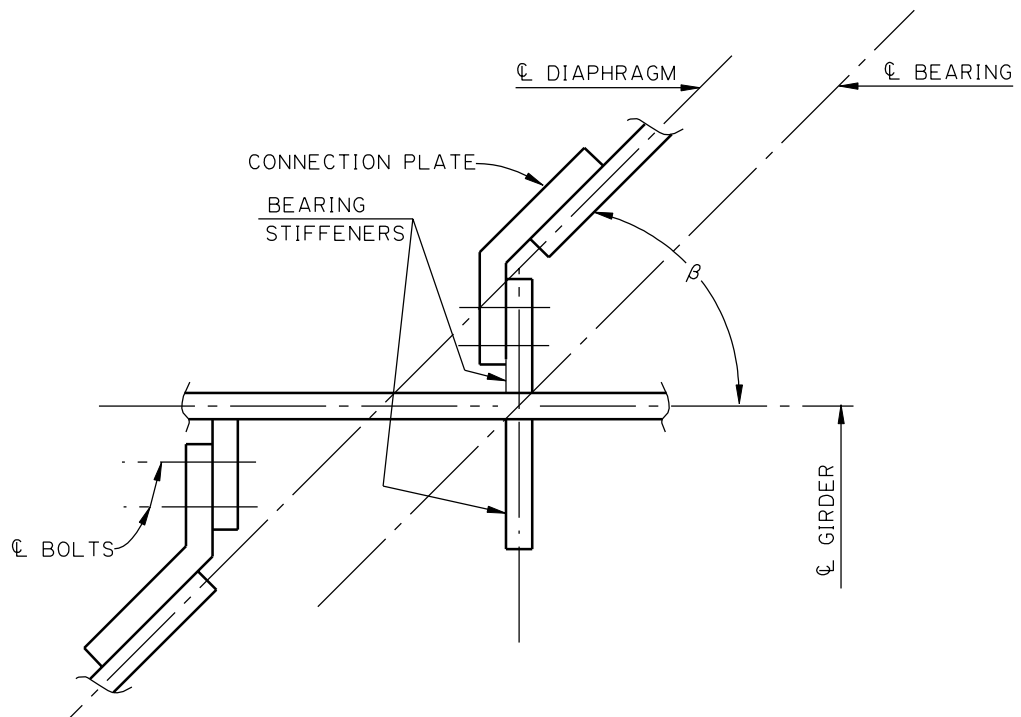


TYPICAL DETAILS

**CROSS-FRAMES**



$\beta = 90^\circ \text{ TO } 75^\circ$



$\beta \text{ UNDER } 75^\circ$

TYPICAL SKEWED DIAPHRAGM CONNECTIONS

TYPICAL SKEWED

## STEEL GIRDER OPTIMIZATION

1. Fabrication costs money. Only about 35% of the total fabricated cost is material. Economy can be realized only when fabrication is minimized. Select fabrication details that are the least complex and yet will be able to perform the required function. Practice design duplication, which means that the greater the number of elements and details on a given job that are replicated, the lower the fabrication costs, will be.
2. Whenever possible, use standard specifications for both bridge material and fabrication.
3. Optimum girder design is more sensitive to web thickness and number of stiffeners than to depth the web.
4. High strength steels result in shallower optimum depths and more economy than grade 250 steel.
5. For girder webs up to 1700 mm in depth, economy favors designs that require no intermediate transverse stiffeners to satisfy shear requirements. It is recommended that 8.0 kg web material be saved for every kilogram of transverse stiffener material added to the structure. Longitudinally stiffened girders do not become economical until girder depths exceed 2.5 m.
6. In general, the greatest economy for multiple girder bridges can be realized by using the least number of girders consistent with a reasonable deck design.
7. Always specify a component with the simplest details that will serve the intended function.
8. Approximately 360 kg. (span > 30 m) or 270 kg. (span ≤ 30 m) of flange material must be saved to justify the introduction of a shop flange splice. Normally, the most economical design results when the flange (tension and compression) size is carried through the entire positive moment field section. Generally two flange splices will be justified in each of the flanges in negative moment field sections.

## FATIGUE DESIGN OF STEEL STRUCTURES

### Introduction

This article covers fatigue design for all types of steel bridges: simple span, continuous spans, composite and non-composite designs. The mechanics of fatigue design, such as the number of load cycles, fatigue category and allowable range of stress shall be as specified by the AASHTO Specifications. This article is to amend and supplement the AASHTO Specifications in accordance with current Department policy.

### Commentary

Bridge fatigue has become a matter of increasing concern in recent years. Details used for attachments to steel structures have been reviewed and modified in an effort to eliminate known fatigue problem areas. The designer should select details that allow a higher stress range. This can be done by using Category "A" through "D" details in lieu of Category "E" and "F" details; bolting attachments instead of welding; and using redundant members instead of non-redundant members. Additional background information is available in the American Institute of Steel Construction "Bridge Fatigue Guide Design and Details" by Dr. John W. Fisher.

### Analysis and Details

1. Cover plates shall generally not be used; however, when there are no other practical options, the plate termination should be located as close to the girder end as possible.
2. Generally, Category "E" and "F" details are not permitted.
3. Return welds at the ends of plates shall be avoided.
4. Butt welds in longitudinal stiffeners must be full penetration and radiographically checked. This is an important connection, because if it fails, it will cause cracking in the web details that will radiate through the flange.
5. Do not use details that bring triaxial welds together, such as at the juncture of a gusset plate and a stiffener. Welds should be stopped short of intersections.
6. Welds for transverse stiffeners generally are stopped short of the flange, and are not returned.

7. Stiffeners at floor beam, cross frame or diaphragm connections, should be welded to both flanges to prevent out of plane distortion of the girder web.
8. Fatigue shall be checked only for MS-18 truck or lane loading as applicable.
9. Unless otherwise directed by the Bridge Design Engineer, the two main girders and the pivot girder on swing span bridges are not designed as FCM.

## FRACTURE CRITICAL MEMBERS

### Introduction

This article applies to steel structures, which contain fracture critical members. A fracture critical member is one whose failure would lead to collapse of the entire structure. Current AASHTO Specifications do not contain information on fracture critical members and are supplemented herein in accordance with current Department policy and proposed AASHTO Specifications.

### Commentary

Fracture critical members (FCM) are those tension components of a bridge whose failure would be expected to result in the collapse of the bridge. Tension components of a bridge consist of pure tension members or flexural members that are subject to tension stress. Any attachment having a length in the direction of the tension stress greater than **100 mm** that is welded to a tension component of a fracture critical member shall be considered part of the tension component and, therefore, shall be considered "fracture critical". All welds in fracture critical members are subject to the welding requirements contained in the fracture control plan.

### Identification

Definition of Fracture Critical Member: These are members that will cause a major collapse or failure of the structure should they fail. The following descriptions explain how to identify the critical areas of fracture critical bridges. In general, the critical areas are the high-tension zones where only a few separate steel elements are available to carry the load.

### Two-Girder Systems

Welded steel bridges with only two main girders have a fracture critical area at the lower flange in the midspan regions and at the upper flange in the region over each continuous support. The upper flanges near the end supports do not constitute fracture critical areas.

### Box Girder Bridges, Single Box Design

The single box design of a steel box girder bridge is a fracture critical bridge. The bottom plate is welded to two or sometimes three web plates, each of which has a flange plate welded to its upper edge. The bottom plate will be the fracture critical area at the midspan region of each span. The upper flange plates will be fracture critical in the region over each continuous support except where the plans show a substantial amount of additional reinforcing steel parallel to the flanges. In this case, the additional reinforcing steel provides redundancy, guarding against a catastrophic failure.



## Steel Caps

Where supports cannot be located directly under the bridge, bridge designers sometimes use a steel box beam cap to span between widely spaced columns. The superstructure is then supported in the midspan region of the cap. In these cases, there is one fracture critical area at the lower flange in the midspan region. If the box beam cantilevers over a supporting column, the top flange over the column is fracture critical.

## Truss Bridges

When a truss bridge has only two main trusses it may contain fracture critical members. The fracture critical members would be single-element tension members such as an eye bar or an I-beam tension member. Tension members consisting of multiple separate steel elements are not FCM. Each fracture critical tension member would count as one fracture critical area.

## Suspended Span Bridges, Two-Girder Systems

The same criteria apply that were discussed for two-girder systems. In addition, the pins and hangers, which support the two-girder suspended span, are considered fracture critical.

## Analysis

When practical, the designer should select a type of structure that eliminates or reduces the use of fracture critical members. Generally, this may be done by use of redundant members. The designer shall determine which components are fracture critical and determine the limits of the members, which are fracture critical.

## Details

1. The contract plans shall clearly delineate the components which are fracture critical members and which components require Charpy V-Notch input testing as per 1013.01 of the Louisiana Standard Specifications. This information may be designated on the girder elevation view or shown on a separate sketch. The limits of tension or reversal stress areas must be clearly dimensioned.
2. All welding procedures must be approved prior to the submitting of shop drawings.
3. Shop drawings shall show the location and extent of fracture critical members. Weld symbols shall indicate the welding procedure to be used.
4. To aid future inspections, fracture critical members shall be identified in tabular form on the first sheet of the bridge plans such as:

IDENTITY OF FRACTURE CRITICAL MEMBERS		
DESIGN SHEET NO.	TYPE OF MEMBER	LOCATION WITHIN MEMBER
115	Main girder	Lower flange
123	Cap	Top flange and web
126	Cross frames	Upper horizontal strut

## GUIDELINES FOR WEATHERING STEEL DESIGN

1. Steel (ASTM A 709 GR 345W) will not develop a protective oxide coating if it remains wet for a long time (greater than 60% of the time) or is contaminated by salt from any source.
2. The most common cause of corrosion problems is caused by runoff water leaking through the deck and wetting the diaphragm, the girders, and the bearings in vicinities of joints.
3. Weathering steel is resistant only to certain specific types of atmospheric corrosion in a limited range of environments. Adequate periods of drying are needed without prolonged periods of wetting. Air must not contain excessive corrosion contaminants. Corrosion penetration exceeding **7.5  $\mu\text{m}/\text{yr.}/\text{surface}$**  will prevent oxide coating from forming.
4. Approval from the Bridge Design Engineer for use south of US 190 will be required.
5. General considerations in weathering steel design:
  - a) Prevent water from ponding.
  - b) Divert deck runoff water from steel superstructure.
  - c) Prevent debris accumulation that traps moisture.
  - d) Avoid environments that would cause salt contamination.
  - e) Make decks continuous where feasible and use drain troughs where continuity is not feasible.
  - f) Use integral abutments whenever possible.
  - g) Welding should be with electrodes matching corrosion resistance of the weathering steel.
  - h) Bolts should have corrosion resistance equal to or exceeding the weathering steel such as ASTM A 325M Type 3; however, galvanized bolts should not be used.
  - i) Load indicator washers are not recommended, as they may create crevices.
  - j) Connections should be designed so as not to entrap water (drain holes in gusset plates, etc.). If this cannot be avoided, painting must protect contact surfaces between plies.

- k) Near white blast cleaning is recommended for surfaces for public view and commercial blast cleaning is satisfactory for other surfaces.
- l) Weathering steel bridges are not maintenance free. Periodically removing debris with compressed air may be needed.
- m) Rehabilitation may require repainting of corroded areas. Paint may require additional specifications in consideration of difficulty of achieving near white surfaces. Paint coverage (due to pitting and roughness) may be as little as one fourth that shown on the manufacturer's product data sheet.
- n) The girder at the expansion bearings will be painted for a distance of 1.5 times the girder depth. (Paint color to match final oxidized surface color.)

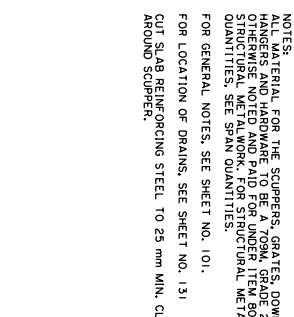
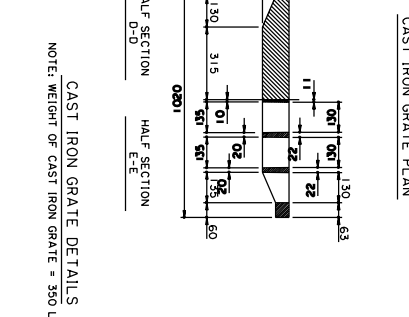
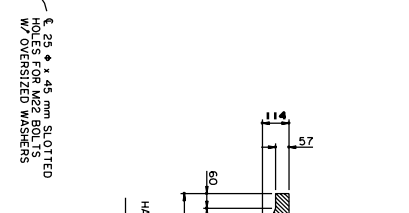
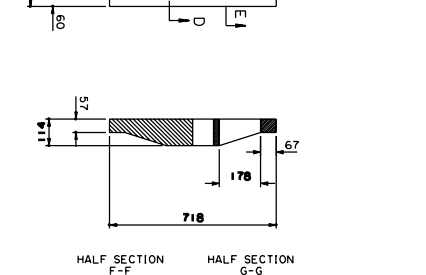
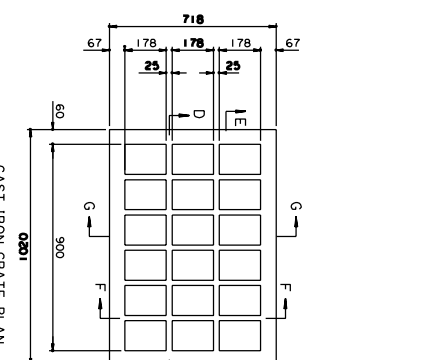
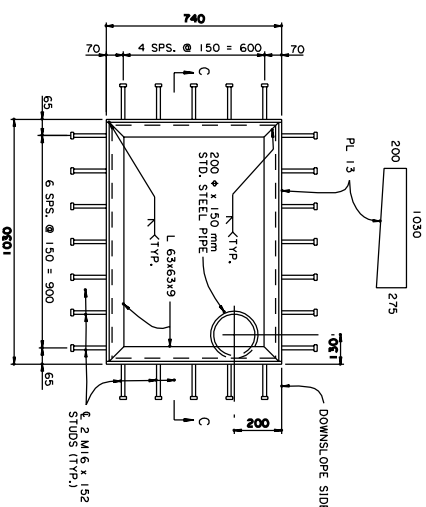
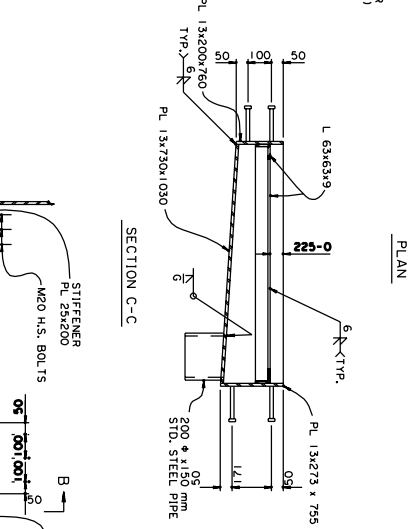
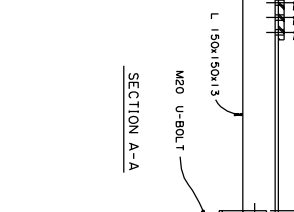
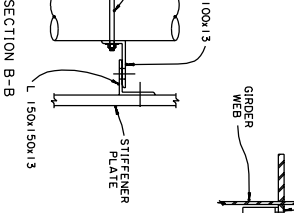
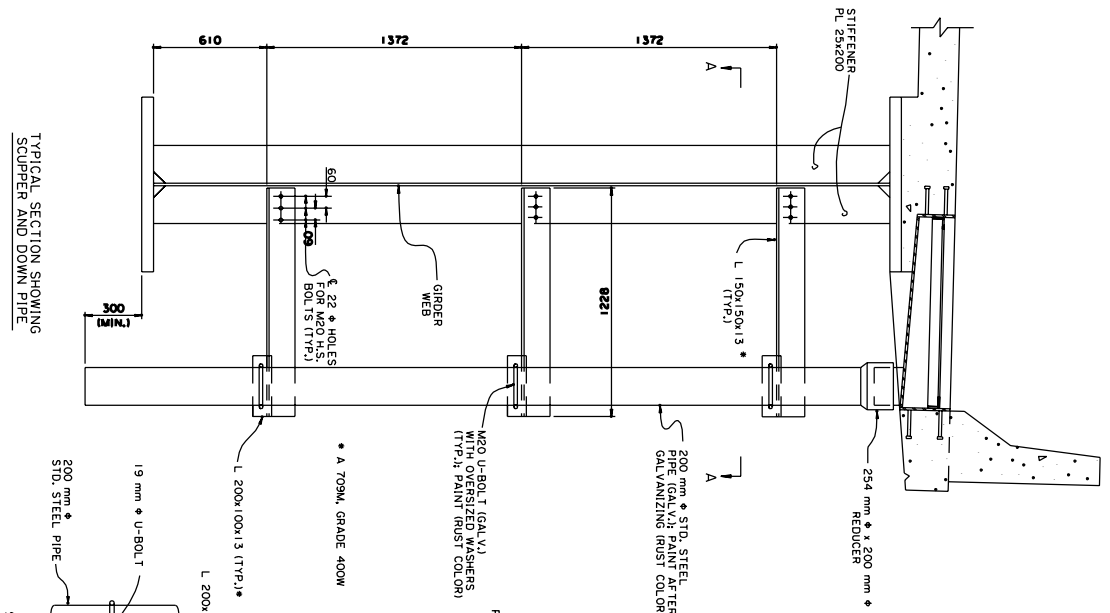
## 6. Girders

- a) Minimize the number of horizontal surfaces on which water can pond or debris can accumulate.
- b) Minimize the number of re-entrant corners.
- c) Use details which are self-cleaning and self-draining.
- d) Avoid crevices.
- e) For members with thickness less than 38 mm an additional thickness of 0.8 mm per exposed surface should be added to compensate for the normal corrosion.

## 7. Box members and girders

- a) Should be constructed tight if feasible (members or orthotropic deck girders).
- b) Where tight construction is not feasible, provide adequate hatches or vents to provide a draft.
- c) Inside surfaces of box girders may be left bare, however, where inaccessible to inspection, inside should be painted.
- d) Inside surfaces of box or tubular members should be painted with an extra heavy coating around openings.

**REFERENCE:** National Cooperative Highway Research Program (NCHRP) Report 314



NO.	DATE	REVISION DESCRIPTION	BY	DESIGNED	CHECKED	DATE	SHEET	BRIDGE AND STRUCTURAL DIVISION	EXAMPLE SCUPPER DRAIN DETAILS	PARISH	FEDERAL PROJECT	STATE PROJECT	SHEET NUMBER

## BEARINGS

The most common bearing system currently being used by the Department is the neoprene bearing system. Neoprene pads are used exclusively for all prestress girder designs and are often used for steel spans where lengths are not prohibitive. As outlined in AASHTO, elastomeric bearings should be of uniform thickness (risers sloped to match grade), with plain pads using 70 and reinforced pads using 60 durometer hardness material. For reinforced bearings, Louisiana uses only steel reinforcement with **3 mm** minimum edge cover. Neoprene pads for prestress girders shall be in accordance with the miscellaneous span and girder details and will be used on all standard projects without additional design effort.

For longer steel spans, other type bearings are used. Teflon sliding bearings may be used, if approved by the Bridge Design Engineer. The rocker bearing is the most common type and should be designed in accordance with the AASHTO Specifications. All large bearings shall be stress relieved. A fully supported pin between the upper and lower saddles should be used in order to prevent bending of the pin which could result in localized high stresses, galling, popping and disintegration. For long span deep girder designs, significant movements can be generated from span deflections and must be accounted for in the bearing design. The use of lead materials for bedding the steel bearings to the bearing surfaces is prohibited.

On horizontally curved girder spans the expansion bearings should be oriented on a line projected from the fixed bearing to the expansion bearing. If finger joints are used, the fingers should also be oriented along this line.

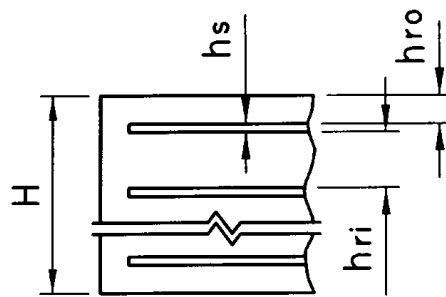
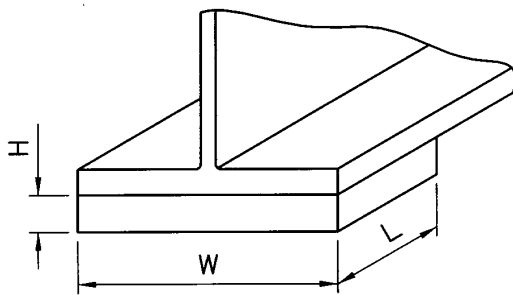
# RECTANGULAR NEOPRENE BEARING DESIGN

## Required Data

Girder: lower flange width ( $b_f$ ) =  
 dead load reaction ( $P_{dl}$ ) =  
 live load reaction ( $P_{ll}$ ) =  
 expansion length ( $l$ ) =

w/o impact  
 distance from fixed bearing to  
 expansion bearing being designed

## Given Data



ITEMS	CONCRETE	STEEL	REFERENCE
CONSTANT			
T (C °)	39 °C	68 °C	3.16
$\alpha$ ( 1/C°)	$10.8 \times 10^{-6}$	$11.7 \times 10^{-6}$	8.5.3.10.2.2
SHRINKAGE	$208.33 \times 10^{-6}$	$104.17 \times 10^{-6}$	BDM, chapter 3

PAD		PLAIN	REINFORCED	REFERENCE
VARIABLE				
HARDNESS		70	60	SHORE "A"
F <sub>c</sub> TL(N/mm <sup>2</sup> )		10.8 × 10 <sup>-6</sup>	1.38	14.4.1.1
G	G <sub>c</sub>	1.38	0.90	T 14.3.1
	G <sub>s</sub>	2.07	1.38	T 14.3.1
B		1.8	1.4 outer	14.2
		1.8	1.8 inner	14.2
CREEP		45%	35%	T 14.3.1

Design (Method A)

- $W \approx b_f$  =  
 $TL = (P_{dl} + P_{tl})$  =  
 $L \geq TL \div (F_{cTL} \times W)$  =  
 $\sigma_c = TL \div (L + W)$  =
- $h_{ri} \leq G_c \times (L \times W) \div [2 \times \sigma_c \times (L + W) \times \beta]$  = compression  
14.4.1.1
  - $h_s = 1.6 \text{ mm}$   
 $F_y = 227.5 \text{ N/mm}^2$  Std Spec 1018.14(a)  
Std Spec 1018.14(a)
  - $F_{all} = 0.55 F_y$  T10.32.1A  
 $\leq 165 \text{ N/mm}^2$  T10.3.1A, 2 million  
cycles
  - $2) h_{ri} \leq (F_{all} \times h_s) \div (1700 \times 4.448 / 25.4)$  = shim strength  
14.4.1.6
  - $\leq 16.9 \text{ mm}$
  - $\Delta h = [\infty(\Delta T) + \text{Shrink}] \times l$  = DOTD & FHWA use  
total \_T



7.  $\Delta s \approx \_h$  for pier flex. =  $\Delta h$  modified

8.  $n =$  No. of inner layers =

3)  $h_{ri} \geq (2 \times \_s) \div (n + 2/1.4)$  = shear 14.4.1.3

4) select  $h_{ri}$  and  $n$  to satisfy equation 1,2,& 3

$h_{ri} =$

$n =$

select  $h_{ro} \approx h_{ri}/1.4 =$

check stress:  $h_{crit}/\beta \geq h_{ri}/1.0 \geq h_{ro}/1.4 =$

$S/\beta = (W \times L) \div [2(W + L)(h_{crit}/\beta)] =$

$\sigma_c < G_c(S/\beta) =$

5)  $h_{rt} = n \times h_{ri} + 2 \times h_{ro} =$

$h = h_{rt} + (n+1) \times h_s =$

$\leq L/5$  (plain) =

$\leq L/3$  (reinforced) =

stability check 14.4.1.5

6)  $H = G_s(L \times W)(\Delta s/2) \div h_{rt}$

$\leq 0.2P_{dl}$

slip check 14.6.1

if no slip apparatus is used

7)  $\epsilon_{ci}^{TL} = f(S/\beta, \sigma_c) =$  See figure F14.4.1.2B or

$$= \left[ \frac{\sigma_c}{2.3 \left( \frac{S}{\beta} \right)^{1.63}} \right] \left( \frac{1}{1.15 + 0.0286 \left( \frac{S}{\beta} \right)} \right)$$

International Bridge Conference 88-17 Eq 37

$\leq 0.07$  FHWA Region 3 SCEF Comm.10

$\Delta_c^{TL} = n \times h_{ri} \times \epsilon_{ci}^{TL} + 2 \times h_{ro} \times \epsilon_{co}^{TL}$

$\leq ?$  mm agency instantaneous deflection limit

$\Delta_c^{DL} = n \times h_{ri} \times \epsilon_{ci}^{DL} + 2 \times h_{ro} \times \epsilon_{co}^{DL} (1 + \text{creep})$

agency long term deflection limit

$\leq 3 \text{ mm}$

GD = grade difference between riser and bottom of girder

1.  $\theta^{\text{TL}} = (\theta^{\text{DL}} + \theta^{\text{LL}}) \approx W_{\text{DL}}L^3/24EI + 1/400 \pm \text{GD}$

## **CORROSION PROTECTION METHODS**

### **GENERAL**

Details given in Chapter V provide adequate corrosion protection for the average application. For those locations where severe corrosion potential exists (exposure to coastal splash zones, deicing chemicals, areas where there is a history of corrosion problems), the Bridge Design Engineer will determine the method to protect the concrete reinforcing steel, including direct treatments (galvanizing or epoxy coatings), corrosion inhibitors (calcium nitrite), and silica fume or fly ash for reducing concrete permeability.

### Fly ash

A pozzolan is a by-product of pulverized coal-fired electric power generation. It is physically smaller than the average cement particle and is round.

### **PROS:**

- 1) Improves workability (pumping and ease of flat-work finishing) of fresh concrete
- 2) Reduces peak temperature of mass concrete
- 3) Long term reaction products help fill in spaces between hydrated cement particles, thus lowering permeability to water and aggressive chemicals
- 4) Reduces required water in mix for given slump
- 5) Increases long-term strength of concrete if moist environment and moderate temperatures maintained
- 6) Low cost
- 7) Allows reduction in cement content

### **CONS:**

- 1) Reduced early strength, increases setting time (both initial and final)
- 2) Decreases entrained air
- 3) Class C can cause corrosion (use Type F)

**COSTS:**

From 3.3 to 4.4 cents per kilogram (1995) with maximum rate of 25% of the cement by weight.

Microsilica

A by-product of the production of silicon and ferrosilicon alloys. It, like fly ash, is a pozzolan, but with a much higher silicon dioxide content and much smaller, rounder particle sizes. It is more reactive than fly ash. Use the densified form.

**PROS:**

- 1) High early strengths
- 2) Significantly reduces permeability

**CONS:**

- 1) Requires use of high water reducing admixtures to maintain slump
- 2) Requires use of admixtures to obtain desired entrained air
- 3) Increased plastic shrinkage, due to less bleed water, requires surface to be covered to prevent rapid evaporation
- 4) More expensive than fly ash

**COSTS:**

\$1.30 per kilogram (1995) with maximum rate of about 10% of the cement by weight.

Calcium Nitrite

A corrosion inhibiting liquid added to the concrete mix that reacts with embedded steel to inhibit chemical action of chlorides on the reinforcing steel. Corrosion initiation is delayed and corrosion rates are controlled by determining the anticipated chloride ion content of the concrete over the design life of the structure and adding sufficient quantity to counteract that value. Recommended rates are from 10 to 30 liters per m<sup>3</sup>.

**PROS:**

- 1) Offers built-in protection that can be adjusted for service life required
- 2) Only proven corrosion inhibitor with enhanced mechanical properties of concrete

**CONS:**

- 1) Price

**COSTS:**

\$1.85 per liter (1995)

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## **INTRODUCTION TO SUBSTRUCTURE**

This chapter deals with some of the more common types of substructures used for bridges, as well as approach slabs, retaining walls and embankment protection.

### **EMBANKMENT AND REVETMENT**

Embankment is most often needed to economically transition the bridge to the roadway. Settlement and stability analyses are important considerations when determining the fill heights and the bridge length. Geotechnical information such as consolidation studies and slope stability analysis should be obtained during preliminary design when fill heights are a consideration.

When erosion of the embankment is a concern due to stream forces, the exposed embankment should be protected with flexible revetment or rip-rap. The type of protection used depends upon hydraulic factors at each site. The Hydraulic Section will normally recommend the type of protection to be used when the Hydraulic Bridge report is submitted.

### **END BENTS, APPROACH SLABS AND RETAINING WALLS**

The end bent and approach slab provides a transition from the rigid bridge structure to the flexible roadway embankment. Normally 12 m approach slabs are used for slab span and girder bridges except in weak soil areas. In these areas, 30 m pile supported approach slabs are often required to achieve a reasonable transition. Wingwalls are normally used on girder bridges to contain the embankment adjacent to the end bent.

Often retaining walls are required to contain the embankment in areas where right-of-way is a constraint. Either cast-in-place or mechanically stabilized earth walls (MSE) may be used. In most cases MSE walls are found to be the most economical unless site conditions dictate otherwise.

### **PILE BENTS AND COLUMN BENTS**

The most commonly used bent type is the pile bent. The pile bent generally consists of a cast-in-place concrete cap used with precast-prestressed concrete piles. Pile bents are limited in height due to the slenderness and buckling capacity of the piles. Pile bents are very economical and can be used for stream crossings, highway crossings and railroad crossings when aesthetics are not a consideration.

The next most common bent type is the column bent. The column bent generally consists of a cast-in-place concrete cap, column and footing supported by piling. The columns may also be supported by drilled shaft footings or may be directly connected to the drilled shaft

Column Bents come in a variety of configurations. The most common is the two-column bent with round columns, normally used on two lane bridges.

Hammerhead column bents are often used on ramp structures. For bridges with column heights greater than 15 m, tapered columns are often used for greater economy.

Inverted T-caps are sometimes used for aesthetics, but primarily, where vertical clearance dictates their need. Inverted T-caps should be used only with approval of the Bridge Design Engineer.

## **RIVER PIERS AND COFFERDAMS**

Where bridges cross major stream or river crossings and pile bents are not feasible, the use of a column bent constructed with a cofferdam is most commonly used. For major Mississippi River Bridge crossings, caissons are commonly used. As an alternate, large diameter drilled shafts should be investigated when deemed appropriate for the site.

All bridge crossings subject to navigational traffic should be investigated for the appropriate protection system due to vessel impact. This may include placing the piers out of the channel when it is feasible, designing the piers for vessel impact, or placing protection systems such as fenders and/or dolphin islands around the piers. The AASHTO "Guide Specification and Commentary for Vessel Collision Design for Highway Bridges" should be referred to for more information.

## **PERMANENT OR TEMPORARY SHEET PILE WALLS**

Steel sheet pile walls are commonly used for both permanent and temporary applications. For sites where a permanent bulkhead is needed such as a navigational waterway, permanent sheet pile walls are often used. They are commonly designed either as a cantilever or tied back wall.

When bridges are built by phased construction (split-slab) on an offset alignment, or adjacent to railroad tracks, temporary steel sheet pile walls are often used to retain the existing or new embankment. In order to temporarily retain embankment, where deemed appropriate, temporary MSE walls may be used as an alternate to steel sheet pile walls.



## **DRIVEN PILES**

### **INTRODUCTION**

The most commonly used driven pile types are precast-prestressed concrete, cast-in-place concrete, steel "H", steel pipe and timber. This section is a guide to methods of pile foundation design and details.

It is conceded that the problem of foundation analysis is a highly complex one and that sometimes experience and intuition will be the better part of analysis. In this light, if any analysis and soil boring interpretation is followed blindly, serious errors in estimating foundation capacities can result.

The bridge designer normally proposes the type and length of pile foundation during preliminary plans. The Geotechnical and Construction sections should be consulted both during preliminary and final design to review and make comments on the proposed pile lengths, pile type and field-testing.

### **PILE DESIGN**

Soil borings are required on all bridge projects for which piling is involved. In cases where an existing bridge will be widened or replaced on an existing alignment, the engineer should evaluate the following information first from the existing bridge records.

- a) Existing bridge borings.
- b) Existing test pile reports.
- c) Existing pile driving records.

On projects for which all or some of the above information is available and contains sufficient information for the design of the foundation, there will be no need to order new borings.

Should the existing information not be sufficient or is not available, new borings must be ordered. New borings must be ordered through our Geotechnical Section. Information on how to order new borings and a boring request form can be found in chapter 1 or you may contact the Geotechnical Section. Any existing deep boring data should be attached to the boring request. The date when the complete geotechnical data (borings, consolidation and settlement analysis) are needed, should be included in the request. In the absence of this information, priority will be established by the preliminary plan date.

Piles shall be designed using service loads excluding live load impact. The maximum pile loads (design load) should always be shown on the construction drawings, normally with bent details or on the pile data sheet. Piles can be designed as friction piles, bearing piles, or a combination of both. The weight of the pile is normally neglected except in special cases involving large diameter piles and when cofferdams and tremie seals are used. The pile lengths for both on-system and off-system bridges are determined using the appropriate safety factors which are selected based on field-testing, type and amount of soils data and geotechnical analysis, type of project, static and dynamic load test and method of modeling pile installation. See Field Testing for more information on safety factors.

In order to set the plan pile lengths, a static analysis to determine ultimate pile capacity is normally performed on each boring for friction and bearing capacity. Due to the variety of soil conditions, this manual will not attempt to describe the analysis procedures. The engineer should confer with the Geotechnical Section when performing a static analysis. The design engineer will normally use the total soil shear strengths determined from either unconfined compression tests or standard penetration tests to determine the pile friction and end bearing for various piles and loads. If economically feasible, the engineer should attempt to tip end bearing piles in very dense sands ( $n > 50$  blows). The end bearing piles should penetrate a minimum of 1.5 m into the 50 blows count material.

The plan pile lengths are established when the design event ultimate pile capacity divided by the required factor of safety is equal to or greater than the design load.

Pile sizes should be proportioned so that the following criteria are met.

- a) As a general rule, the maximum slenderness ratio of  $L/d \leq 20$  should be maintained.

$L$  = pile unsupported length (mm). The unsupported length is measured down below the channel bottom or ground line accounting for estimated scour, if appropriate (1.5 m minimum), plus a distance to the assumed point of pile fixity. In general, pile fixity can be assumed at 1.5 m below scour line or ground line. See figure on page 25.

$d$  = the least dimension or diameter of the pile section (mm).

The maximum unsupported pile lengths based on a  $L/d = 20$  are as follows:

Pile Size(mm)	<sup>1</sup> Max. unsupported length (mm)
350	7000
400	8000
450	9000
600	12000
750	15000

- b) If  $l/d > 12$ , batter exterior piles.
- c) All pile friction above the estimated scour line should be ignored. A minimum of 1.5 m of scour shall be assumed.
- d) Piles should be proportioned so that the maximum pile design load is less than the allowable axial compressive loads and the allowable lateral loads. The allowable axial compressive pile loads are shown on page number 6 (6).

When favorable soil conditions exist, the design pile load should approach the upper limit of the allowable load range. In cases where the soil strength is questionable, lower design loads should be used.

- e) The design of laterally loaded piles is usually governed by the lateral movement criteria. Proprietary computer programs are available for lateral pile geotechnical analysis. In addition the pile must be able to resist the additional lateral loads structurally. In the absence of lateral pile test information or a more detailed lateral analysis as described above, the following allowable lateral loads may be used.

Pile Type	Allowable Lateral Pile Load (kN)
Timber	13.0 kN
Concrete	18.0 kN
Steel	22.0 kN

- f) Pile splices for concrete piles may be required when pile order lengths are expected to exceed the maximum casting length shown on the Standard Detail CS-216. The plans will have an S-item for pile splices (per each) with the anticipated number that may be required. The item will be bugged noting that this item may be deleted if final order lengths are less than maximum casting lengths shown in the plans.

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<sup>1</sup> Maximum unsupported lengths may be exceeded in special situations with the BDE's approval. However,  $l/d > 25$  will require investigations for elastic stability as columns.

Table, Allowable Axial Pile Load

PILE TYPE	PILE SIZE	ALLOWABLE AXIAL COMPRESSIVE LOAD	STANDARD DETAIL NAME
<sup>1</sup> Precast Prestressed Concrete Piles (square)	350 400 450 600 750	310-490 kN 400-575 kN 454-665 kN 710-1065 kN 1155-1730 kN	<sup>2</sup> CS-216(M)
Precast Prestressed Cylinder Piles	1370	2000-2500 kN	1370 mm Prestressed Cylinder Pile
Cast-in-place Concrete Steel Pipe Piles	350 400	490 kN 755 kN	Concrete Pile Alternates
Cast-in-place Concrete : Tapered: Raymond Helcor or Corwell Monotube	350, 400 350, 400 350, 400	490 kN, 755 kN 490 kN, 755 kN 490 kN, 755 kN	Concrete Pile Alternates
Timber	Butt Dia. (500-300) Tip Dia. (225-125)	265 kN 355 kN (Special Cases)	N/A
<sup>3</sup> Steel "H" (common sizes)	HP250×62 HP250×85 HP360×108 HP360×132 HP360×152 HP360×174	495 – 650 670 – 885 855 – 1130 1050 – 1385 1200 – 1590 1375 – 1820 –	N/A
Steel Pipe (other sizes available, check w/suppliers)	PP460× 9.5 PP610× 12.7 PP760× 15.9	830 – 1100 1475 – 1952 2310 – 3050	N/A

<sup>1</sup> The allowable loads are based on the formulae set up by the joint AASHTO and PCI for piles with  $f'c = 35\text{MPa}$  PSI. (F.S. =  $4 \frac{L}{D} = 25$  and 10 respectively); The loads are further reduced to account for soil capacity (Additional F.S. = 1.6 to 2.2). For situations where  $\frac{L}{D}$  is approaching zero, i.e., footing piles, and very favorable soil conditions exist, the designer may consider loads 1.5 times higher than those shown.

<sup>2</sup> Refer to standard detail CS-216(M) for maximum pile casting lengths.

<sup>3</sup> The lower and upper values represent allowables of the pile area  $0.25F_y$  and  $0.33 F_y$  respectively. Loads above the lower value may be used only with approval of the BDE and must incorporate static and/or dynamic load tests to confirm satisfactory results.

The following typical splices are approved to be used on precast concrete and steel piles.

Pile Type	Pile Size (mm)	Pile Splice Type
Precast Concrete	350, 750	Cement dowel
Precast Concrete,	350,400,450	Dyna-a-splice (proprietary)
Precast Concrete,	600	ABB (proprietary)
Steel	All sizes	Full penetration butt weld

Standard details are available for the precast concrete pile splices, except for ABB splices.

- g) For piles with a diameter less than 0.6 m, an 8 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.
- h) For pile diameters equal to or greater than 0.6 m, a 9 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.

Battering piles is an expensive process and should be specified only when necessary. The exterior pile in bents should be battered when the unsupported pile length is excessive. Battering footing piles provides the necessary lateral support that is sometimes required to resist excessive lateral loads transferred from the column to the footing. This is particularly true for short column bents due to cap shrinkage. Maximum batter is usually 1 on 4 for footing piles and 1 on 8 on pile bents.

The allowable strength of precast concrete piles is seldom, if ever, exceeded by the design loads. Pile handling and transportation govern the design, thus establishing the maximum casting length and pick up point locations.

Cast-in-place concrete piles are used primarily in south Louisiana and are designed either as friction piles or combination friction and bearing piles. When cast-in-place piles are included as an alternate for precast piles, the pile lengths should be set based on the cast in-place pile, and only precast piles will be allowed in the end bents.

When hard driving is anticipated, particularly where jetting is not desirable, such as footing piles, the designer should consider non-displacement piles such as open-ended pipe or H piles. The designer should discuss this with the Geotechnical section.

The pile group capacity will be considered in foundation analysis if the center to center spacing is less than three pile diameters. Under normal situations, this is not allowed.

The consolidation settlement shall be computed for all pile groups. The pile group settlement shall be the same as shown for drilled shafts on page 19.

All timber piles for permanent structures shall be treated timber according to the Standard Construction Specification. Coastal treatment should be considered for use at locations south of I-10/I-12 line. Where coastal treatment is used, it should be clearly specified in the plans. Temporary structures such as detour bridges shall use treated timber piles.

## PILE DETAILS

1. The following pile standard details are available and shall be included in the plans when applicable.

Standard Detail	Description
CS - 216(M)	Precast-Prestressed Piles
Concrete Pile Alternates	Cast-in-place Concrete Piles
Pile Splice Details	Cement Dowel, Dyna-a-Splice

2. Steel pipe piles shall generally be driven with open ends only.
3. Pile lengths should normally be shown on the general bridge plan. Pile tips, cutoff elevations, pile lengths and design loads should be shown on a pile data table. In addition, a column for end of driving pile capacity should be provided.
4. For moderate to complex projects involving skews, horizontal curves, interchanges, etc., or where interaction with existing foundations is present, the plans should include a foundation layout. The layout must show bents and/or footing pile locations and referenced to the centerline or P.G.L. Existing structures or substructures that may conflict with the pile driving must be clearly shown. Boring locations as well as test piles, CPT probings, PDA monitor piles and indicator piles must also be shown.

## **FIELD TESTING PROGRAM**

### **INTRODUCTION**

For most bridge projects, some type of pile testing or pile monitoring is normally performed. Soil conditions, design loads, magnitude of project, pile types, and economics are some of the factors determining the type and extent of the field-testing program to be implemented. Prior to beginning the field-testing program, the contractor must submit the necessary pile driving equipment information and the pile installation plan for evaluation and approval. The pavement and geotechnical design section will evaluate the proposed equipment based on the wave equation analysis (GRLWEAP™) for each pile type and size required in the plans. The criteria used in the evaluation consist of the pile driving stresses and the number of hammer blows per 0.25 m at the required ultimate pile capacity. The equipment and installation method shall be such that the piles will obtain the required penetration without damage.

The field-testing program is initiated in order to confirm or revise the estimated plan pile lengths as well as the contractor's proposed pile driving operations and installation plan. Upon evaluation of the data and results of the tests/monitoring, the project engineer, Construction, Geotechnical, and Bridge Design sections concur on pile order lengths and installation plan which allow the contractor to begin the pile fabrication process.

Field verification of pile capacity may be eliminated when either of the following two (2) conditions exist:

1. The soil boring data is consistent and indicates a very dense bearing strata ( $N > 50$ ) which should be a minimum of 5 m thick.
2. Static load calculations indicate with the appropriate factor of safety (normally 2.75), it will be more economical to extend the piling than to enter into a test pile program with shorter length piles.

In these cases, the plans will specify order length piles.

## DEFINITION OF TERMS AND PLAN REQUIREMENTS

### Test Piles

Test piles are driven in advance of the permanent piles and are used to determine the length of the foundation piles by applying static loads at predetermined intervals. They may also be used to further evaluate the contractor's proposed method of installation and equipment. They are generally located in close proximity to a boring with consideration given to accessibility to the site for the driving and loading equipment and should model the most critical subsurface conditions for the area for which they will control. In some cases this may require the contractor to excavate the test pile location or utilize a casing to eliminate side friction in the upper portion. If cone penetrometer tests are utilized, they will generally govern the final location and tip elevation of the test piles.

Test piles should be cast long enough to be redriven, if necessary, to the plan tip elevation of the piles at the nearest bent and also sufficiently long to permit static and dynamic monitoring with the Pile Driving Analyzer.

Test piles are an expensive item for bridges, particularly on small projects and therefore, should not be used indiscriminately.

In addition to testing maximum axial compression, test piles may also be used to test the uplift (tensile) capacity of the pile primarily used for footings in cofferdams with tremie seals.

The plans or specifications should clearly designate if test piles are to serve as permanent piles.

When an item for a Test Pile is given in the plans, it is generally accompanied by items for Loading Test Pile, Reloading Test Pile, and Redriving Test Pile.

Due to the inherent properties and characteristics of soils and soil/pile interaction, the plans should always contain an item for *Loading Permanent Piles* for those unanticipated situations.

### Cone Penetrometer Test, (CPT)

CPT probings may be used to determine pile order lengths. The CPT probings are also used to determine the final location and final pile tip elevation of the Test Piles and Indicator Pile. One of the following notes should be placed in the **General Notes of the bridge plans** depending on if the Department will perform the work, (note a), or if the Contractor will perform the work, (note b).



- a) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE DEPARTMENT IN ACCORDANCE WITH SECTION 804.04 (I) OF THE SPECIFICATIONS.
- b) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE CONTRACTOR.

When the CPT probings are performed by the contractor, (note b), the maximum CPT penetration elevation should be specified in the plans as follows:

- a) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR ALL CPT PROBINGS SHALL BE \_\_\_ (*elevation in meters*).
- b) THE MAXIMUM CPT PROBING PENETRATION ELEVATION SHALL BE \_\_\_ (*elevation in meters*). FOR CPT PROBINGS TAKEN AT BENTS (##) THROUGH (##).
- c) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR TEST PILE (##) SHALL BE \_\_\_ (*elevation in meters*).

#### Pile Driving Analyzer, (PDA)

PDA may be used to monitor the pile driving installation of Test Piles, Indicator Piles, and Monitor Piles with the Pile Driving Analyzer (PDA). A note similar to the following note should be placed in the **General Notes of the bridge plans**. It should be modified as needed.

PDA MONITORING: PILE DRIVING ANALYZER (PDA) MONITORING WILL BE REQUIRED AT EACH TEST PILE, INDICATOR PILE, AND MONITOR PILE OR AS DIRECTED BY THE ENGINEER.

#### Indicator Piles

Indicator Piles may be used to determine the final pile order lengths. In this case, an Indicator Pile is driven in advance of the production piles. The difference between Indicator Piles and a standard test pile is that loading Indicator Piles is not anticipated. Indicator piles should be cast long enough to be redriven, if necessary, to the plan tip elevation of the piles at the nearest bent or as determined necessary by the CPT probing. Indicator Piles are usually piles tipped on marginal end bearing soils. The Indicator Pile is used to access pile driveability problems such as hard driving which may require jetting or predrilling and to assess the bearing capacity of marginal bearing soil. The Indicator Pile driving installation is monitored with the PDA to evaluate the pile driving equipment performance and to monitor the pile driving stresses. Pile bearing capacity and driving criteria will be developed from data obtained from the PDA monitoring. The location of

these piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The indicator pile is paid for as a modified test pile (i.e. Item 804.07(A) Precast Concrete Test Pile (Indicator Pile)). Pay items for each type of indicator pile used should be shown in the plans.

Redriving of indicator piles is paid for under Item 804(14), Redriving Test Piles. If it is determined from the driving records and PDA monitoring that the indicator pile should be load tested, each load test shall be paid for under Item 804(12)(A).

The following note should be placed in the **General Notes of the bridge plans**.

INDICATOR PILE: INDICATOR PILES WILL BE REQUIRED AT THE LOCATIONS SHOWN ON THE GENERAL PLANS OR FOUNDATION LAYOUT.

### Monitor Piles

A Monitor Pile may be used to monitor the pile driving installation with the PDA. This is usually accomplished by monitoring the first permanent pile of its type and size to be driven at each bridge structure or at a specified bent location. The location of these Monitor Piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The PDA is used to evaluate the pile driving equipment and to monitor the pile driving stresses. Pile driving criteria will be developed from this information. The Monitor Pile is paid for as a permanent pile. The dynamic monitoring is paid for with the PDA Monitoring item. One of the following notes should be placed in the **General Notes of the bridge plans** depending on where the indicator pile(s) is located.

- a) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT EACH BRIDGE SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- b) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENT NO. (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- c) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENTS (##) THROUGH (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).

## Permanent Piles

Permanent Piles are those piles that are furnished by the contractor in accordance with an approved order list for use in production driving of foundation piles for the final substructure. If the driving resistance of a permanent pile should not correlate with the test pile or be less than that of the test pile, the engineer may require a static load test among other courses of action.

The following plan note should be placed in the **General Notes of the bridge plans**.

PILES: ALL PILE REQUIREMENTS INCLUDING SIZE, TYPE AND MAXIMUM DESIGN LOAD AND TEST PILE REQUIREMENTS AS TO LOCATION AND TEST LOADING SHALL BE AS DESCRIBED ON THE PLANS OR IN THE SPECIFICATIONS. SEE STANDARD DETAIL CS 216(M). THE MINIMUM PILE TIP ELEVATIONS WILL BE PLAN PILE TIP ELEVATIONS UNLESS NOTED ON THE PLANS OR OTHERWISE AS DIRECTED BY THE ENGINEER.

In addition, one of the following pile length notes shall be included as needed in the PILES: note in the plans.

- a) PILE LENGTHS SHOWN IN THE PLANS ARE ORDER LENGTH PILES.
- b) PILE ORDER LENGTHS WILL BE PROVIDED AFTER COMPLETION OF THE CPT PROBINGS AND/OR TEST PILE LOAD TESTING AND/OR INDICATOR PILE INSTALLATION AND EVALUATION AS REQUIRED BY THE PLANS.

## Jetting

When appropriate, jetting may be used to facilitate pile installation. This practice shall be predominately used when hard driving is anticipated during pile installation of end bearing piles. Jetting should not be allowed for friction piles, piles in footing, header banks or where stability of embankment or other improvements may be endangered. When jetting is allowed or required, the following note shall be added to the Special Provisions

JETTING: JETTING MAY BE REQUIRED IN ACCORDANCE WITH SECTION 804.05(I) AT (list of the locations).

The note above amends the Standard Specifications sub section 804.05(I), Water Jets.

For more specific information on this subject as well as appropriate plans and specifications requirements including pay items, refer to the latest DOTD's Standard Specifications.

## Types of Field Load Testing

1. **Static Load Test:** This work consists of applying static loads at predetermined intervals to Test Piles and in some cases to Indicator Piles or Permanent Piles. The static loads are applied in increments of 10 to 15 percent of the design load and held for an interval of 5 minutes. The loads are increased until pile failure occurs or three times the design load is reached. The ultimate pile capacity is determined through the analysis of the load settlement curve then a safety factor of 2.0 is applied to determine adequacy of pile tip elevation. Test piles will be loaded unless otherwise directed by the engineer. Test piles shall remain undisturbed for at least 14 calendar days after driving, unless otherwise directed by the engineer, to required penetration before beginning loading operations.
2. **Dynamic Load Test:** This work consists of assisting the Department in obtaining dynamic measurements with the Department's Pile Driving Analyzer (PDA) of test piles, indicator piles, and permanent piles during initial pile driving and during pile restrikes. The cost of equipment mobilization or any delays due to dynamic monitoring shall be at no direct pay. To allow space for attachment of instrumentation when dynamic monitoring is specified on test piles, indicator piles, and monitor pile, the piles shall be long enough to allow access to the top 2.5 pile diameters or side dimension of the pile at the end-of-driving penetration. The dynamic monitoring shall be performed for the purpose of obtaining the ultimate pile capacity, pile driving stresses, pile integrity, and pile driving system efficiency.

## Types Of Pile Capacities

1. **Static Load Test Capacity:** This is the computed ultimate pile resistance that we are anticipating during the static load testing of a test pile, indicator pile, or permanent pile. The soil resistance will depend on the as-driven conditions such as overburden of the scour zone, scour zone soil resistance if it has not been cased or excavated, etc. The reaction system shall be sized to resist three times this estimated Static Load Test Capacity shown in the plans or as directed by the engineer.
2. **Ultimate Pile Capacity:** This is the ultimate pile capacity that has been determined from either a static or dynamic test of a test pile, indicator pile, or permanent pile.
3. **Design Load:** Is the maximum computed working load that the pile foundation is anticipated to support during the life to the structure.
4. **Design Event Ultimate Pile Capacity:** This is the computed static ultimate pile resistance that should be available after neglecting the scour zone and accounting



### Pile Design and Construction Control Safety Factors

Construction Control Method		Static Design Safety Factor $SF_{Design}$	Construction Control Safety Factor $SF_{EOD}$
<b>Field Testing</b>	Test Pile with Static Load Test	2.00	2.00
	Indicator Pile with Dynamic Monitoring	2.50	2.50
<b>No Field Testing</b>	On-System: Permanent Pile with Wave Equation	2.75	2.75
	On-System: Permanent Pile with Gates Dynamic Formula	3.50	3.50
	Off-System: Permanent Pile with Wave Equation	2.50	2.50
	Off-System: Permanent Pile with Gates Dynamic Formula	3.00	3.00

## **DRILLED SHAFTS**

### **INTRODUCTION**

As an alternate to driven piling, for certain projects, drilled shafts can prove to be an economical foundation alternate. A drilled shaft consists of an augered hole that is filled with reinforced concrete to establish a foundation. Drilled shafts will only be used with the approval of the Bridge Design Engineer Administrator, or his designated representative.

In the past, drilled shafts have been primarily used in the northern part of the state, where hard clays are prevalent. Wilcox material is particularly suited for drilled shafts because of its strength characteristics, its cohesiveness and its impermeability. In some of these areas, drilled shafts should be used exclusively, however, in other areas, where their economy is questionable, they may be specified as an alternate to piling, requiring separate substructure details. These cases will be determined on a project by project basis. In the past few years, the Department has been gaining confidence constructing drilled shafts in the lower part of the State in sandy soils using the slurry displacement method.

It is always preferable to construct shafts in the dry, however this is not always possible. A test hole will be placed in most contracts so that the contractor can demonstrate his ability to construct a drilled shaft. If a dry hole cannot be maintained, the contractor will have to construct the drilled shafts using the slurry displacement method with approved slurry. Construction methods are dependent on soil conditions, and will conform to Section 814 of the Standard Specifications.

### **APPLICATION**

1. Projects with obstructions that impede the pile driving operation. There is construction equipment available today to construct drill shafts under existing structures with vertical clearances as low as 4.0 m.
2. Projects requiring heavily loaded foundations.
3. Projects involving conflicts with utilities, existing drainage, roads, bridge structures and/or projects where vibrations and excessive noise cannot be tolerated.
4. Projects using large drilled shafts to take the place of footings and extend the shaft to the top of the substructure using conventional columns.
5. Projects which have hard clays, particularly when it is anticipated that precast concrete piles cannot be driven through the soil without a pilot hole that extends to within a few feet of the founding elevation.

## DESIGN

1. All projects involving drilled shafts will be approved prior to design, by the Bridge Design Engineer Administrator.
2. As a general rule, size the drilled shaft for a compressive stress of **3 MPa** across the cross section of the shaft. However, the soil characteristics and the design requirements for the shaft to sustain both axial and lateral loads will determine the final size and length of the required shaft.
3. Side friction will be utilized, i.e., the shafts will be constructed with the casing extracted, unless otherwise approved by the Bridge Design Engineer Administrator.
4. For drilled shaft design, Class S concrete will be used and the concrete compressive strength will normally be limited to  $f'c = 18 \text{ MPa}$ .
5. All drilled shafts, where the concrete or slurry is placed under water, will be constructed with access tubes to allow for cross-hole sonic logging, CSL. The test will determine if anomalies are present in the shaft, which may reduce its capacity. If the shaft has a reduced capacity the payment and/or rejection will be based on the CSL testing.
6. Drilled shafts used in abutments shall have a minimum diameter of 600 mm, however, a diameter of 750 mm is preferable.
7. A minimum reinforcement of 1% of the gross shaft area shall be extended to the bottom of the shaft.
8. Drilled shafts are available in 150 mm increments from 450 mm to 3600 mm. Some shafts may be available in the 4800 mm range.
9. Drilled shafts should be spaced center to center a minimum of three (3) times the shaft diameter, however, shafts can be placed closer if group capacity is accounted for in the foundation analysis.
10. Battered drilled shafts will not generally used.
11. Belled footings will not be used.
12. Detailed clearances for the reinforcement to the outside of the drilled shaft will be 75 mm for shafts with a diameter of 750 mm or less and 150 mm for shafts greater than 750 mm.

For further design information consult the Pavement and Geotechnical Design Section and AASHTO.



## Design Criteria

Service load design will be used. The maximum shaft load shown in the plans should be broken into two components, dead load and other group loads. The effects of down drag or uplift should be accounted for in the loads.

The final shaft diameter and length will satisfy the following axial load, lateral load and consolidation settlement criteria:

### **Axial Load:**

1. The shaft size and length will be designed based on the following:
  - a) Without a test load: Three (3) times the maximum shaft service load, however if the soil conditions are consistent from boring to boring and the designer has a high degree of confidence in the predictability of capacity of the shaft, 2½ times the maximum load can be considered.
  - b) With a test load: Two (2) times the maximum shaft service load
2. Short term settlement due to load transfer will be limited to the following:
  - a) (Settlement resulting from two times the maximum shaft service load)  $\approx$  20 mm to 25 mm.
  - b) (Settlement resulting from 1½ times the maximum shaft service load)  $\leq$  7 mm.

### **Lateral Load:**

1. Design the shaft for lateral loads, beginning with the size and length of shaft determined from the axial load design. The potential for loss of lateral capacity due to scour will be considered in the design.
2. Lateral movement will be considered and based on the specific type of structure and the nature of the lateral loads.

### **Consolidation Settlement:**

1. Consolidation information should be obtained at the time the deep foundation borings are taken. The Geotechnical Section should be advised that this project is a potential drilled shaft site and consolidation information is required.

2. Consolidation settlements will be limited to the following:
  - a) Standard Structures - 50 mm maximum or 25 mm / 50 m of span length.
  - b) Movable Structures - 15 mm total and 15 mm differential between adjacent substructure elements

### Construction

1. Drilled shafts may be constructed using the dry, wet or casing method of construction, or a combination of methods. However, the preferred and most economical method is the dry method.
2. Drilled Shafts shall be constructed in accordance with the plans and Section 814 of the Standard Specifications for Roads and Bridges.
3. Types of Drilled Shaft Construction:
  - a) Dry Method:

The dry construction method shall be used only at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation. And also where the sides and bottom of the shaft may be visually inspected by the Engineer prior to placing reinforcement and concrete. The dry method consists of drilling the shaft excavation, placing the reinforcing cage, and concreting the shaft.
  - b) Wet Method:

The wet construction method may be used at sites where a dry excavation can not be maintained for placement of the shaft concrete. This method consists of using slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. Where drilled shafts are located in open water areas, exterior casings shall be extended from above the water elevation into the ground. The casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that no seepage of water or other materials occurs into or from the shaft excavation.
  - c) Casing Method:

The casing method may be used when shown on the plans or at sites where the dry or wet construction methods are inadequate to prevent caving or excessive deformation of the hole. In this method the casing may be either placed in a predrilled hole or advanced through the ground by twisting, driving or vibration before being cleaned out. In either case (b) or case (c), the designer determines that the casing must be permanent, then a separate pay item must be included in the plans.

4. Slurry Types:

a) Polymer Slurry:

This type of slurry is a polymer powder that is pre-mixed with potable water and placed in the drilled hole. The weight of the slurry is used to counteract the hydrostatic pressure from the surrounding soil formation. The polymer prevents caving of the sides of the hole and is destroyed during the placement of the concrete by the chemical reaction with the cement. The polymer slurry, once destroyed, normally leaves no residual material in between the concrete and the soil interface. The advantages of this type of slurry is that it may be easily disposed of.

b) Mineral Slurry:

This type of slurry puts soil particles in suspension and will form a membrane or a filter cake at the walls of the hole. The membrane acts to prevent caving or collapse of the hole provided the hydrostatic fluid pressures inside the hole exceed the pressures in the soil formation. This filter cake can reduce the perimeter load transfer of the shaft to the surrounding soil if left in place for extended periods of time. The advantage of the Mineral Slurry is that you can counteract a larger hydrostatic pressure. The disadvantage is that it must be recovered and disposed of as a hazardous waste.

## PILE BENTS

### INTRODUCTION

Pile bents consist of prestressed-precast concrete piles with a cast-in-place reinforced concrete cap. (Steel pipe piles or HP piles may be used in site-specific locations). The piles extend out of the ground to serve as columns and are imbedded into the bottom of the cap. The following is a guide for the structural analysis and the construction details for general use in the preparation of plans for pile bents. The AASHTO Specifications shall be adhered to except as amended or supplemented herein.

#### Commentary

Due to the high variable conditions of foundation soils and tolerances allowed or expected in the construction of pile bents, the analysis should be kept relatively simple to reflect this variability. Rigorous frame analysis on pile bents is also frustrated by the indeterminate amount of fixity where the pile enters the ground and at the juncture between the pile and the cap.

Double row pile bents may be considered when additional capacity or stability is desired. The particular uses of double row pile bents are to resist longitudinal live load movement of long trestle type structures, and to add stability for high level crossings or weak soil areas. This practice should be limited to the extent that if a small number of larger piles are required, a column bent with foundation piles may be more economical.

In the absence of a complete analysis, the designer should consider using one double row pile bent in every continuous unit. Where the  $L/a$  ratio is approaching the maximum limit, set forth herein, the distance between double row pile bents shall not exceed 150 m. In cases where the  $L/a$  ratio approaches the moderate range of 14 to 16, the distance between double row pile bents shall not exceed 200 m.

### ANALYSIS

Traffic loads should be placed in accordance with the AASHTO Specifications, anywhere within the design traffic lanes to cause maximum or critical stresses in the bent structure. Live load impact shall be applied to pile bent caps in the analysis.

The general method used for the analysis of pile bents containing four (4) or more piles is simplified because of the indeterminate nature of the bent structure. The maximum cap moment is computed assuming a simple span between adjacent pile centers allowing for a maximum mislocation of piles. The positive cap moment due to dead load plus live load plus live load impact is adjusted by a 20% reduction for continuity and the resulting value is used for both positive and negative moments. The related simple span shears should be used unaltered.

If the designer prefers more precision, the cap may be considered as a continuous beam over the pile support points to get a more precise steel requirement. Bent caps with less than four (4) pile support points shall be considered as a continuous beam.

Unequal dead load reactions from adjacent spans will be placed on the bent cap such that there are no appreciable dead load moments caused in the longitudinal direction. This will be accomplished by shifting the joint. An effort should be made to space the piles equally and at the same time balance the dead load reaction such that there will not be more than 50% deviation between the interior and exterior pile dead loads.

The allowable structural limit of a pile is controlled by the slenderness ratio which in effect keeps the pile structurally "a short column" (where column buckling is not critical). It can be shown that the standard prestressed pile has tremendous reserve strength against axial failure. The implication is that the foundation soil, the practical span of the bent cap and the allowable slenderness ratio of the pile will influence the pile size more than the allowable structural limit of the pile. The measure of the pile slenderness ratio is  $L/d$ .

$L$  = the unsupported length

$d$  = the least dimension or diameter of the pile section

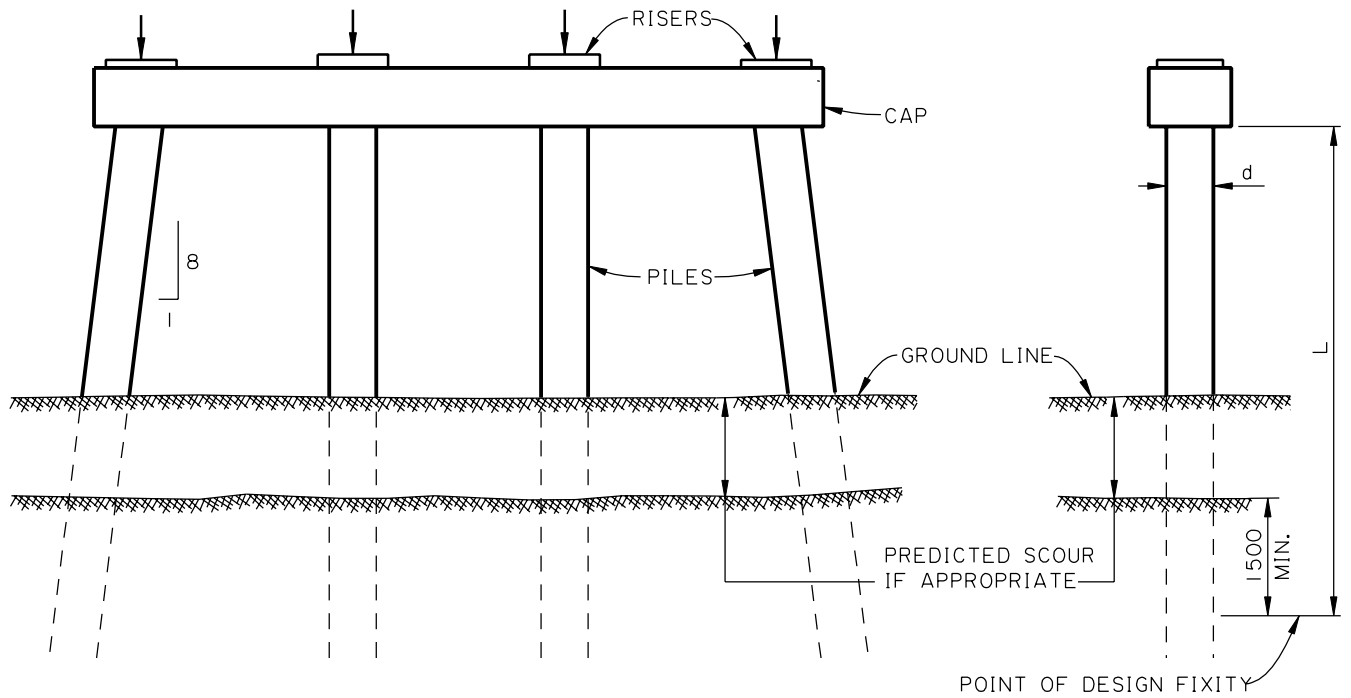
The unsupported pile length ( $L$ ) is usually measured from the bottom of the cap to the ground line plus penetration into the ground. The point of fixity is dependent on judgement, accounting for the soil stiffness at the surface or predicted scour at stream crossing. The point, which the pile is considered fixed, shall not be less than 3 m below an existing streambed or 1.5 m below the ground surface outside the floodplain.

For slab spans, the live load shall be placed to cause a maximum reaction to the bent. The wheels on the bent may be treated as concentrated loads. The contributing reaction of the wheels on the slab span may be summed and equally distributed to all the piles in the bent as a uniform load to the bent cap. The same number and size of bars shall be used in the top and bottom of cap.

## DESIGN DETAILS

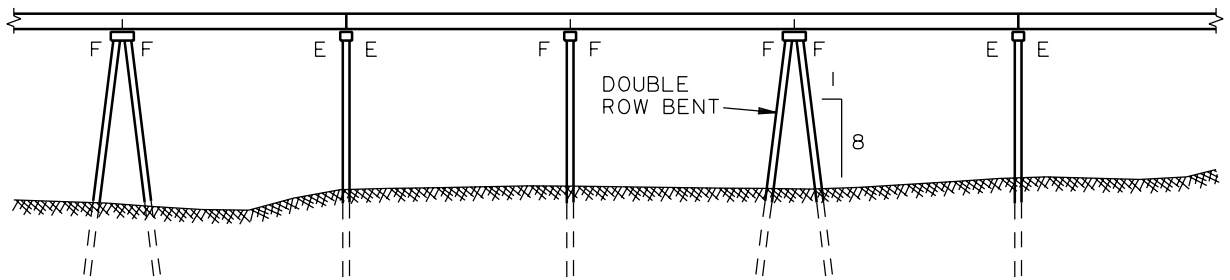
1. Batter exterior piles when  $L/d > 12$ .  $L$  should account for the predicted scour depth and distance to pile fixity. A minimum of 1.5 m of scour should be accounted for as well as 1.5m to point of fixity.
2. Particular attention shall be given to battering the exterior piles on stream crossings and on bridges in a horizontal curve.
3. Pile batter shall be 1 on 8.
4. Maximum pile loads shall be determined from service loads applied without live load impact and should be shown on the bent details indicated on the bent details.

5. Double stirrups shall be used in all pile bent caps exceeding 750 mm in width.
6. Stirrups shall be spaced at a maximum of 300 mm. The stirrups adjacent to piles shall be located at a maximum of 75 mm from the face of the pile and the first space shall be a maximum of 150 mm. The size of stirrups shall be a minimum of No. 10 bars.
7. The centerline at the top of the exterior pile shall not exceed more than 460 mm beyond the centerline of the exterior girder.
8. The pile bent design should account for at least two (2) adjacent piles being mislocated 75 mm each or one(1) pile mislocated 150 mm in the direction parallel to the cap..
9. Pile bent caps shall have a minimum depth of 600 mm for all slab span supporting bents and all single row pile bents with less than 600 mm piles and 700 mm for all single row pile bents with 600 mm piles or larger. Double row pile bents shall have a minimum cap depth of 750 mm.
10. The minimum longitudinal cap steel shall be in accordance with the AASHTO Specifications.
11. As a general rule,  $l/d$  in pile bents should not be over 20. See further discussion under driven piles.
12. The top and bottom reinforcement in caps shall be the same.
13. The concrete quantity for the pile cap shall not include the volume of concrete displaced by the pile embedment.
14. Spacing for double row pile bents shall be determined on an individual basis.



ELEVATION VIEW OF PILE BENT  
(SINGLE ROW)

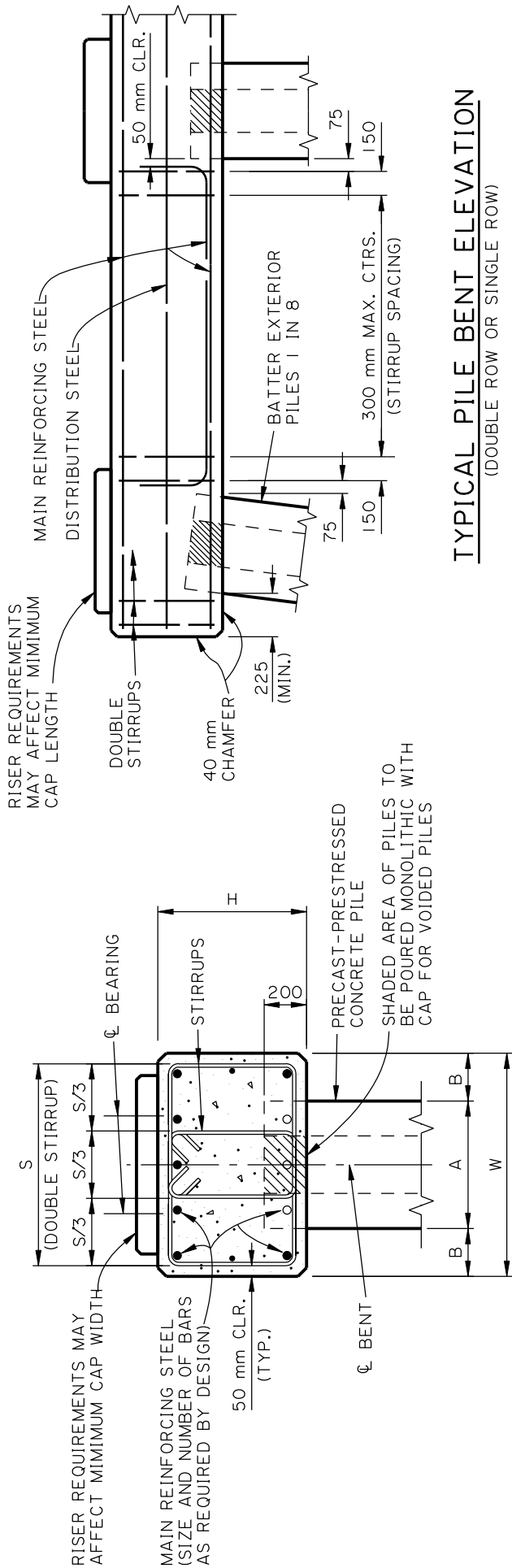
END VIEW



TYPICAL BRIDGE LAYOUT  
WITH BATTERED PILE BENTS

PILE BENT TYPICAL LAYOUT

**PILE BENT DETAILS**



**TYPICAL SECTION OF SINGLE ROW PILE BENTS**

SINGLE ROW REQUIREMENTS			
A	B	W	H
350 $\phi$	150	650	600
400 $\phi$	150	700	600
450 $\phi$	150	750	600
500 $\phi$	225	950	600
600 $\phi$	225	1050	700
750 $\phi$	225	1200	700
900 $\phi$	225	1350	700

A = PILE SIZE  
 B = MINIMUM PILE TO CAP EDGE  
 W = MINIMUM CAP WIDTH = A+2B  
 H = MINIMUM CAP HEIGHT

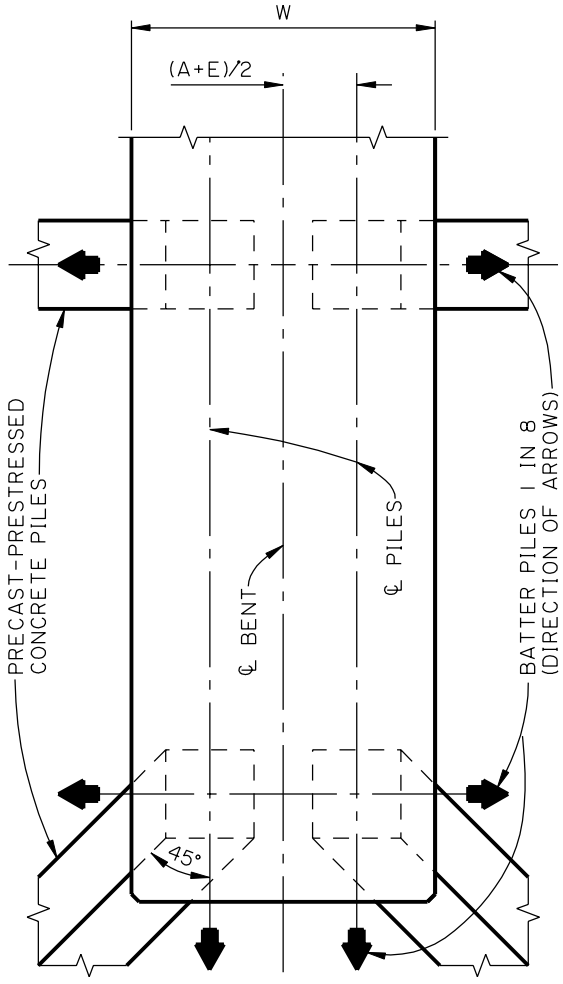
**TYPICAL PILE BENT ELEVATION**  
 (DOUBLE ROW OR SINGLE ROW)

**NOTE:**

THIS IS A GENERAL CRITERIA AND WILL NOT SATISFY ALL CONDITIONS THAT MAY BE ENCOUNTERED. SPECIAL CONSIDERATION SHOULD BE GIVEN TO THE DESIGN OF THOSE PILE BENTS FOR WHICH THE CONDITIONS ARE UNUSUAL.

**PILE BENT DETAILS**

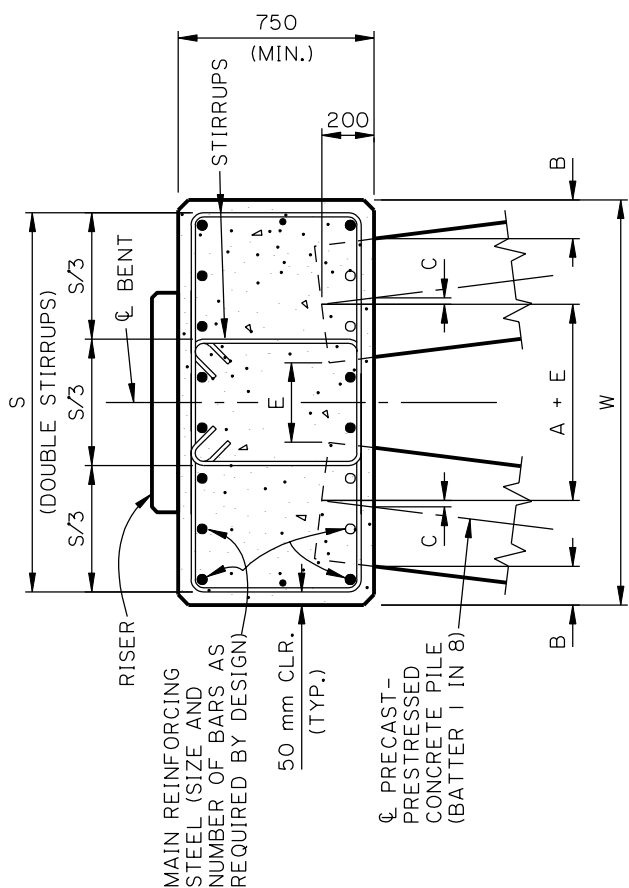




**PART PLAN SHOWING PILE BATTER**

**NOTE:**

THIS IS A GENERAL CRITERIA AND WILL NOT SATISFY ALL CONDITIONS THAT MAY BE ENCOUNTERED. SPECIAL CONSIDERATION SHOULD BE GIVEN TO THE DESIGN OF THOSE PILE BENTS FOR WHICH THE CONDITIONS ARE UNUSUAL.



**TYPICAL SECTION OF DOUBLE ROW PILE BENTS**

DOUBLE ROW REQUIREMENTS					
A	B	C	E	W	
350 φ	150	25	300	1350	
400 φ	150	25	300	1450	
450 φ	150	25	300	1550	
500 φ	225	25	350	1850	
600 φ	225	25	350	2050	
750 φ	225	25	350	2350	
900 φ	225	25	350	2650	

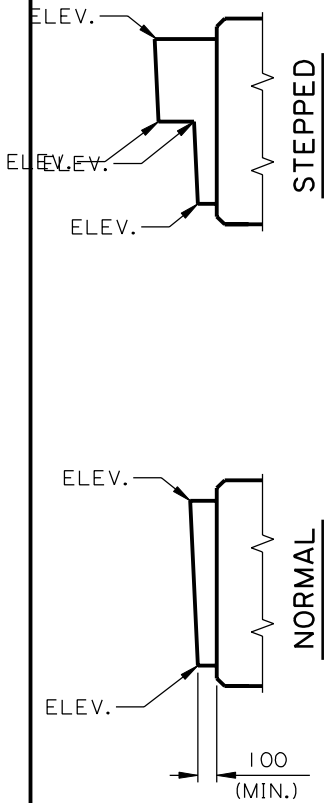
- A = PILE SIZE
- B = MINIMUM PILE TO CAP EDGE
- C = BATTER OFFSET
- E = MINIMUM CLEARANCE BETWEEN PILES
- W = MINIMUM CAP WIDTH = 2A+2B+2C+E

**DOUBLE ROW CONSIDERATIONS**

**PILE BENT DETAILS**

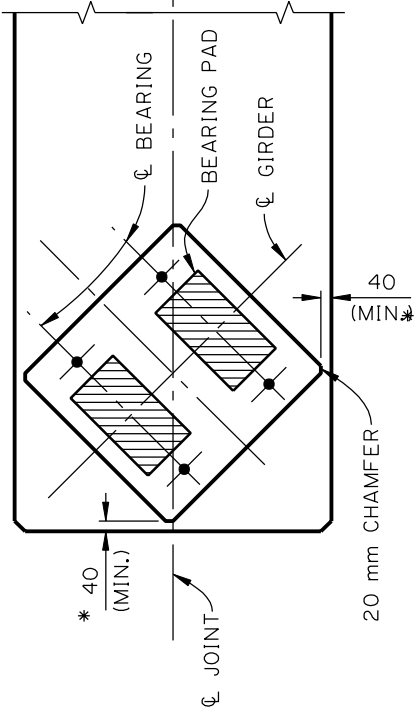






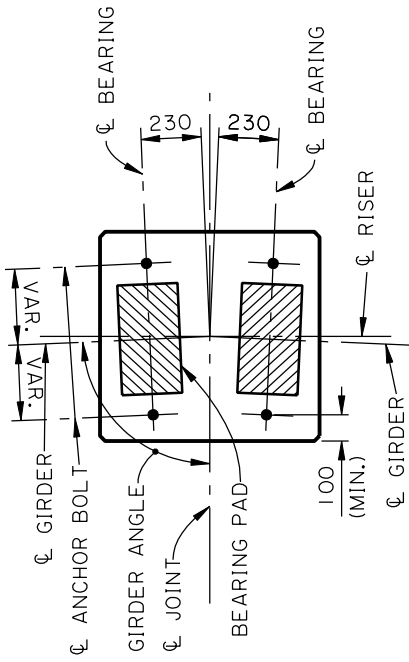
**TYPICAL SLOPED RISERS**

RISERS MUST BE SLOPED WHEN FINISH GRADE EXCEEDS 1%.  
SHOW RISER ELEVATIONS AT LOCATIONS NOTED.

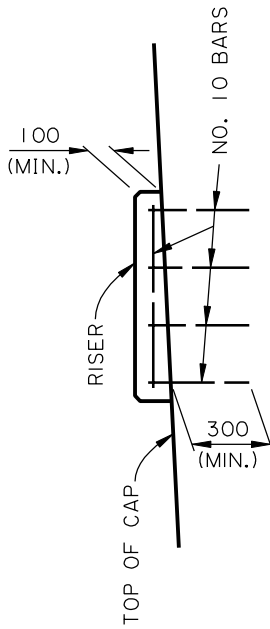


**PLAN AT SKEWED BENT**

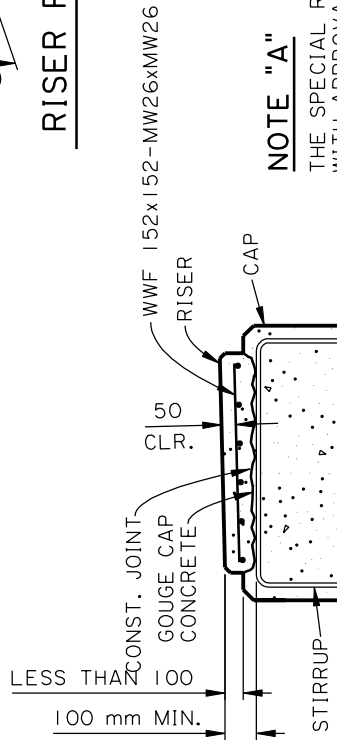
\* DO NOT USE THESE CONTROLS  
TO REDUCE CAP SIZE BELOW SIZE  
REQUIRED FOR 90° CROSSINGS.



**RISER FOR CURVED SPAN**  
(AND OTHER SLIGHTLY SKEWED GIRDERS)



**RISER FOR SLOPED CAP**



**SPECIAL RISER SECTION**

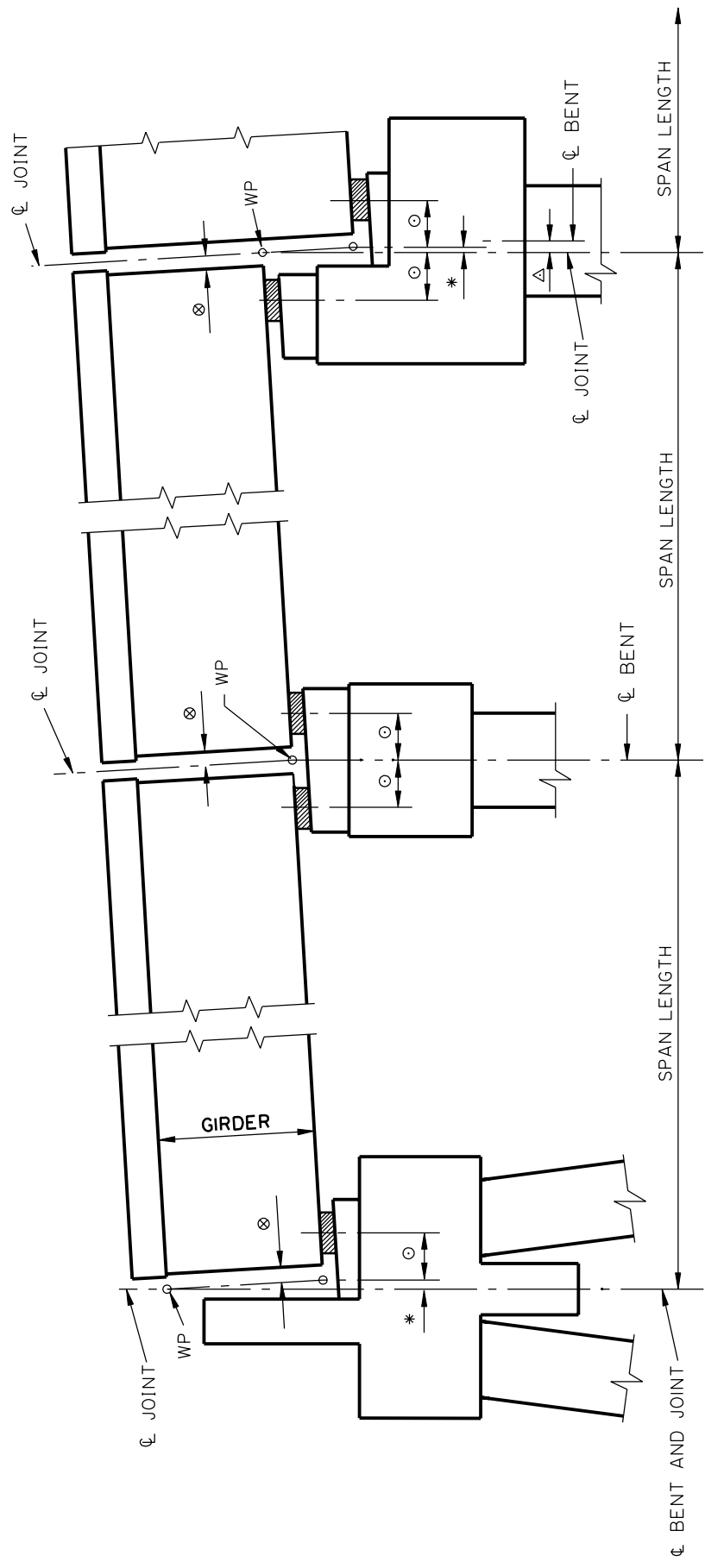
(SEE NOTE "A")

**NOTE "A"**

THE SPECIAL RISER SECTION MAY BE USED,  
WITH APPROVAL FROM THE BRIDGE ENGINEER,  
WHEN AN UNUSUAL SITUATION REQUIRES THE  
RISER HEIGHT TO BE LESS THAN 100 mm.  
USE WWF 152x152-MW26xMW26 IN LIEU OF  
NO. 10 BARS.

**MISC. RISER DETAILS**

**PILE BENT DETAILS**



⊙ 230 mm STANDARD BEARING DISTANCE.

\* SHORTEN GIRDER THIS MUCH.

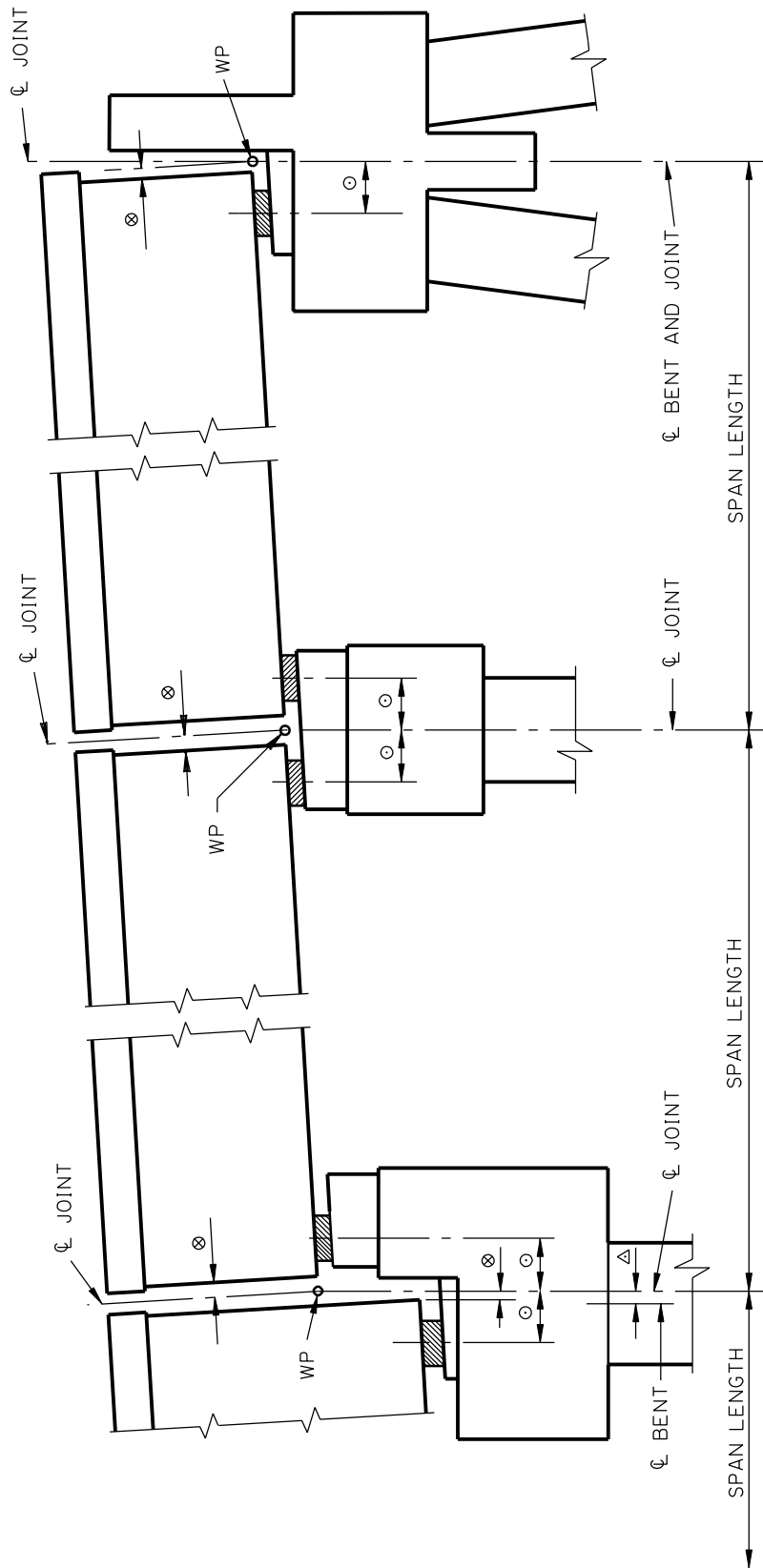
⊙ 75 mm NORMAL CLEARANCE FOR PRESTRESSED GIRDERS.

Δ DEAD LOAD OFFSET (SEE SHEET 2 OF 2).

WP = WORKING POINT (REFERENCE POINT FOR SPAN LENGTH MEASUREMENT)

BRIDGES ON A VERTICAL GRADE

BRIDGE LAYOUT CONSIDERATIONS



$\odot$  230 mm STANDARD BEARING DISTANCE.

$\otimes$  75 mm NORMAL, CLEARANCE FOR PRESTRESSED GIRDERS.

$\Delta$  DEAD LOAD OFFSET (TO COUNTERACT EFFECTS OF UNSYMMETRIC DEAD LOAD).

WP = WORKING POINT (REFERENCE POINT FOR SPAN LENGTH MEASUREMENT).

BRIDGES ON A VERTICAL GRADE

BRIDGE LAYOUT CONSIDERATIONS

2 OF 2

## **COLUMN BENTS**

### **INTRODUCTION**

Column bents are reinforced concrete frames, which are attached to a separate foundation of pile footings, spread footings or drilled shafts. The frame generally consists of columns and a cap and it supports the superstructure. Occasionally, on tall bents, intermediate struts are inserted to reduce the effective length of the column in the transverse direction.

### **ANALYSIS AND DESIGN DETAILS**

#### Analysis

1. The ratio of unsupported column length to least dimension (diameter) of column ( $l/a$ ) should generally be limited to a maximum value of between 9 to 10. Values of greater than 10 will be considered in special situations.
2. Bundled steel will not be used.
3. Unequal dead load reaction from adjacent spans shall be balanced by shifting the centerline of the bent with respect to the centerline of joint, such that there are no appreciable dead load moments caused out of the plane of the bent frame.
4. Live loads from traffic shall be allowed anywhere in the travel roadway and not confined to a design lane.
5. An attempt should be made to place the live load on the span to cause a maximum stress condition in each member to be designed. This is primarily accomplished by trial and error.
6. Columns should be placed under the cap such that the dead load moments induced in the columns are minimized.
7. The number of columns used should be minimized for typical and repetitively used bents. The criteria should be the structural limit of the columns and a proportional size of cap required. Economy and aesthetics will generally be served when the latter is attempted.
8. Circular and square columns will normally be designed as tied columns. Special circumstances may exist where circular columns must be designed as spirally reinforced columns. This method needs the approval of the Bridge Design Engineer. The typical spiral wire reinforcement used with our circular column details does not meet the requirements of a spirally designed column. The spiral reinforcement is only a more desirable method of providing confinement reinforcement, which meets the requirements for the ties in a tied column design. In some cases,

particularly in drilled shafts, contractors may request the use of individual ties in lieu of the spiral cage. This substitution is normally allowed.

9. Careful attention should be paid to stresses caused by temperature and shrinkage when most column lengths get near or below 3.5 m.
10. The foundation for column bents and piers shall be designed so that no piling or drilled shaft goes into tension, except for temporary cases during construction (i.e., cofferdam/steel design) or when designing for extreme events.
11. For bents and piers which require seals, the seal shall be designed for a bond stress of 70 kPa of pile, providing the pile and or soil interaction have been checked for uplift. This shall apply to timber, steel, or concrete piles.
12. In all cases, maximum pile loads shall be determined using the service load design procedure, without live load impact.



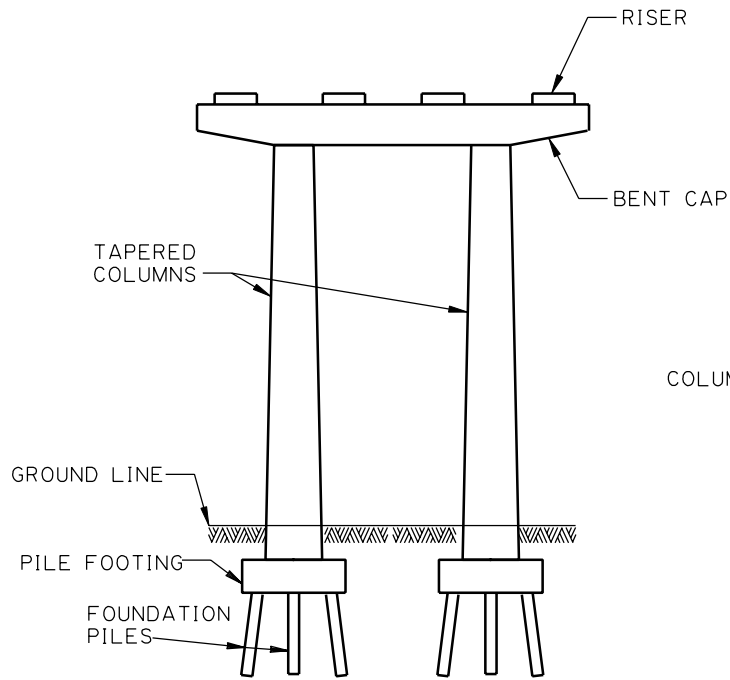
## Design Details

1. The minimum column diameter shall be 750 mm and larger columns will be in even 150 mm increments.
2. The minimum width of cap will be 100 mm greater than the column diameter or as dictated by the clearance to the bearing areas. The cap dimensions should be incremented in 100 mm increments.
3. The maximum stirrup spacing in a bent cap will be 300 mm. The first stirrup adjacent to the surface of a column will be a maximum of 75 mm away and the first space not greater than 150 mm. The minimum size of stirrups shall be a No. 15 bar.
4. Although designed as a tied column, circular columns shall have 9.5 mm spiral steel at 150 mm pitch with 2½ closed turns top and bottom. This does not meet the design requirements for a spiral design.
5. Columns shall be of solid cross-section.
6. Shrinkage and temperature moments in short columns, resulting from long concrete cap pours, can be relieved by using effective hinge details or staging the cap pours. A more detailed analysis of the structure / soil interaction may also be investigated to determine the actual effects of these moments on the structure.
7. It is advantageous to batter peripheral piles to minimize group action and stabilize the footing against horizontal movement when needed. However, battering should be practiced only when deemed necessary due to economics.
8. On transition bents, a wall and riser should be used when riser height > 350 mm.
9. For steel and concrete piling, the minimum spacing for foundation piling will be 1200 mm center to center or 3 x diameter, whichever is greater. Timber piling shall be spaced at 900 mm minimum centers. A minimum edge distance of 450 mm shall be provided.
10. When square tapered columns are used, a ratio of 1:50 shall be applied to all tapered faces.
11. Except in cases where uplift is anticipated, steel piles and timber piles shall penetrate the bottom of the footing a minimum of 300 mm and cast-in-place and precast piles shall have a 150 mm minimum penetration. In cases where uplift is anticipated the pile footing connection shall be designed.

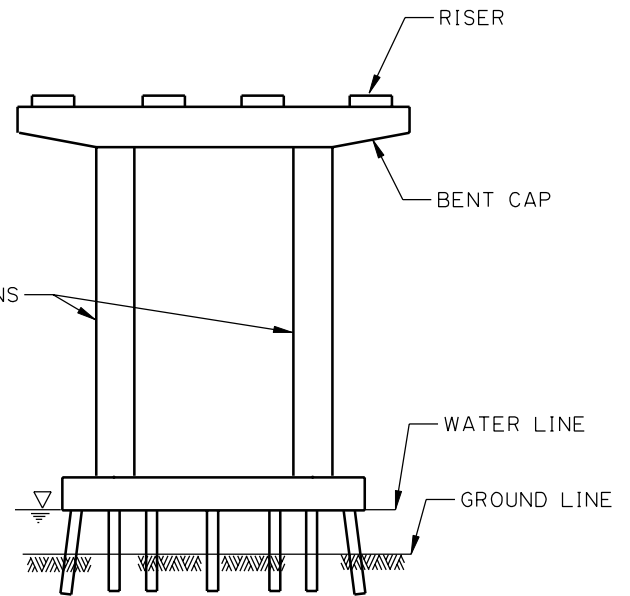
12. In most situations, the primary layers of reinforcement shall be placed 75 mm above the tops of the piles. For specific conditions, the design may require placing reinforcing steel between the piles.
13. The top of footings will be a minimum of 300 mm below natural ground elevation and 900 mm below the roadway subgrade for footings under the roadway.
14. Straps should be considered between isolated footings in a column bent when founded on soft soil or where erosion is possible. The primary purpose is to eliminate differential horizontal movement of the footings.
15. Longitudinal skin reinforcement in the vertical faces of caps exceeding 900 mm shall be provided for in accordance with AASHTO Specifications.
16. For structural mass concrete components whose least dimension exceeds 1200 mm (caps, piers, footings, etc.), minimum reinforcement shall be provided in accordance with AASHTO. This requirement is to reduce the effects of cracking due to the heat of hydration. For extreme situations of massive pours in adverse conditions, other specific counter measures may be required (See ACI). Seal concrete shall not be considered mass concrete.

#### Typical Column Sizes

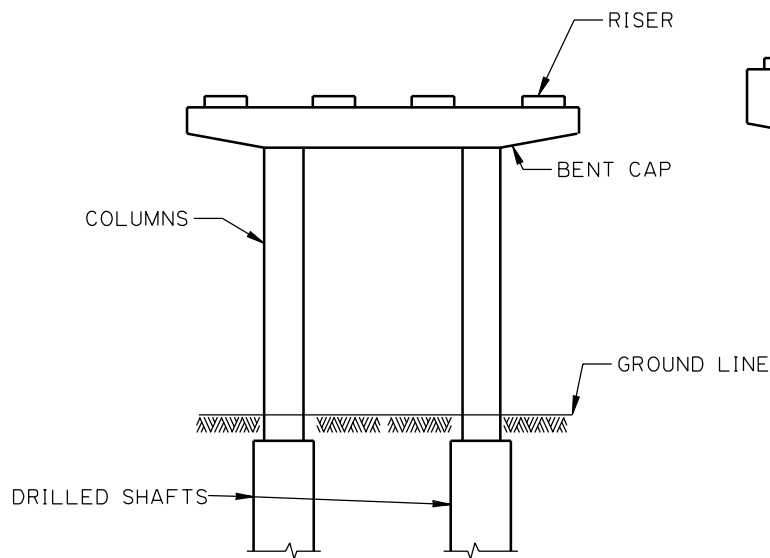
METRIC	ENGLISH EQUIVALENT
750 mm	30"
900 mm	36"
1050 mm	42"
1200 mm	48"
1350 mm	54"
1500 mm	60"



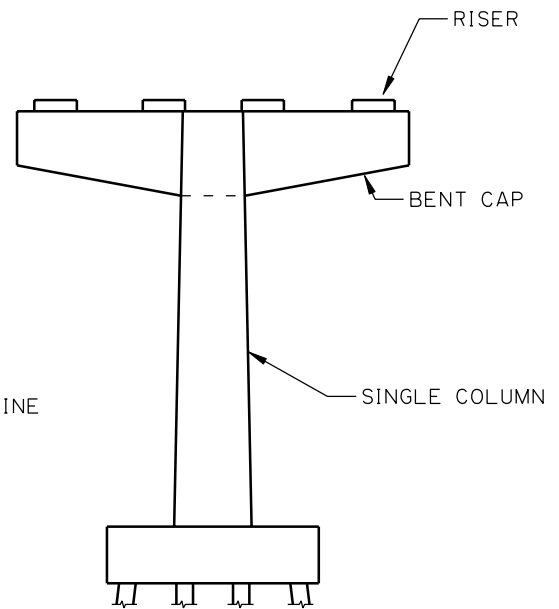
TALL BENT WITH FOOTING



BENT WITH LOW WATER FOOTINGS



BENT WITH DRILLED SHAFTS



HAMMER HEAD

**COLUMN BENTS**

## **END BENTS AND APPROACH SLABS**

### **INTRODUCTION**

The end bent, as its name suggests, is located at the end of a bridge where the transition is made from the normally deep founded bridge structure to a shallow founded pavement via the approach slab. The typical end bent to be discussed, unless otherwise noted, is constructed of reinforced concrete with a breast wall and wingwalls to contain a soil backfill and pile supported cap. This article is a guide to the analysis criteria and design considerations given to end bents and approach slabs, and is intended as a general policy statement and a supplement to the AASHTO Specifications.

#### Commentary

The approach slab serves as a transition apron from the soil supported pavement to the pile supported structure. It is intended to smoothly bridge minor differential settlements between the roadway slab and the bridge structure. When large differential long term settlements between the roadway slab and the bridge structure are expected, the Geotechnical Design Section will perform a fill height study to determine if long, flexible, pile supported approach slabs are required. The designer shall furnish the Geotechnical Design Section the required fill height and the time frame of the construction. Two (2) advantages are realized with this solution:

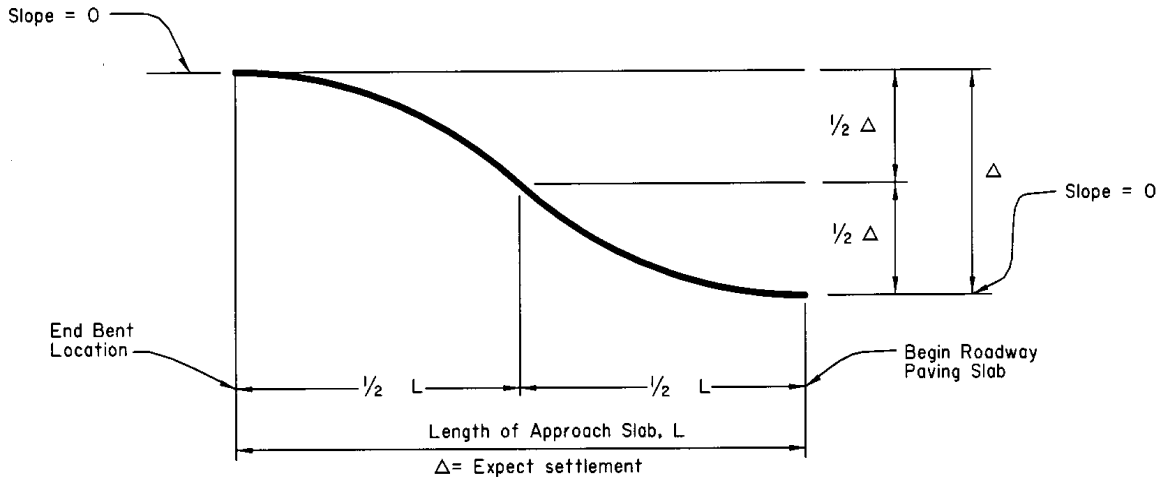
1. A smooth transition is maintained for improved riding characteristics for large expected settlements.
2. The length of conventional bridge structure may be reduced by replacement with the less expensive approach slab.

### **ANALYSIS**

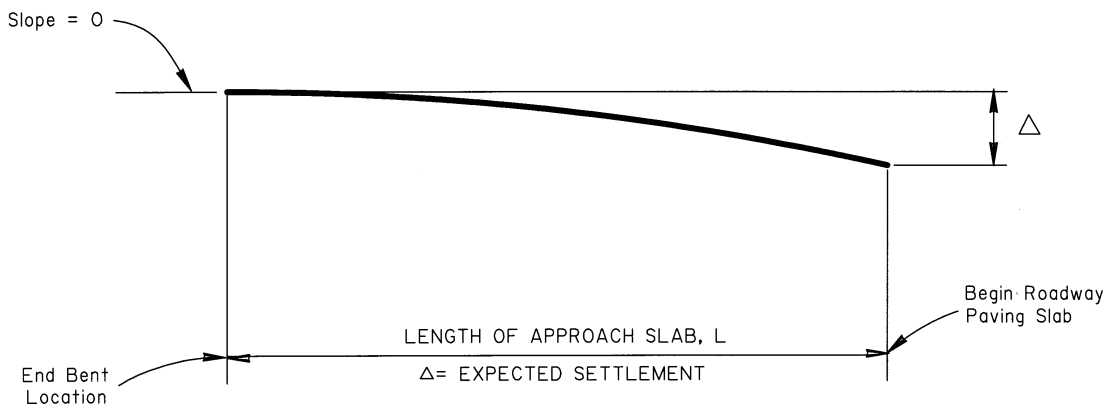
1. The short approach slab is founded directly on the paving base and is a one-way slab with its main reinforcement parallel to traffic. No design calculations are required and details are to be in accordance with the guidelines shown.
2. The long pile supported approach slab is designed to transition differential settlements between the shallow foundation roadway pavement and the deep foundation bridge structure at the end bent. The total length of the approach slab shall be determined by the Geotechnical Design Section. The permanent deflection due to settlement is assumed to be either a reverse parabola or a single parabola as shown. Piling are usually designed to carry the full live load and dead load near the end bent, and are shortened progressively toward the roadway pavement end of the approach slab. The soil beneath the approach slab should be checked to assure that no piles are tipped in a bearing layer. This configuration is intended to cause a progressive transition from the expected deep foundation behavior to the shallow

foundation behavior. The slab is also designed to carry the additional moment caused by the assumed parabolic deformation.

Condition 1,  
Design Deflection for Long Pile Supported Approach Slabs



Condition 2,  
Design Deflection for Long Pile Supported Approach Slabs



3. Wingwalls, breast walls and the bent as a unit shall be designed to resist active earth pressure under the appropriate group loads.
4. The reaction of the approach slab to the shelf of the end bent is based on the same assumption as in Items 1 and 2.

## DESIGN DETAILS

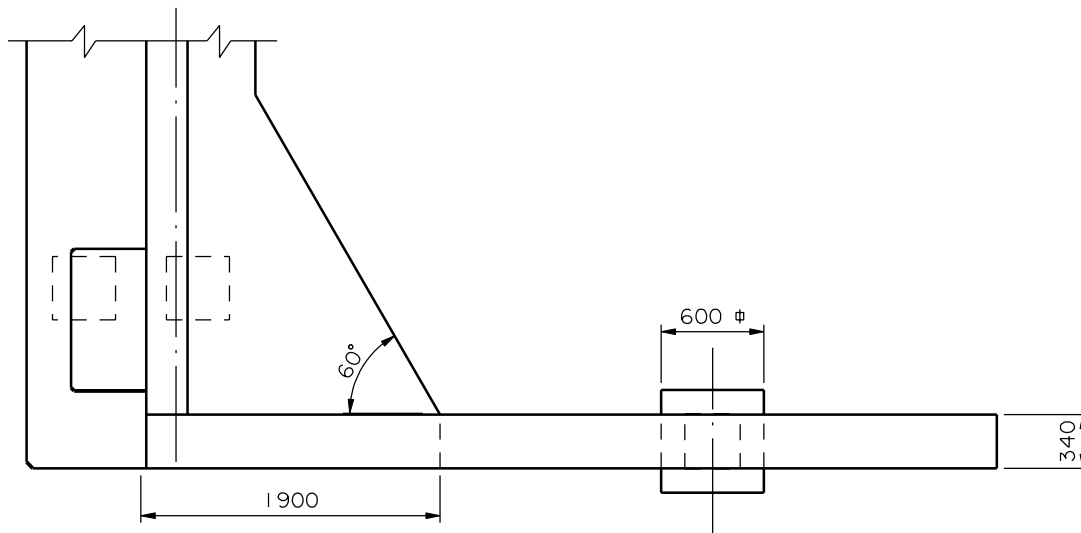
1. Wingwalls with stabilizing piles are required for all end bents on fills with the exception of slab span bridges and concrete girder spans with Type II girders.
2. Double-row, battered piles are required on all end bents except those for slab spans. Pile batter shall be 1 on 8.
3. On double row pile end bent caps, a 300 mm thick baffle shall extend 600 mm below the cap between rows of piling to prevent the movement of the soil confined by the bent.
4. On skewed or normal end bents, the roadway end of the approach slab is to be squared off for both rigid and flexible pavements.
5. Negative skin friction, caused by the consolidation of the fill and in situ soil in contact with the piles, is assumed to be insignificant because pilot holes are used for piling driven through a compacted fill. Granular material is used to fill the void between the pilot hole and the pile.
6. Pile supported approach slabs are continuous slabs supported by rows of timber piles on 3 m centers. The spacing between the piles in these rows usually varies between two (2) and three (3) meters. The timber piling shall be varied in length from row to row by a constant amount. Piling shall penetrate the footing to resist the tension required to hold the slab in its deformed configuration after settlement has occurred. Pile supported slabs are designed as one way slabs spanning between transverse grade beams at the pile rows.
7. When pile supported approach slabs are used, the barrier rail shall be extended the full length of the approach slab. This will prevent potential guardrail problems caused by embankment settlement in the deep pile region of the approach slab.
8. Prestressed girders end bent caps shall have a depth of 750 mm .
9. In south Louisiana, sand embankments are terminated by a shell plug, which eliminates erosion, formation of cavities, and settlement problems related to sand embankments and sand header banks. In north Louisiana, where shell is not readily

available, sand embankments are to be terminated by a clay plug at structure header banks in the same manner a shell plug is used in south Louisiana.

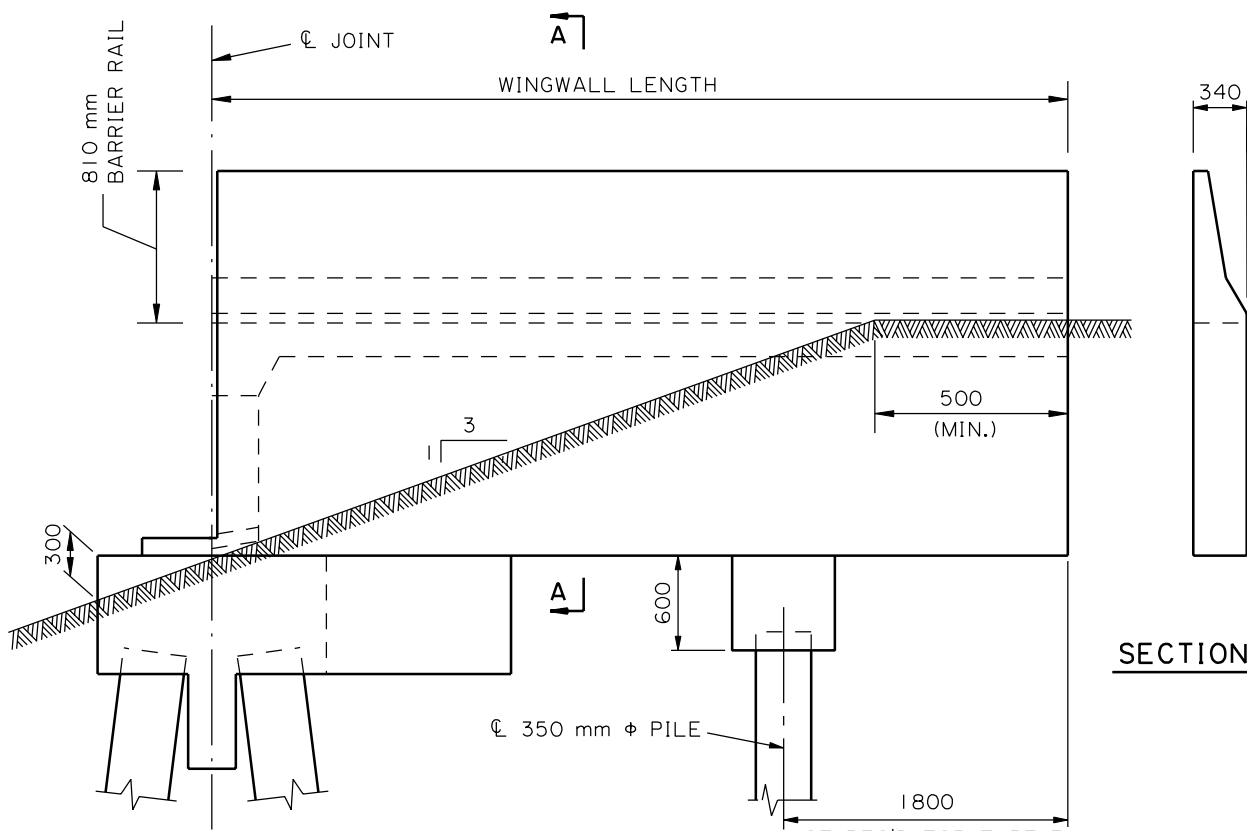
10. The following criteria will be used in determining slab lengths:

On fill sections, use 12 m long approach slab.

On cut sections, use 6 m long approach slab.



**PART PLAN**



**ELEVATION**

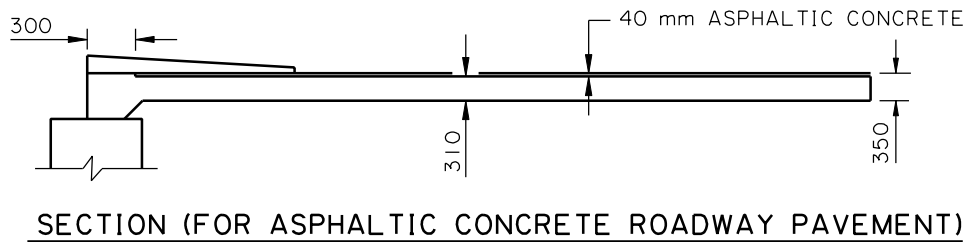
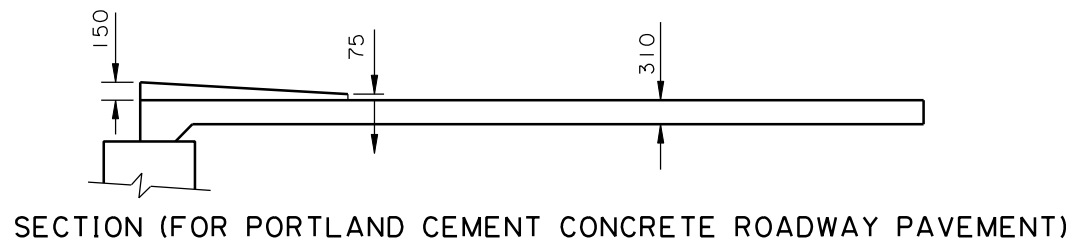
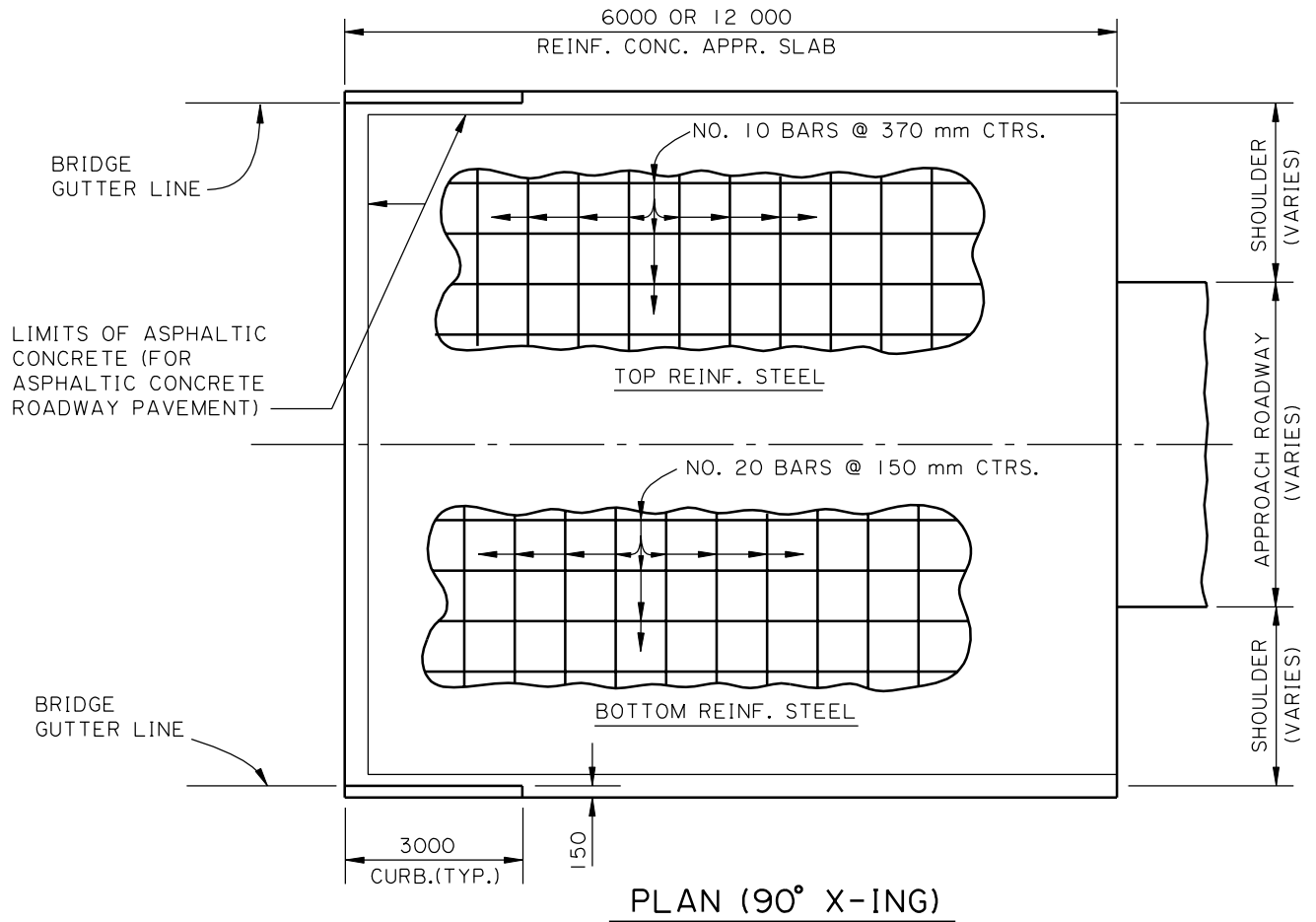
**SECTION A-A**

GIRDER TYPE	WINGWALL LENGTH
II	4500
III	5500
IV	6000
BT	7500

VALUES SHOWN ARE FOR BENTS ON 90° CROSSINGS WITH EXTERIOR RISERS OF 100 mm. ADJUST LENGTHS AS REQUIRED FOR SKEWED BENTS OR THOSE WITH HIGHER RISERS AND ROUND UP TO THE NEAREST 100 mm INCREMENT.

**WINGWALL DETAILS**



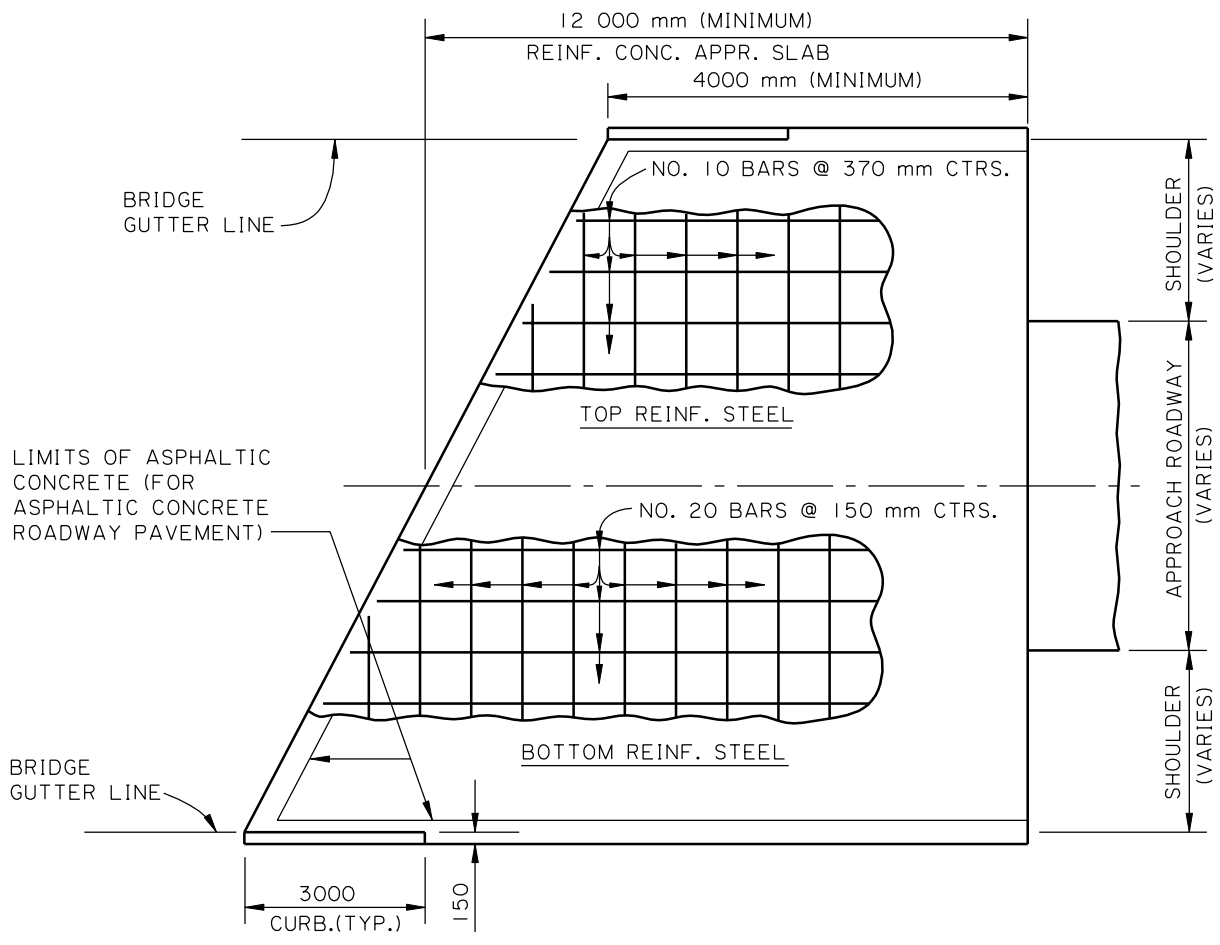


**NOTE:**

FOR BEDDING MATERIAL AND DRAINAGE UNDER APPROACH SLAB

SEE STANDARD DETAIL ASD-SS(M).

**STANDARD APPROACH SLAB  
FOR SLAB SPAN BRIDGE**



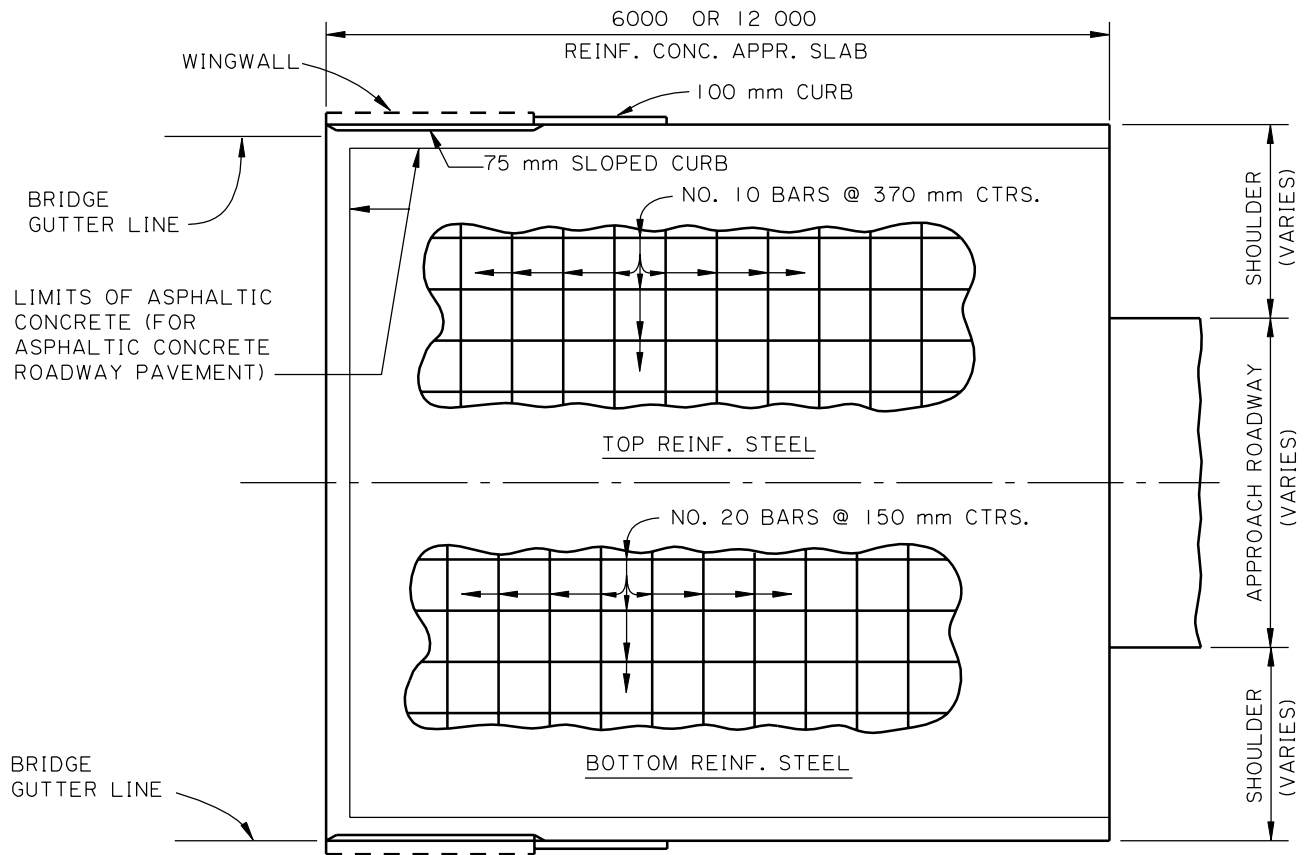
PLAN (SKEWED X-ING)

**NOTE:**

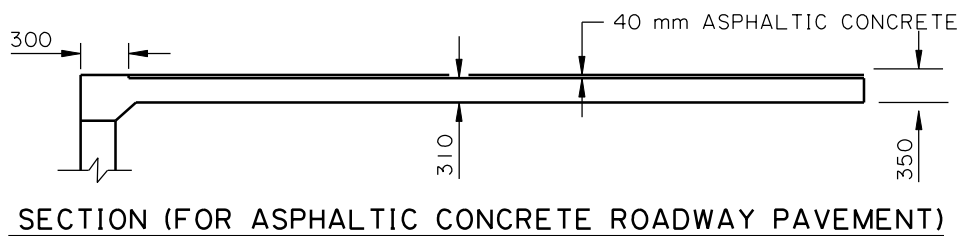
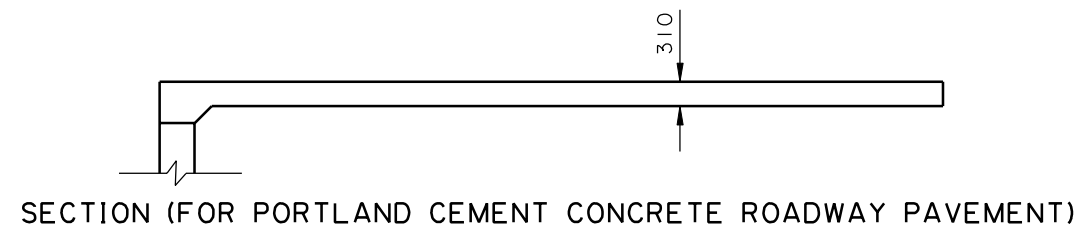
FOR BEDDING MATERIAL AND DRAINAGE UNDER APPROACH SLAB

SEE STANDARD DETAIL ASD-SS(M).

**SKEWED APPROACH SLAB  
FOR SLAB SPAN BRIDGE**



PLAN (90° X-ING)

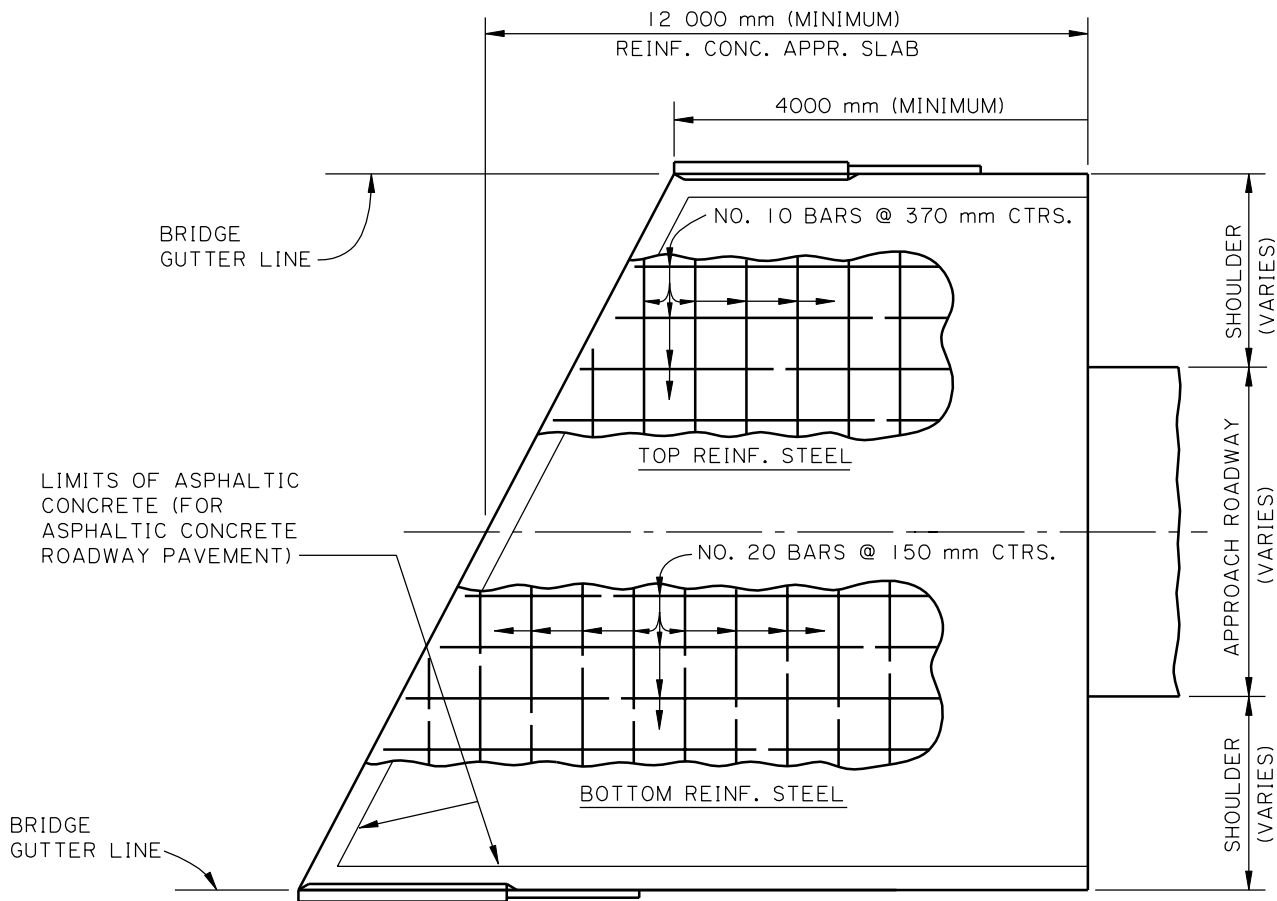


**NOTE:**

FOR 75 mm SLOPED CURB, 100 mm CURB AND WINGWALL DETAILS  
SEE BRIDGE END DRAIN DETAILS.

FOR BEDDING MATERIAL AND DRAINAGE UNDER APPROACH SLAB  
SEE STANDARD DETAIL ASD-SA(M).

**STANDARD APPROACH SLAB  
FOR GIRDER SPAN BRIDGE**



PLAN (SKEWED X-ING)

**NOTE:**

FOR 75 mm SLOPED CURB, 100 mm CURB AND WINGWALL DETAILS  
SEE BRIDGE END DRAIN DETAILS.

FOR BEDDING MATERIAL AND DRAINAGE UNDER APPROACH SLAB  
SEE STANDARD DETAIL ASD-SA(M).

**SKEWED APPROACH SLAB  
FOR GIRDER SPAN BRIDGE**



## RETAINING WALLS

### INTRODUCTION

Retaining walls are used primarily in urban areas to retain embankment slopes which would, otherwise, spill onto adjacent property, or force adjacent ramps or frontage roads outward, thus requiring additional right-of-way. Retaining walls are sometimes connected to the bridge abutment. The breast wall and wingwalls of the end bent is considered a type of a retaining wall since it is retaining the embankment behind the end bent.

Retaining walls are typically either cast-in-place concrete walls or proprietary Mechanically Stabilized Earth (MSE) walls. Typically the MSE wall is found to be most economical in most situations, although certain sites and applications may still require the use of a cast-in-place wall. Cast-in-place walls are placed on either pile footings or spread footings depending on soil conditions and the height of the wall. MSE walls normally require only a small non-reinforced concrete leveling pad for the wall panels or blocks to sit on. The pads are usually 300 mm wide by 150 mm thick.

The bridge section currently maintains standard plan RW-01(M) which is a cast-in-place wall used for minor heights (maximum 1.8 m). The road design section normally uses this standard for minor roadway applications.

### CAST-IN-PLACE RETAINING WALLS

#### Design

1. The working stress method shall be used to design the walls, footings and piles.
2. The Rankine Theory shall be used with the following assumptions:  
Phi = 30 degrees  
Unit soil weight = 1920 Kg/m<sup>3</sup>  
Equivalent fluid pressure = 640 Kg/m<sup>3</sup>
3. The wall and footing shall be designed for a Class "A" concrete with a  $f'c = 22$  MPa.
4. AASHTO seismic criteria shall be accounted for in the design.
5. Neglect friction between the wall and the backfill.
6. Passive pressure shall be used for resistance only if the fill is high enough on the front of the wall to significantly affect the design.

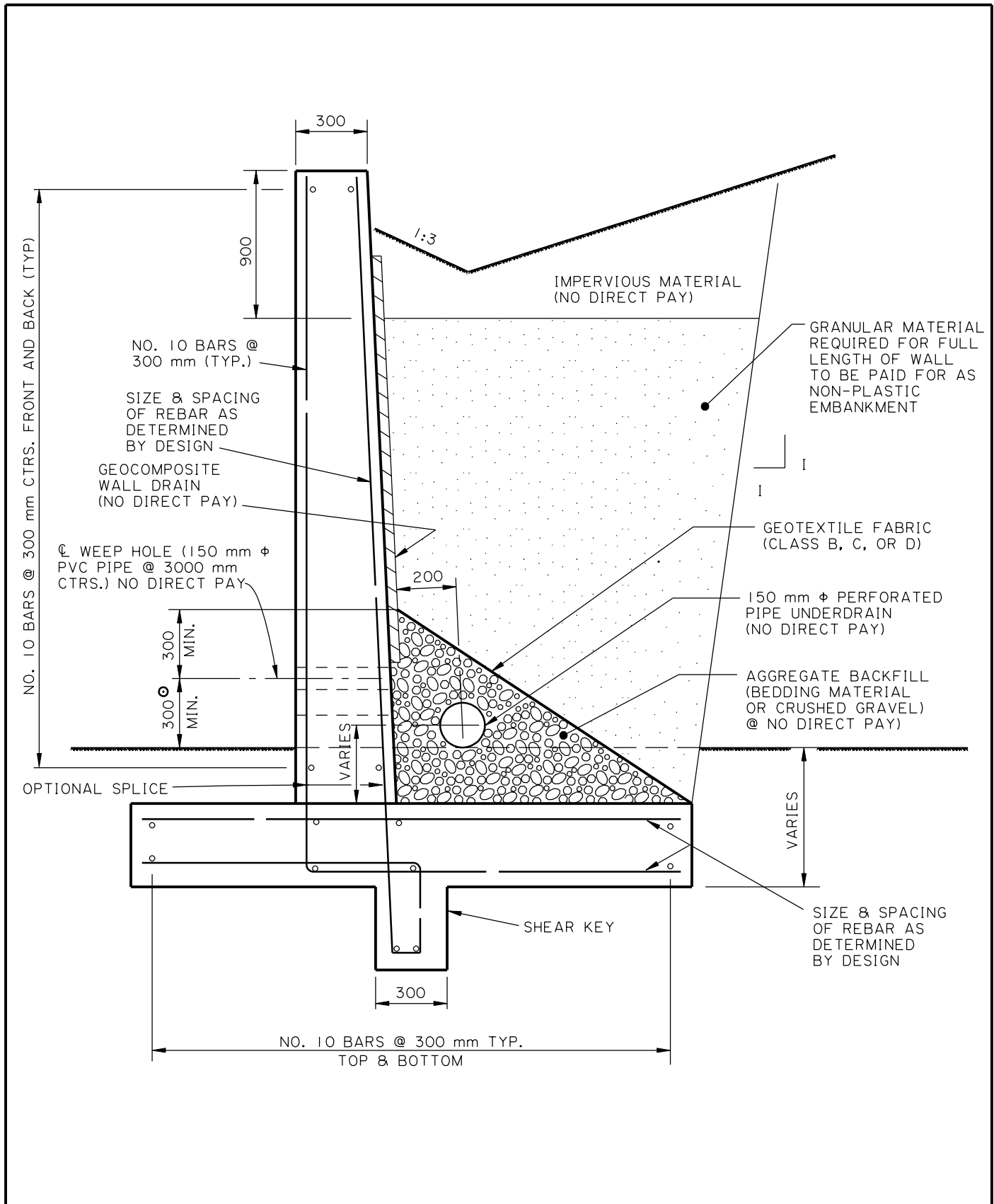
7. Allowable lateral loads for piles shall be based on information from Chapter 6, Driven Pile Section.
8. Generally, counterforts are recommended for walls in excess of 7.6 m in height. Exceptions should be discussed on a case by case basis. Where counterfort wall sections abut cantilever wall sections, the latter shall have a single counterfort adjacent to the interface.
9. Spread footings are permissible wherever soil conditions, water table elevations and wall heights, are favorable for such footings. A shear key (stub wall) is generally used with spread footings to resist sliding.
10. Timber piles are normally used for retaining walls, however depending on driving conditions, steel or concrete piles or drilled shafts may be required.
11. For spread footings, a factor of safety of 2.0 shall be used for overturning, and 1.5 for sliding.
12. Pile footings shall be designed for no tension in heel piles.
13. The overall stability of slopes in the vicinity of the wall must be checked. This should be coordinated with the Pavement and Geotechnical Design Section

#### Details

1. Expansion joints should be provided in the wall at approximately 27 m intervals, and contraction joints at 9 m intervals. Expansion joints in the footings shall coincide with joints in the wall.
2. Weepholes for drainage should be provided at 3 m intervals.
3. A geo-composite wall drain should be provided against the backwall with aggregate backfill.
4. A 150 mm diameter perforated pipe drain should generally be placed against the backwall with aggregate backfill.
5. Bridge end drain details with appropriate modifications shall be provided when applicable.
6. In general, stepped footings are permissible. Wall transitions should generally be sloped, except when they support sound walls, in which case they should be stepped
7. If a concrete barrier transition is to be provided, a transition length of 4.6 m should be used. A concrete barrier face is required when the face of the wall is within

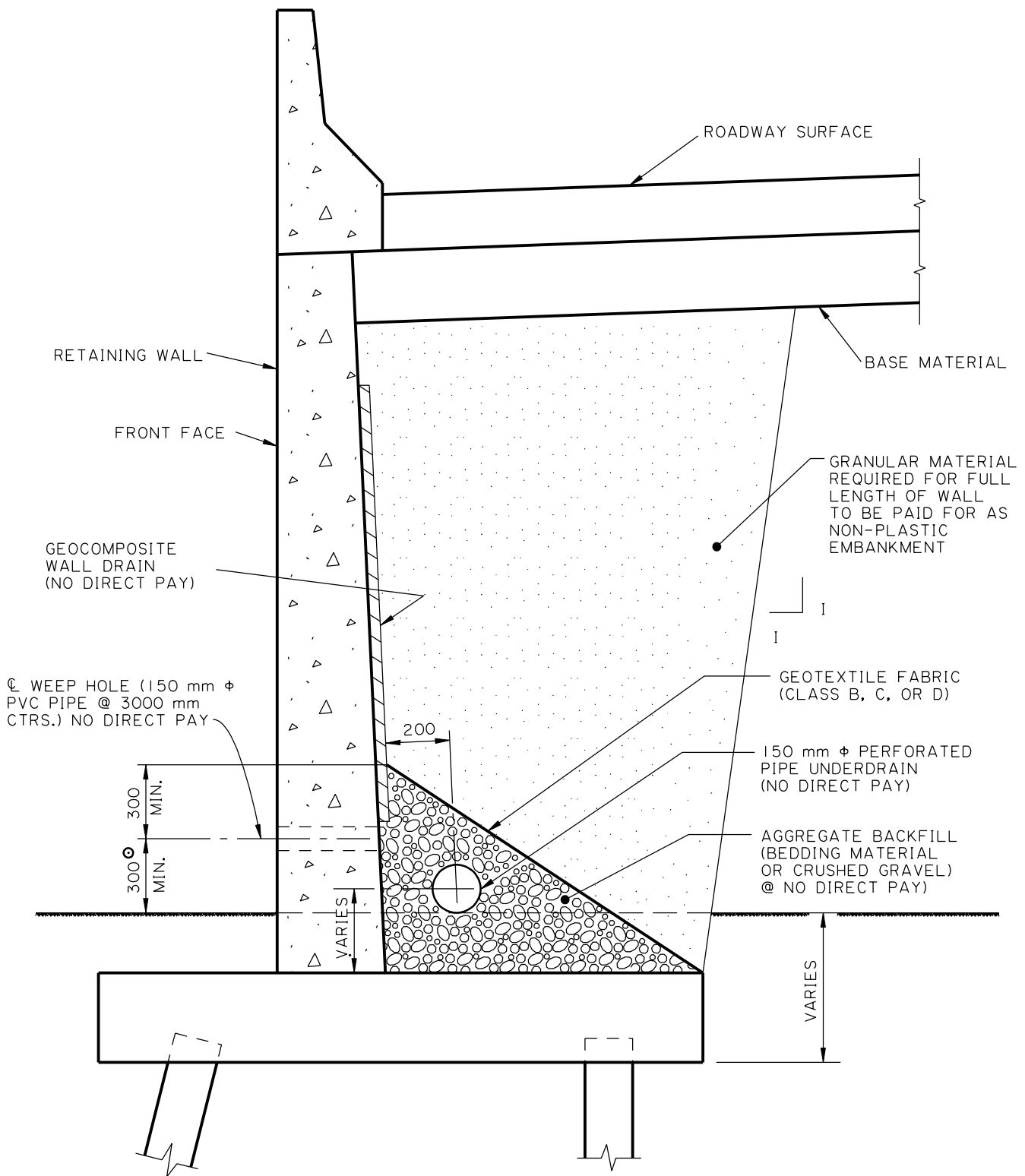
- 9.1 m of the edge of the travel lane. Pedestrian rails or combination rails should be provided for walls more than 0.9 m high if pedestrian traffic is probable.
8. Tangent sections of retaining wall, approximately 9 m long, will be allowed in curved sections of roadway with a low degree of curvature.
  9. No direct payment will be made for water stop or joint materials.
  10. Shear keys should generally be provided at the expansion joints of both walls and footings, and at the contraction joints of wall.
  11. Noise barrier requirements shall be accounted for in the detailing when applicable.
  12. A pile data sheet that includes pile cutoff, tip, plan pile length or order pile length and maximum pile loads should also be included.





○ WEEP HOLES ARE TO BE LOCATED TO DISCHARGE ABOVE GROUND LINE OR GUTTER LINE. EXACT LOCATION TO BE DETERMINED BY THE PROJECT ENGINEER.

**TYPICAL DRAINAGE DETAILS AND REINFORCING STEEL FOR CAST-IN-PLACE RETAINING WALL**



⊙ WEEP HOLES ARE TO BE LOCATED TO DISCHARGE ABOVE GROUND LINE OR GUTTER LINE. EXACT LOCATION TO BE DETERMINED BY THE PROJECT ENGINEER.

**TYPICAL DRAINAGE DETAILS FOR CAST-IN-PLACE RETAINING WALL WITH BARRIER**

## MECHANICALLY STABILIZED EARTH WALLS

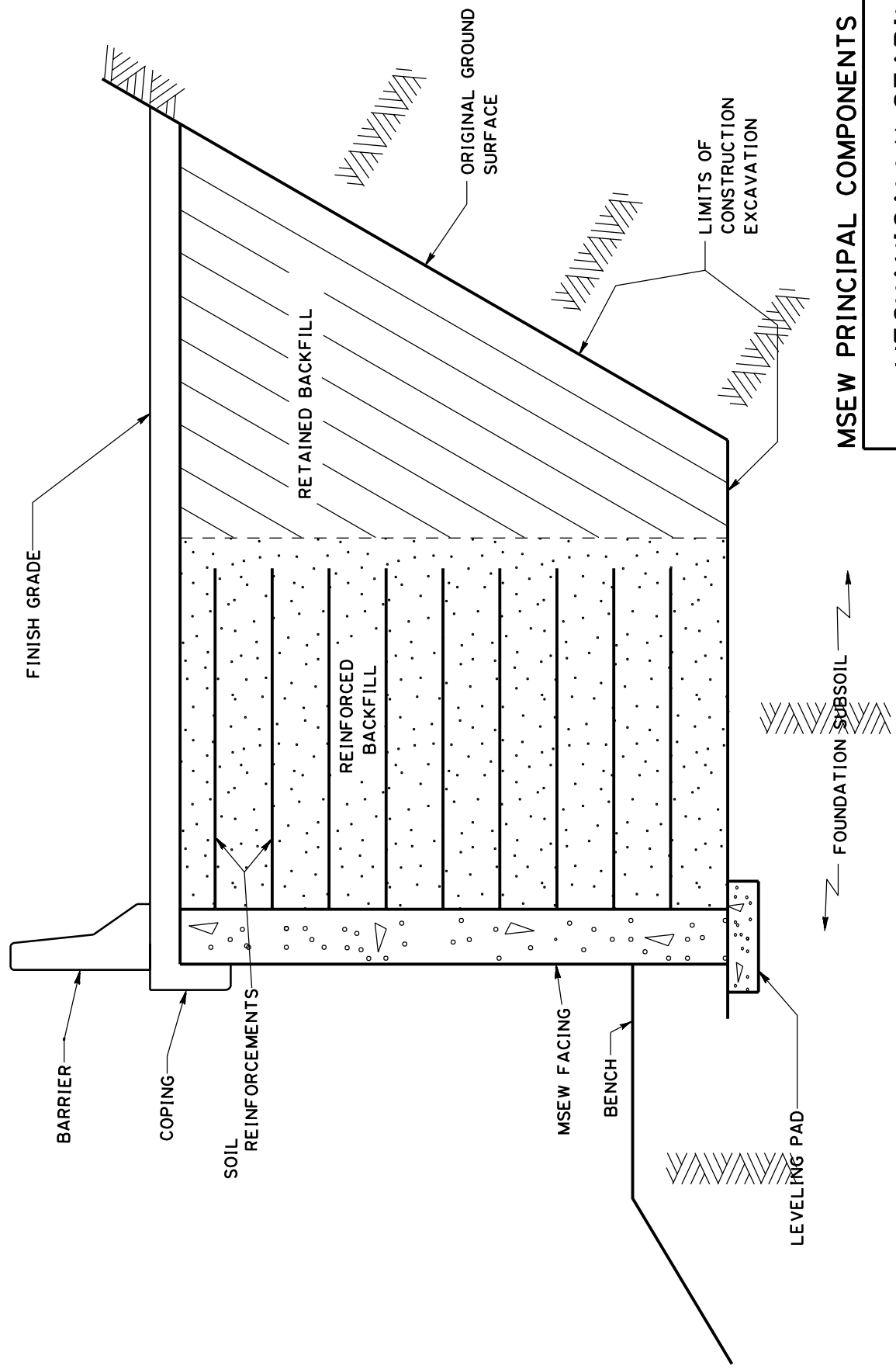
A broad definition of reinforced soil or mechanically stabilized embankments would be the inclusion of reinforcing elements such as straps, bars, welded wire mats, polymer grids, sheets of fabric (geosynthetic) and various anchor systems for the purpose of improving the mechanical properties of the soil mass. All of the system elements including the back fill must receive adequate attention during the design and construction stages.

The concept of soil reinforcement has a well established history dating back to biblical times. However, modern techniques for mechanically stabilizing or reinforcing soil were only introduced about 20 years ago.

Reinforced soil structures are constructed in a manner that produces a structure of alternating layers of soil and reinforcing elements as shown in Figure 1. In general, the spacing between reinforcement layers varies from about 300 mm to 750 mm. Soil reinforcing systems have three main components: reinforcement elements, backfill material and facing elements, see figure 1, page 6 (54). The primary differences between various soil reinforcement systems that are currently available are the materials and configuration of the materials that are used for the reinforcing and facing elements.

Even though different materials are used, the same basic criteria must be employed to design the systems. In general, the basic design procedure for reinforced soil structures is well established. The basic design criteria for reinforced soil retaining walls involves satisfying external stability and internal stability.

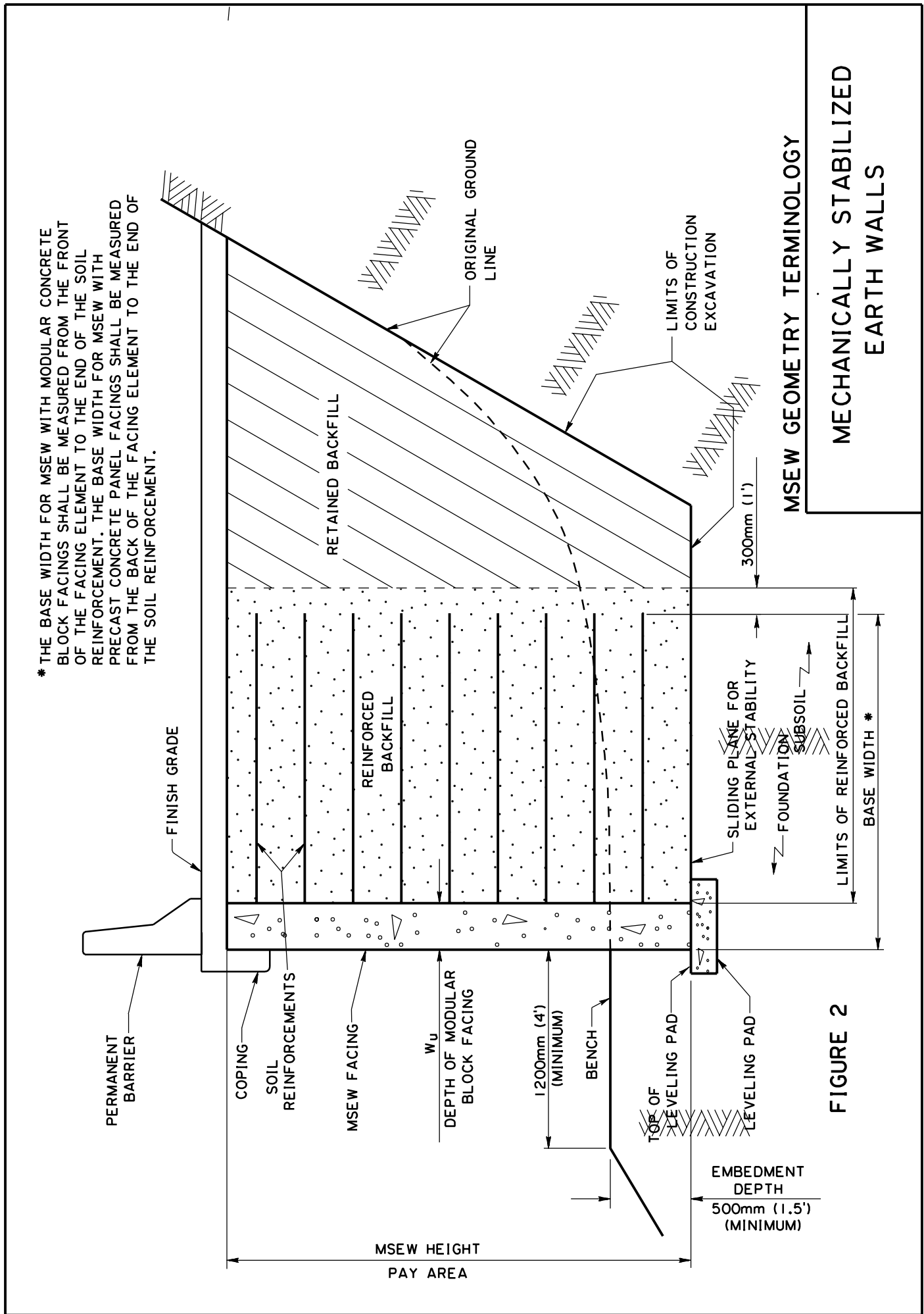
For complete information on this subject, including but not limited to approval procedure for suppliers, design and selection considerations, contracting methods, pay items, details, specific design requirements and construction specifications, please refer to the MSEW Design Guide prepared by the Pavement and Geotechnical Design Section



MSEW PRINCIPAL COMPONENTS

MECHANICALLY STABILIZED EARTH WALLS

FIGURE I



\* THE BASE WIDTH FOR MSEW WITH MODULAR CONCRETE BLOCK FACINGS SHALL BE MEASURED FROM THE FRONT OF THE FACING ELEMENT TO THE END OF THE SOIL REINFORCEMENT. THE BASE WIDTH FOR MSEW WITH PRECAST CONCRETE PANEL FACINGS SHALL BE MEASURED FROM THE BACK OF THE FACING ELEMENT TO THE END OF THE SOIL REINFORCEMENT.

MSEW GEOMETRY TERMINOLOGY

MECHANICALLY STABILIZED EARTH WALLS

FIGURE 2

## **COFFERDAMS**

### **INTRODUCTION**

Cofferdams, for the purpose of this manual can be defined as a temporary structure, usually braced steel sheet piling, built to exclude earth and water from an excavation so that work can be performed in a dry condition. Cofferdams should be conservatively designed, soundly constructed and well maintained in order for them to function most often under the most adverse conditions, sometimes including floods and shifting river bottoms. The fact that these structures are temporary, necessitate that they be economically constructed yet the design must take into account all local conditions and make good use of engineering knowledge and judgement.

Most cofferdam systems are composed of two primary components. The sheet pile perimeter with the walers, struts and bracing, and the tremie seal. The tremie seal is a non-structural, non-reinforced layer of concrete poured under water after excavation has been performed to the required elevation. Its purpose is to partially "seal" the bottom of the cofferdam against water seepage and partially or totally counter-act the hydrostatic uplift due to buoyancy. The seal depth is usually a minimum of 1.5 m and can be as thick as 5 m. In some very isolated situations, a tremie seal may not be necessary as in the case of a very hard, non-permeable, clay stratum.

The designer is responsible for the design of the tremie seal and pile/soil interaction. A design water surface elevation must be established after consideration of past historical hydrographs and depth of foundation. The contractor is responsible for the design of the cofferdam sheeting and bracing including length of the sheet piles. The special provisions must include information on the design water elevation and an allowance for the contractor to redesign at a different elevation to accommodate his operations subject to the approval of the Bridge Design Engineer.

### **DESIGN CRITERIA**

1. The total depth of the tremie seal shown in the plans shall be the design depth utilized plus 300 mm.
2. Assume 100% full hydrostatic head acting on the bottom of the seal for the purpose of calculating uplift.
3. Do not use the weight of the sheet piles, struts, etc. in the computation of downward loads. The weight of the structures' piles may be used if properly anchored into the seal.

4. Neglect the friction force between the seal and the sheet piles.
5. 5) Use an allowable 69 KPa friction force between the structural piles and the design seal depth. If more load needs to be developed, anchorage should be designed (AASHTO 1977).
6. Design of the seal and piles in uplift shall be in accordance with Case 1 and 3 of AASHTO 1992 Section 4.5.6.6.2.
7. If pile lengths are being governed by tension, a test pile in tension should be considered to reduce the factor of safety from 3.0 to 2.0.
8. The perimeter of the cofferdam should be sized at least 1 m larger than the footing all around and should also be checked for conflict at the sheet pile/structural battered pile intersection using a realistic sheet pile penetration assumption.

## EMBANKMENTS AND REVETMENTS

### EMBANKMENT PROTECTION

The following types of embankment protection are generally used for bridges:

1. Cast-in-place revetment is normally used for grade separation structures where hydraulics is not a consideration or above the water line for urban bridges where aesthetics is a consideration. (See Standard Plans on Appendix A)
2. Unless site conditions warrant otherwise, flexible revetment or rip rap shall be specified for all waterways crossings in accordance with the following criteria:
  - a) For waterways with design average velocity ( $v$ ) of 1.0 m/sec. or less, use flexible revetment to a limit of 2 m outside the fascia of the structure.
  - b) For velocities between 1.0 m/s and 1.5 m/s, the plans should specify class 25 (kg) rip rap to be wrapped around the embankment on the upstream side to the limits of the approach slab. For certain situations where existing site conditions reveal a history of problems and the design average velocity exceeds 1.5 m/sec., class 55 (kg) or larger rip rap should be specified and wrapped around upstream side as previously noted. Coordination with the District Maintenance and Headquarters Hydraulics sections is recommended as unusual situations arise.
3. Erosion control covering is a system, which should be specified to protect embankments from erosion until vegetation takes over. It may consist of a fiberglass roving or curled wood matting.
4. Spur dikes are occasionally required to break the flow of water around the corner of the bridge embankment in order to prevent abutment scour. Close coordination with the Hydraulics' section is necessary. (See Standard Plans SD-50, SD-100, SD-150, and SD-200)
5. Bridge end drainage is an important aspect of embankment protection. Open deck drains are generally discontinued near the abutments to prevent erosion of the foreslope. In the case of overpasses, or other bridges with vertical curves or relatively high embankments, bridge end drains are normally used. (See Bridge End Drain Standard Detail, Appendix A)
6. Clay blankets or clay or shell plugs are generally required for sand embankments, except when retaining walls are used to contain the sand embankment. In all cases, a select backfill is used adjacent to the abutment See approach slab drainage



standard details, (Appendix A). Embankments and specification thereof are generally covered in the road plans.

The following bridge embankment items should be considered in preliminary planning:

1. When fill heights are a major factor in establishing bridge lengths, a settlement and a stability analysis should be requested from the Geotechnical Design Section at an early stage along with the deep borings. Special construction methods may be employed to minimize the effects of settlement. These may include the use of wick drains, surcharge or prolonging the placement of the approach slab and roadway or a combination of these. In some situations, the Geotechnical Design Section may recommend the installation of settlement plates or other instrumentation to monitor the settlement under roadway embankments or bridge approaches. The results of the settlement monitoring may be used to determine when to remove surcharges or allow paving or construction of approach slabs. If required, the following note shall be placed in the General Notes of the bridge plans: "Settlement Instrumentation: Settlement plates will be required at (locations)".
2. Generally, 1:3 foreslopes will be used for fill heights of 6 m or less. In cases where fill heights exceed 6 m 1:4 foreslopes will be used. Fill heights in excess of 9 m will not be permitted, except with the approval of the Bridge Design Engineer. In cut sections, foreslopes of 1:2½ may be used if soil and hydraulic conditions permit.
3. The designer should exercise caution when placing fill within the channel. This is particularly true when stream velocities are high, or when unstable soil conditions exist, such as "rapid draw down", in which the water level drops quickly, leaving a heavy, saturated embankment.
4. When placing fill in existing channels, lakes, sloughs, etc., the District Construction Engineer should be contacted to provide probing in order to determine the quality and depth of mucking required. This information will also be useful in investigating the stability of the embankment.

### Procedure For Determination Of Toes Of Slope And Computation Of Quantities For Embankment Surfacing Materials

1. When General Plan is drawn the detailer should coordinate with Road Design to obtain roadway typical sections.
2. The General Plan Checker is responsible for checking cross sections sheets for accuracy. The checker is responsible for obtaining the latest roadway typical sections and embankment widening details. Permissible error in toe of slope location is  $\pm$ one (1) meter except where toe location is critical.
3. Computations for embankment surfacing materials are to be shown on cross sections sheets by the checker using correct toes of slope. These computations are to be back checked by the detailer. A 5% difference between checkers and detailer's quantity will be considered within tolerance. Use the higher number.

## SEISMIC REQUIREMENTS

### GENERAL

In order to design to resist the effect of earthquake motions, the designer is referred to by AASHTO Standard Specifications for Highway Bridges, Section 3.21 to Division 1-A. The provisions in this section apply to bridges of conventional steel and concrete girder and box girder construction with spans not exceeding 150 m. Suspension bridges, cable-stayed bridges, arch type and movable bridges are not covered.

From the contour map of horizontal Acceleration Coefficients (A) provided in AASHTO's Section 3.2, Louisiana has coefficient values that range from about 2 to 4 percent of gravity. Bridges additionally are assigned an Importance Classification (IC) [Section 3.3]. Based on "A" and "IC", all bridges in Louisiana are placed into Seismic Performance Category (SPC) "A" [Section 3.4].

Category "A" requires the least analysis [Section 4.2] and is covered in Section 5. The two requirements which must be met are:

1. Minimum support length

Provide minimum bearing support length (N) for expansion end of all girders.

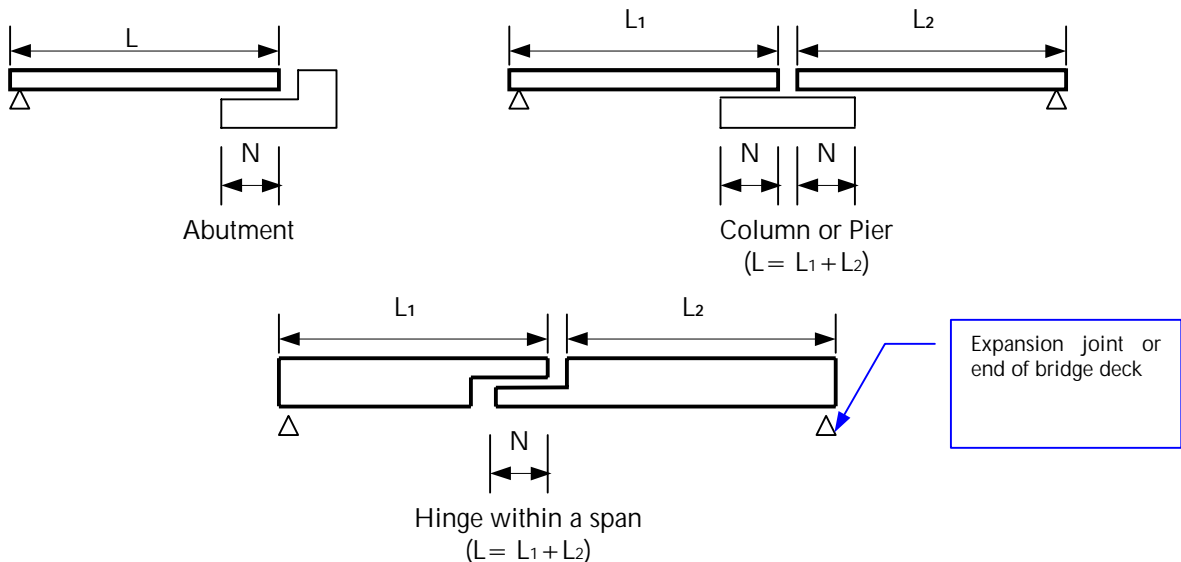
N = Minimum bearing support length for expansion end of all girders in mm.

$$= (203 + 1.67L + 6.66H)(1 + 0.000125S^2) \text{ where}$$

L = length (m) as shown

H = average (m) height of columns supporting the bridge deck to the next expansion joint

S = angle of skew of support in degrees, measured from a line normal to the span



### DIMENSIONS FOR MINIMUM SUPPORT LENGTH REQUIREMENTS

## 2. Horizontal restraint

A mechanical device used to connect the superstructure to the substructure shall be designed to resist a horizontal seismic force in each restrained direction equal to 0.20 times the dead load reaction at that bearing.

For precast-prestressed concrete girders, the following design values are derived. For other types of superstructures, compliance with the seismic provisions can be accomplished in a similar manner.

### a) Allowable Shear Stress:

ITEM	GRADE	SERVICE LOAD (MPa)
Anchor bolts	ASTM F1554 <sup>1</sup> Grade 36	$F_v = {}^21.5 \times ({}^30.40F_y) = 148.8$
Cap Screws	ASTM A307 Grade A	$F_v = {}^21.5 \times ({}^475.8) = 113.8$
Dowels	ASTM A615M Grade 420	$F_v = {}^21.5 \times ({}^30.40F_y) = 252.0$

### b) Type of Anchorage:

expansion ends: two 30.0 mm diameter anchor bolts with four M24 cap screws  
 fixed ends: galvanized #35M deformed reinforcing dowels, 1000 mm long

### c) Restraint resistance:

#### Expansion Ends

Anchor bolts:

$$A = 502 \text{ mm}^2 \text{ (root area) [assumed for Service Load]}$$

$$PR = \text{Horizontal Resistance}$$

$$= 148.8 \text{ N/mm}^2 \times (502 \text{ mm}^2) \times 2 \text{ bolts}$$

$$= 149.4 \text{ kN/anchored girder end}$$

Cap screws:

$$A = 452.4 \text{ mm}^2 \text{ (gross area) [T10.32.3A(b)]}$$

$$PR = 113.8 \text{ N/mm}^2 \times (452.4 \text{ mm}^2) \times 4 \text{ screws}$$

$$= 205.9 \text{ kN/anchored girder end}$$

Control  $\leq$  Anchor Bolts  $\leq$  Cap screws

**PR = 149.4 kN/anchored girder end**

<sup>1</sup> 36Ksi=248MPa

<sup>2</sup> AASHTO Standard Specifications, Division I-A, Section 5.5

<sup>3</sup> AASHTO Standard Specifications, Division I, Table 10.32.1A

<sup>4</sup> AASHTO Standard Specifications, Division I, Table 10.32.3A

c) Restraint resistance (continued):

Fixed Ends

Dowels:

$$A = 1000 \text{ mm}^2 \text{ (gross area) [assumed for SL]}$$

$$PR = 252 \text{ N/mm}^2 \times 1000 \text{ mm}^2 \div 2 \text{ ends}$$

$$PR = 126.0 \text{ kN/anchored girder end per dowel}$$

d) Provided restraint:

$$\Sigma PR > 0.2 * \text{Dead Load of Superstructure at support}$$

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## **ENVIRONMENTAL CONSIDERATIONS**

### **GENERAL**

Environmental clearance is needed prior to obtaining most permits. The agencies issuing the permits are; U.S. Coast Guard, Department of Army, U.S. Corps of Engineers, LA Department of Natural Resources Coastal Management Division and LA Department of Wildlife and Fisheries. For most "normal projects" a preliminary environmental clearance will be sufficient prior to ordering a survey. However for projects which affect wetlands, cause displacements, or affect environmentally sensitive areas, an environmental clearance will be required prior to ordering a survey. The environmental document will fall into one of the following categories: Environmental Impact Statement, Environmental Assessment, or Categorical Exclusion. An Environmental Assessment (EA) provides sufficient environmental documentation to determine whether an Environmental Impact Statement (EIS) is required or whether a Finding of No Significant Impact (FONSI) can be made. A Categorical Exclusion (CE) is a class of actions, which do not have a significant effect on the human environment. This action requires minimal documentation.

### **REQUIRED INFORMATION**

#### Preliminary Project Description

1. Written Preliminary Project Description<sup>1</sup>
2. Identify The Preferred Alternate,( if one exists, and its justification)<sup>1</sup>
3. Existing Right-Of-Way and/or Existing Apparent Right-Of-Way<sup>1</sup>
4. Typical Required Right-Of-Way<sup>1</sup>
5. Which Side Of The Road The Right-Of-Way Extends<sup>1</sup>
6. Aerials with Approximate Existing and Required Right-Of-Way Marked<sup>1</sup>

---

<sup>1</sup> NEEDED FOR DETERMINATION OF CATEGORICAL EXCLUSION OR ENVIRONMENTAL ASSESSMENT



### Traffic Data

1. Average Daily Traffic<sup>2</sup>
2. Turning Movement Diagrams

### Information To Forward As Obtained

1. Field Rolls<sup>2</sup>
2. Construction Cost<sup>2</sup>
3. Data from The Reconnaissance Evaluation/Pre-Design Planning Conference
4. Location and Survey Plans
5. Preliminary Plans
6. Building Outlines and Elevations
7. Profiles of Main Line, Ramps, and Crossroads
8. Cross Sections by Stations or Half Stations
9. Contour Maps,( if available)

### Information From Initial Field Study

1. Presence of Hazardous Waste<sup>2</sup>
2. Presence of Above Ground Storage Tanks<sup>2</sup>
3. Presence of Filler Caps Or Pump Islands<sup>2</sup>
4. Presence of Water Wells<sup>2</sup>
5. Presence of Parks/Playgrounds/Recreational Facilities<sup>2</sup>
6. Presence of Hotel/Motels/Offices<sup>2</sup>
7. Presence of Cemeteries/Churches<sup>2</sup>

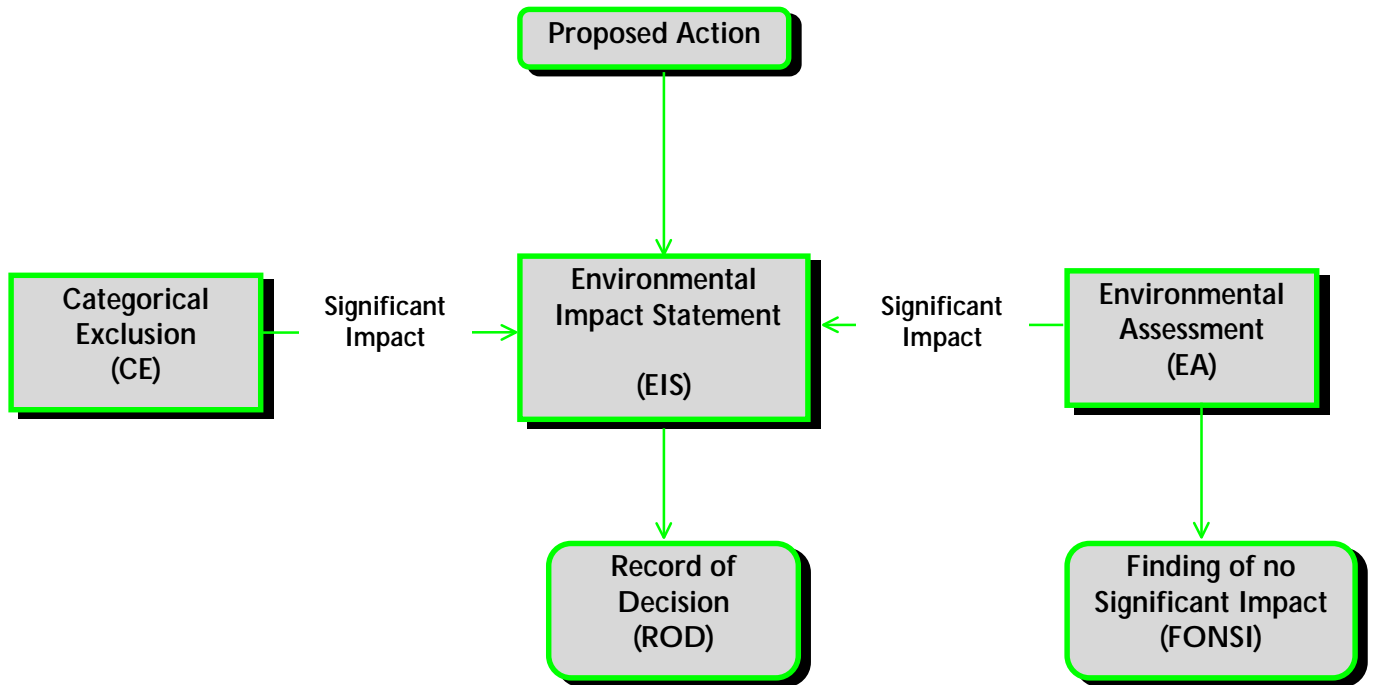
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<sup>2</sup> NEEDED FOR DETERMINATION OF CATEGORICAL EXCLUSION OR ENVIRONMENTAL ASSESSMENT

## ENVIRONMENTAL PROCESS FLOW CHART

### PROCESSING OPTIONS:

1. Categorical Exclusion
2. Environmental Assessment
3. Environmental Impact Statement



## **PERMITS**

### **Section 4(f) (Title 49, United States Code, Section 303)**

Section 4(f) applies to historic properties and archaeological sites listed or eligible for listing on the National Register, **publicly owned** public parks, recreation areas, wildlife refuges and waterfowl refuges. When parks, recreational areas, and wildlife and waterfowl refuges are owned privately, even if such areas are open to the public, Section 4(f) does not apply. The Federal Highway Administration does, however, strongly encourage the preservation of such privately owned lands. If a governmental body has a proprietary interest in the land (such as fee ownership, drainage easement, or wetland easement), it can be considered "publicly owned". Any action requiring the use of Section 4(f) property cannot proceed until the Federal Highway Administration gives a Section 4(f) approval (49 U.S.C. 303(C)). It must be clearly demonstrated that there is no other prudent and feasible alternate to the use of the 4(f) property. The Environmental Section obtains this approval.

### **Section 6(f) (Title 16, United States Code, Section 4601-8(F))**

Section 6(f) establishes restrictions on the use of land acquired with funds authorized under the Land and Water Conservation Fund Act and is administered by U.S. Department of the Interior. The Environmental Section obtains this approval.

### **Section 106 (Title 33, Code of Federal Regulations, Part 800)**

This is the review process established by the National Historic Preservation Act of 1966 to determine and mitigate the effect of federal projects on historic properties listed on or eligible for listing on the National Register of Historic Places.

## **DEFINITIONS**

The following is a list of environmental terms and their definitions:

### **WETLANDS**

According to the United States Department of Transportation wetlands are defined as lowlands covered with shallow and sometimes temporary or intermittent waters. This includes but is not limited to, areas known as swamps, marshes, bogs, sloughs, pot holes, wet meadows, river overflows and shallow lakes and ponds with emergent vegetation. Areas covered with water for such a short time that there is no effect on moist soil vegetation are not included in the definition, nor are the permanent waters of streams, rivers, reservoirs and deep lakes. The United States Corps of Engineers define wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstance do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas".

### **FILL MATERIAL**

Any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of a waterway.

### **FINDING OF NO SIGNIFICANT IMPACT ( FONSI)**

The Federal Highway Administration, after reviewing the Environmental Assessment along with public hearing transcript (if one was held), determines that the proposed activity will not have significant impacts.

### **ENVIRONMENTAL IMPACT STATEMENT**

The EIS is a complex, comprehensive document which summarizes the major issues to be resolved, the alternatives, the conclusions, the purpose and need for the project and the affected environment. The topics usually included in the Draft EIS are: summary; table of contents; purpose of and need for action; alternatives considered; affected environment; environmental consequences; land use impacts; farmland impacts; social impacts; relocation impacts; economic impacts; joint development; consideration relating to pedestrians and bicyclists; air quality impacts; noise impact; water quality impacts; permits; wetland impacts; water body modifications and wildlife impacts; floodplain impacts; wild and scenic rivers; coastal barriers; coastal zone impacts; threatened or endangered species; historic and archeological preservation; hazardous waste sites; visual impacts; energy; construction impacts; relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; any irreversible and irretrievable commitments of resources which would be involved in the proposed action;

list of preparers; list of agencies, organizations and persons receiving copies of the statement; comments and coordination. The Final EIS incorporates the Draft EIS (essentially in its entirety) with changes made as appropriate to reflect the selection of an alternative, modifications to the project, updated information on the affected environment; changes in assessment of impacts; selection of mitigation measures; wetland and floodplain findings; results of coordination; comments received on the draft EIS and responses to the comments.

### **RECORD OF DECISION (ROD)**

Record of Decision(ROD) is a result of the EIS.

### **ENVIRONMENTAL ASSESSMENT (EA)**

The primary purpose of this document is to provide sufficient environmental documentation for the Federal Highway Administration and the Department to decide whether or not an Environmental Impact Statement is needed. The EA should thus address only those resources or features that will have a likelihood of being significantly impacted. It is a concise document and does not contain lengthy descriptions or detailed information. Topics included are purpose and need for action; alternatives; impacts; comments and coordination; appendices; Section 4(f) evaluation (if applicable).

### **CATEGORICAL EXCLUSION (CE)**

CFR 771.117 identifies CEs as actions which meet the definition contained in 40CFR 1508.4 and, based on past experience with similar actions, do not involve significant environmental impacts. They are actions which, do not induce significant impacts to planned growth or land use for the area; do not require the relocation of significant numbers of people; do not have a significant impact on any natural, cultural, recreation, historic or other resource; do not involve significant air, noise or water quality impacts; do not have significant impacts on travel patterns; or do not otherwise, either individually or cumulative, have any significant environmental impacts.

Examples of projects which are normally classified as CEs include the approval of utility installations along or across a transportation facility and emergency repairs under 23 USC125.

Projects which may be processed as CEs based on the supporting documentation include bridge rehabilitation, reconstruction, or replacement.

## **DEPARTMENT OF THE ARMY**

### **U.S. CORPS OF ENGINEERS PERMITS**

#### **GENERAL**

The United States Army Corps of Engineers has been the authority for regulating activities in the nation's waters since 1890. Until the 1960's the primary purpose of the regulatory program was to protect navigation. Since then, as a result of laws and court decisions, the program has been broadened so that it now considers the full public interest for both the protection and utilization of water resources.

Permits are obtained by the Federal Permit Coordinator, Bridge Design Section from the four (4) Corps of Engineers Districts which have jurisdiction over this State.

In the preliminary design phase of major roadway and bridge projects, transmit by letter pertinent data (such as Advanced Draft Environmental Assessment, Engineering Report, Navigation Study, Draft ENG 4345, and permit sketches) to the appropriate Corps of Engineers District and Coast Guard (if applicable) for review and comment.

Boring operations may be conducted prior to obtaining a permit. In this case, transmit for the Corps' information, review, and comment all pertinent data (number, location, description, and depth below surface) along with a copy of the bridge general plan. Also, through a copy of the transmittal letter, request the appropriate Levee District Board of Commissioners and Office of Public Works to comment directly to the District Engineer in accordance with established procedures.

The permit process should begin approximately nine (9) months prior to the letting of a roadway or bridge construction contract. Projects must be environmentally cleared prior to submitting permit application. The Federal Permit Coordinator is responsible for direct contact with the Corps of Engineers and attends and coordinates, when necessary, all meetings concerning the permit process. This will include, but is not limited to, on-site permit determinations with personnel from the Corps of Engineers, Louisiana Department of Wildlife and Fisheries, DOTD Environmental Section, etc., and in-house meetings.

#### **DEFINITIONS**

##### Dredged Materials

Material that is excavated or dredged from waters of the United States.

## PERMITS

### [Section 10 \(Title 33, United States Code, Section 403\)](#)

Rivers and Harbors Act of 1899, Section 10 prohibits the obstructions or alterations of any navigable waters of the United States without a permit. Permits are issued by the U.S. Department of the Army, Corps of Engineers.

### [Section 404 \(Title 33, United States Code, Sections 1357-1376\)](#)

This is a permit program administered by the United States Department of the Army, Corps of Engineers under the Environmental Protection Agency guidelines. The Corps of Engineers has been the authority for regulating activities in the nation's waters since 1890. Until the 1960's the primary purpose of the regulatory program was to protect navigation. Since then, as a result of laws and court decisions, the program has been broadened so that it now considers the full public interest for both the protection and utilization of water resources.

The Section 404 Permit Program prohibits the discharge of dredged or fill material into water of the United States without a permit. Permits applications are processed by the Federal Permit Coordinator, Bridge Design Section. Permits are issued by Corps of Engineers.

### [Nationwide Permits, 33 Cfr Part 330 - Federal Register Volume 56, No. 226, P.59110 - 59147, November 21, 1991](#)

The two (2) most commonly used by DOTD are Nationwide Permit 23, Approved Categorical Exclusions, and Nationwide Permit 26, Headwaters and Isolated Waters Discharges. The Corps of Engineers determines which projects qualify for this program after reviewing permit submittals and on-site inspections.

**NOTES:**

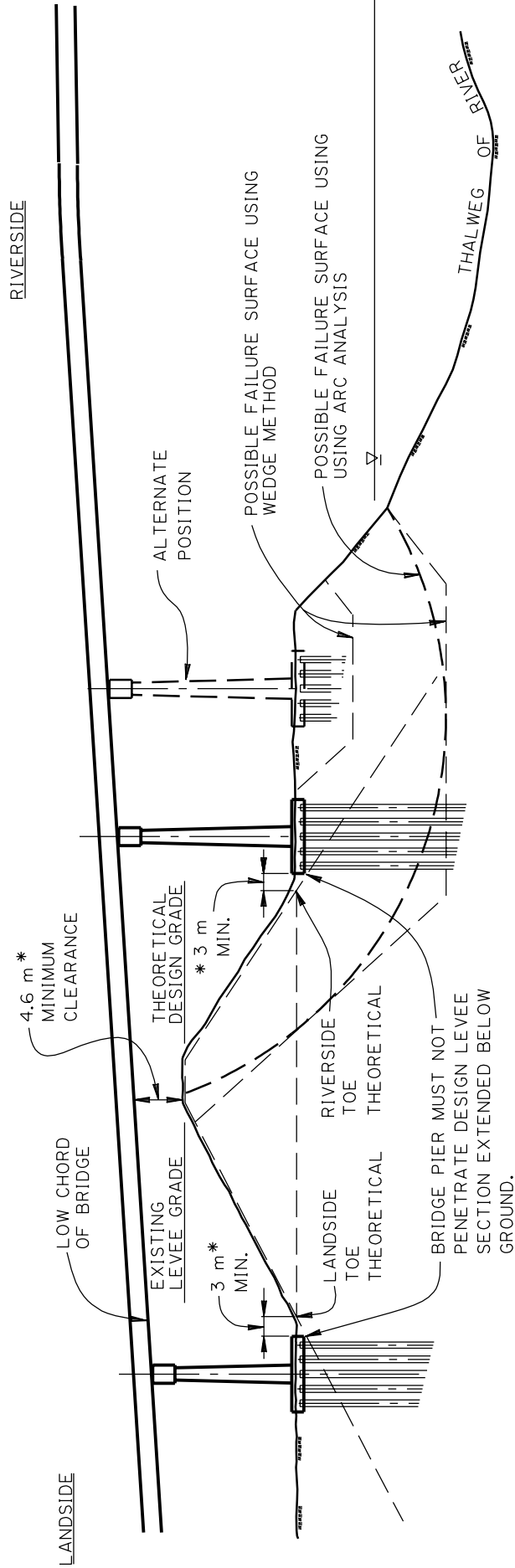
1. BRIDGE PIERS AND SUPPORTS ARE NOT PERMITTED ON OR WITHIN THE THEORETICAL DESIGN LEVEE SECTION. OBTAIN THE THEORETICAL DESIGN LEVEE SECTION FROM THE CORPS OF ENGINEERS. IF LEVEES AT THE BRIDGE CROSSING ARE DEFICIENT IN GRADE OR SECTION, DESIGN THE BRIDGE TO ALLOW FOR LEVEE ENLARGEMENT TO THEORETICAL DESIGN SECTION IN THE FUTURE.
2. PREPARE A STABILITY ANALYSIS FOR THE LEVEE AND ADJACENT RIVERBANK USING THE FOLLOWING PROCEDURE AND SUBMIT THE STABILITY ANALYSIS WITH THE APPLICATION FOR PERMIT.
  - A. MAKE BORINGS TO DETERMINE FOUNDATION CONDITIONS, AND MAKE LABORATORY TESTS OF THE SUBSURFACE MATERIALS. CONSULT WITH THE CORPS OF ENGINEERS ON THE SCOPE OF THE BORINGS AND TESTS BEFORE PREPARING THE STABILITY ANALYSIS.

CONTINUED.... NO. 2

- B. MAKE AN INSTRUMENTAL SURVEY OF THE GROUND SURFACE BEGINNING 6 m LANDWARD OF THE LANDSIDE LEVEE TOE AND EXTENDING RIVERWARD TO THE THALWEG OF THE RIVERBED.
- C. AFTER IMPOSING THE BRIDGE LOADS, ANALYZE THE STABILITY OF THE LEVEE AND ADJACENT RIVERBANK USING THE WEDGE METHOD. A MINIMUM FACTOR OF SAFETY OF 1.30 MUST BE PROVIDED FOR THE MOST CRITICAL LOADING CONDITIONS CONSIDERING BOTH DURING CONSTRUCTION AND AFTER-CONSTRUCTION CONDITIONS.
- D. THE PERMIT APPLICANT MAY ALSO CHOOSE TO PRESENT ANY OTHER TYPE OF ANALYSIS PREPARED FOR THE BRIDGE DESIGN.

3. PAVE THE RIVERSIDE LEVEE SLOPE BENEATH THE BRIDGE, AND EXTEND 1.5 m UPSTREAM AND DOWNSTREAM OF THE LIMITS OF THE BRIDGE DECK, WITH A 100 mm UNREINFORCED CONCRETE SLAB.

4. A MINIMUM OF 4.6 m OF VERTICAL CLEARANCE ABOVE THE EXISTING LEVEE CROWN IS REQUIRED FOR FLOODLIGHT AND MAINTENANCE OPERATIONS. A HORIZONTAL CLEARANCE OF 4.6 m IS ALSO REQUIRED AT THE CROWN.



**ELEVATED BRIDGE CROSSINGS OVER LEVEES**

NTS

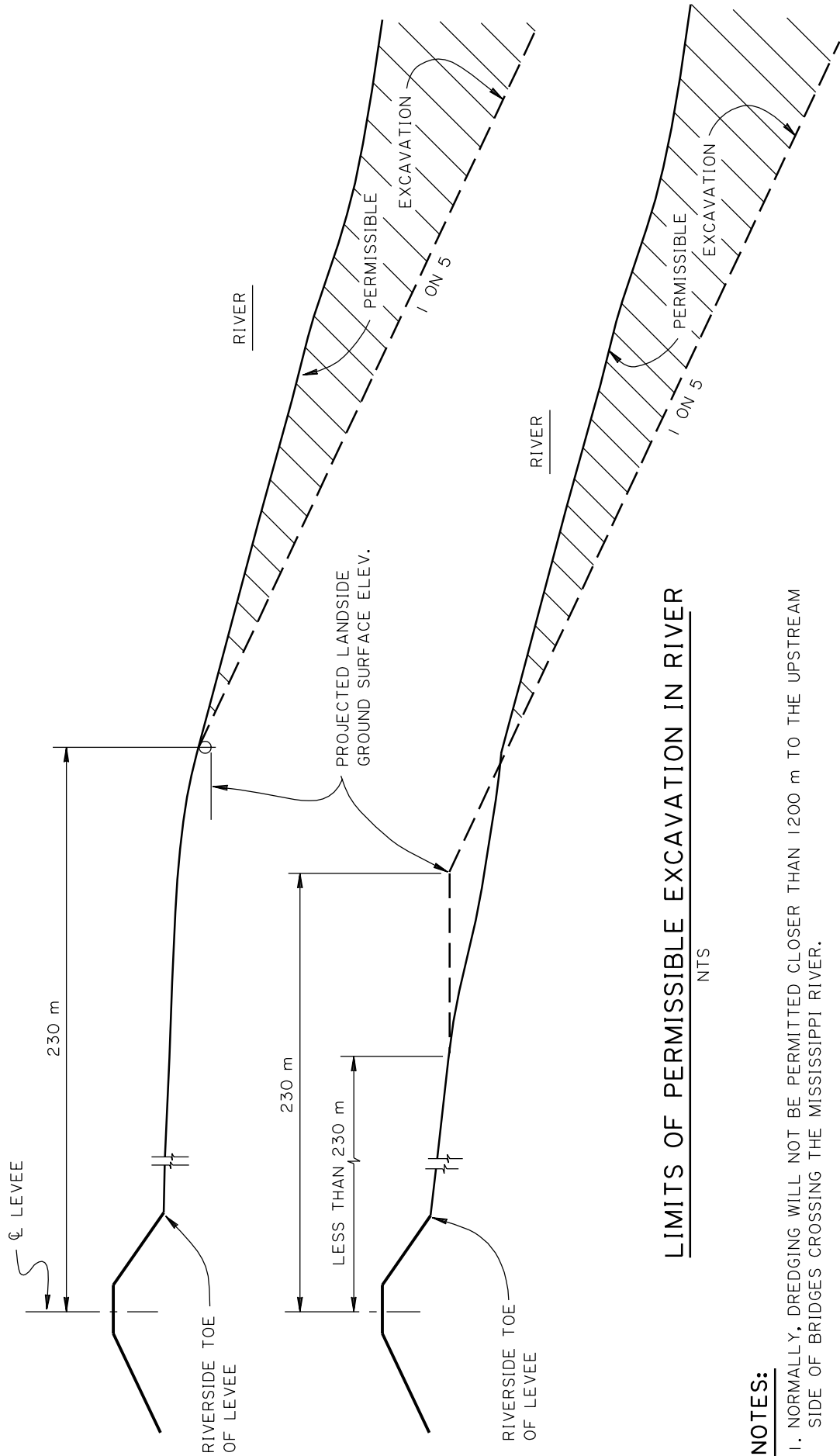
\* DEVIATIONS FROM THE REFERENCED CLEARANCE HEIGHTS OVER THE LEVEE, AND REFERENCED PIER DISTANCE FROM THE LEVEE DESIGN TOE, WILL ONLY BE AUTHORIZED ON A CASE-BY-CASE BASIS WITH THE SPECIFIC APPROVAL FROM THE AFFECTED LEVEE DISTRICT. FACTORS CONSIDERED IN DETERMINING THE AUTHORIZATION OF SUCH DEVIATIONS MAY BE THE AVAILABILITY OF "RUN-A-ROUND" ROADWAYS, THE PRESENCE OF LEVEE BERMS, AND THE CONSTRUCTION OF HEADWALLS AS ABUTMENTS, ETC.

**CORPS OF ENGINEERS  
LEVEE REQUIREMENTS**



LANDSIDE

RIVERSIDE



LIMITS OF PERMISSIBLE EXCAVATION IN RIVER

NTS

**NOTES:**

1. NORMALLY, DREDGING WILL NOT BE PERMITTED CLOSER THAN 1200 m TO THE UPSTREAM SIDE OF BRIDGES CROSSING THE MISSISSIPPI RIVER.
2. EXCAVATION MADE WITHIN THE PERMISSIBLE AREA SHALL HAVE AVERAGE SLOPES NOT STEEPER THAN 1 ON 5. BOX CUTS ARE PERMITTED TO A MAXIMUM DEPTH OF 2.0 m.
3. EXCAVATION SHALL PROCEED FROM THE LANDSIDE TO THE RIVERSIDE LIMITS OF EXCAVATION TO MINIMIZE THE POSSIBILITY OF AN "OVERBURDEN FAILURE" OF THE BANK.

**CORPS OF ENGINEERS  
LEVEE REQUIREMENTS**

## **UNITED STATES COAST GUARD BRIDGE PERMITS**

### **GENERAL**

All bridges which cross navigable waterways of the United States of America require a United States Coast Guard Bridge Permit. Permits are obtained by the Federal Permit Coordinator, Bridge Design Section, from the Eighth Coast Guard District which has jurisdiction over all navigable waterways in Louisiana.

In 1967, the Coast Guard was transferred to the newly formed Department of Transportation. One of the new assigned duties was the authority to issue bridge permits approving location and plans under authority of several Acts pertaining to bridges including Section 9 of the Rivers and Harbors Act of 1899 and the General Bridge Act of 1946. The Bridge Permit Application Guide states "the purpose of these Acts is to preserve the public right of navigation and to prevent interference with interstate and foreign commerce". The General Bridge Act of 1946, as amended, and the Rivers and Harbors Act of 1899, as amended, require that the location and plans be submitted to and approved by the Secretary of Transportation prior to construction of bridges and causeways across navigable waters of the United States. (The General Bridge Act of 1946 is cited as the legislative authority for bridge construction in most cases.) The Secretary of Transportation has delegated this authority to the Commandant, U. S. Coast Guard by Transportation Order 1100.1 dated 31 March 1967 (9 CFR 1.4(a)(3)).

The permit process should begin approximately one (1) year prior to the letting of a bridge construction contract. Projects must be environmentally cleared prior to submitting permit application. The Federal Permit Coordinator is responsible for direct contact with the Coast Guard and will attend and coordinate, when necessary, all meetings concerning the permit processes. These will include, but are not limited to, pre-design conferences, site inspections, etc.

In the preliminary design phase of major bridge projects, transmit by letter pertinent data (such as Advanced Draft Environmental Assessment, Engineering Report, Navigation Study, Draft ENG 4345, and permit sketches) to the Eighth Coast Guard District and the appropriate Corps of Engineers District for review and comments.

Permission must be obtained from the Eighth Coast Guard District prior to conducting boring operations in any navigable waterway, in order that a Notice to Mariners may be issued.

## DEFINITIONS

### Navigable Waters

For Coast Guard bridge permitting purposes a navigable waterway is defined as (unless specifically declared otherwise by Congress) "Any waterway which is presently used and/or is susceptible to use in its natural condition, or by reasonable improvements, as a means to transport interstate or foreign commerce". Also, "any waterway which is subject to the ebb and flow of the tide".

## BRIDGE CLEARANCE GAUGES

1. Clearance gauges installed on bridges across navigable waters shall be so constructed and placed as to indicate the vertical distance between "low steel" of the bridge channel span and the level of the water. The gauge shall read from top to bottom. Measured from low steel to the bottom of the foot marks. The gauge shall be installed so as to face approaching traffic and shall extend to a reasonable height above high water so as to be meaningful to the viewer.
2. When a clearance gauge shall be required by the regulations, such gauge shall be installed on the end of right channel pier or pier protection structure facing approaching traffic.
3. The costs of installation and maintenance of clearance gauge installations shall be borne by the bridge owner or operator.
4. Clearance gauges shall be of durable material permanently fixed to the bridge pier, or pier protection structure, and of such strength as to provide a structure resistant to weather, tide, and current. However, clearance gauges may be painted directly on the bridge channel pier of the face if the pier is flat and has sufficient width to accommodate the foot marks (graduations) and numerals.
5. The type, size, and spacing of numerals shall conform to the "Standard Highway Signs" manual. A copy of this manual is kept in the Geometrics Section.

## SETTING NAVIGATIONAL CLEARANCES

1. Obtain approved horizontal and vertical clearances for any existing bridges on the project waterway from the most recent Coast Guard publication of "Bridges over Navigable Waterways in the U.S."
2. Contract any Mariners or River Pilot associations to get any applicable information or comments about vessel traffic for your bridge site.
3. Other data that is available from DOTD or other agencies is:

- A) "Summary of Navigational Openings - Movable Bridges" can be obtained from the Bridge Maintenance Section. This report is done yearly and contains the total number of bridge openings on a monthly basis.
  - B) "Bridge Tenders Report" can be obtained from General Files. This yearly file contains the monthly data of the number of openings at the movable bridge, the name of the vessel, the estimated height, direction of tow, number of barges, and if the barge was empty or loaded.
  - C) U.S. Army Corps of Engineers, "Waterborne Commerce of the U.S."
  - D) U.S. Army Corps of Engineers, "Waterborne Transportation Lines of the U.S."
4. If time is available, send out a survey through the District Bridge Maintenance Engineer to the Bridge Tender. The Bridge Tender would be asked to complete a form to collect data on all vessels passing through the movable bridge for a certain period of time. Any needed data such as length, width and height of vessel and tow could be obtained.
  5. Contact Corps of Engineers to determine what water datum should be used to set the vertical bridge clearance. Typical datum such as 2% flow line or mean highwater have been used in the past. Normally the Corps of Engineers will provide data such as the 2% flow line upon written request. Also the authorized channel (required depth and width) should also be obtained from the Corps of Engineers.
  6. Once any of the above available data is obtained and studied, a proposed horizontal and vertical clearance may be submitted to the Coast Guard in order to solicit any views and comments from the various groups. A scaled sketch of the proposed bridge and clearances should be made based on the Coast Guard's permit requirements.
  7. Address any comments from the Coast Guard's Solicitation of views.
  8. Write Environmental Section with appropriate data to start environmental clearing process.
  9. Prepare preliminary plans.
  10. Do not proceed with final plans until environmental clearance is obtained.
  11. Complete the Coast Guard Permit Form after environmental clearance is received.

## **UNITED STATES COAST GUARD BRIDGE NAVIGATIONAL LIGHTING PERMITS**

Bridges across navigable waterways which support nighttime navigation may be required to display navigational lights in accordance with Part 118.4(c) of Title 33 Code of Federal Regulations. Approval of the navigational lights and other signals required shall be obtained prior to construction. The permittee is responsible for maintaining proper temporary navigational lighting and other such markings, as may be prescribed, during construction. When the bridge is completed permanent navigational lighting is the responsibility of the permittee.

## **VESSEL COLLISION**

The U.S. Coast Guard maintains strict guidelines to insure the least possible interference with navigation. For newly constructed bridges crossing navigable waterways, it is required that a permit sketch be submitted to the Coast Guard for their review and approval of the navigation permit. This is also generally true for reconstruction projects and extensive maintenance projects, where navigation might be affected, or any changes to the original permit is made. However, for maintenance repairs this is usually not required.

Whenever economically possible piers should be located on the banks when there are no requirements to design for vessel collision. If it becomes economically or physically unfeasible to locate the piers on the banks every effort should be made to place the piers as far away from the main channel as possible.

Bridges crossing navigable waterways where vessel collision by merchant ships or barges may be anticipated shall be designed to prevent collapse of the superstructure. Consideration should be given to the size and type of the vessel, available water depth, vessel speed, and structure response. It should be noted that the specifications do not apply to special purpose vessels, wood, or fiberglass constructed vessel, ships smaller than 1,000 DWT, naval vessels, or to recreational vessels. Vessel impact requirements for these types of vessels shall be determined by the Bridge Design Engineer.

There are various types of pier protection systems that can be used such as fender systems, dolphins, bulkheads, dikes, subshafts, protective islands, and pier walls. However, in waterways with excessive depth, these systems become unfeasible. When conditions are such, that protection from collision is not feasible, it then becomes necessary to account for vessel collision in the design of the pier. Vessel collision design should conform to the AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges.

## PERMIT

### Section 9 (Title 33, United States Code, Section 401)

Rivers and Harbors Act of 1899, Section 9 and the General Bridge Act of 1946 as amended establishes authority to issue permits for bridges and causeways across any navigable waters of the United States. The Secretary of Transportation delegated this authority to the Coast Guard by Department of Transportation Order 1100.1 dated March 31, 1967. Permits are issued by the U.S. Coast Guard.

## **LOUISIANA DEPARTMENT OF NATURAL RESOURCES COASTAL USE PERMIT**

### **GENERAL**

The Coastal Management Division of the Department of Natural Resources is charged with implementing the Louisiana Coastal Resources Program under authority of the Louisiana State and Local Coastal Resources Management Act of 1978, Act 361, La. R.S. 49:214.21 - 214.41).

This law seeks to protect, develop and, where feasible, restore or enhance the resources of the State's Coastal Zone. Its broad intent is to encourage multiple uses of resources and adequate economic growth while minimizing adverse effects of one resource use upon another without imposing undue restrictions on any user.

Permits are obtained by the Federal Permit Coordinator, Bridge Design Section from the Department of Natural Resources, Coastal Management Division.

The permit process should begin approximately nine (9) months prior to the letting of a roadway or bridge construction contract. Projects must be environmentally cleared prior to submitting permit application. The Federal Permit Coordinator is responsible for direct contact with the Coastal Management Division and attends and coordinates when necessary, all meetings concerning the permit process. This will include but is not limited to on-site permit determinations with personnel from the Coastal Management Division, Corps of Engineers, Department of Wildlife and Fisheries, DOTD Environmental Section, etc., and in-house meetings.

### **PERMIT**

#### **COASTAL USE PERMIT**

All State and Federal Aid projects which fall within the Coastal Zone require a Coastal Use Permit. The Department of Natural Resources, Coastal Management Division, is responsible for issuing permits within the Coastal Zone. Therefore, if the project is within the Coastal Zone the permit application letter and attachments are sent to the Coastal Management Division. The Corps of Engineers and Coastal Management Division issue a joint Public Notice for interested parties to comment on the proposed project. Permits applications are processed by the Federal Permit Coordinator, Bridge Design Section. Permits are issued by the Coastal Management Division.

## COASTAL ZONE BOUNDARY

The Coastal Zone is the area located south of Interstate Highways I-10 and I-12. Parishes within the Coastal Zone are as follows:

Ascension	Jefferson	St. Charles	Terrebonne
Assumption	Lafourche	St. James	Vermilion
Cameron	Plaquemines	St. John	
Iberia	St. Bernard	St. Mary	

**Only** the areas south of I-10 or I-12 in the following parishes are within the Coastal Zone:

Acadia	Iberville	Livingston	Tangipahoa
Calcasieu	Jefferson Davis	St. Martin	West Baton Rouge
East Baton Rouge	Lafayette	St. Tammany	



## **LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY PERMIT**

### **GENERAL**

One of the permits necessary for having environmental clearance is a water quality certification. This permit is obtained through the Louisiana Department of Environmental Quality. The purpose of this permit is to prevent any projects from occurring that would compromise the quality of our waters. This permit is requested through the Federal Permit Coordinator (Bridge Design Section).

### **PERMIT**

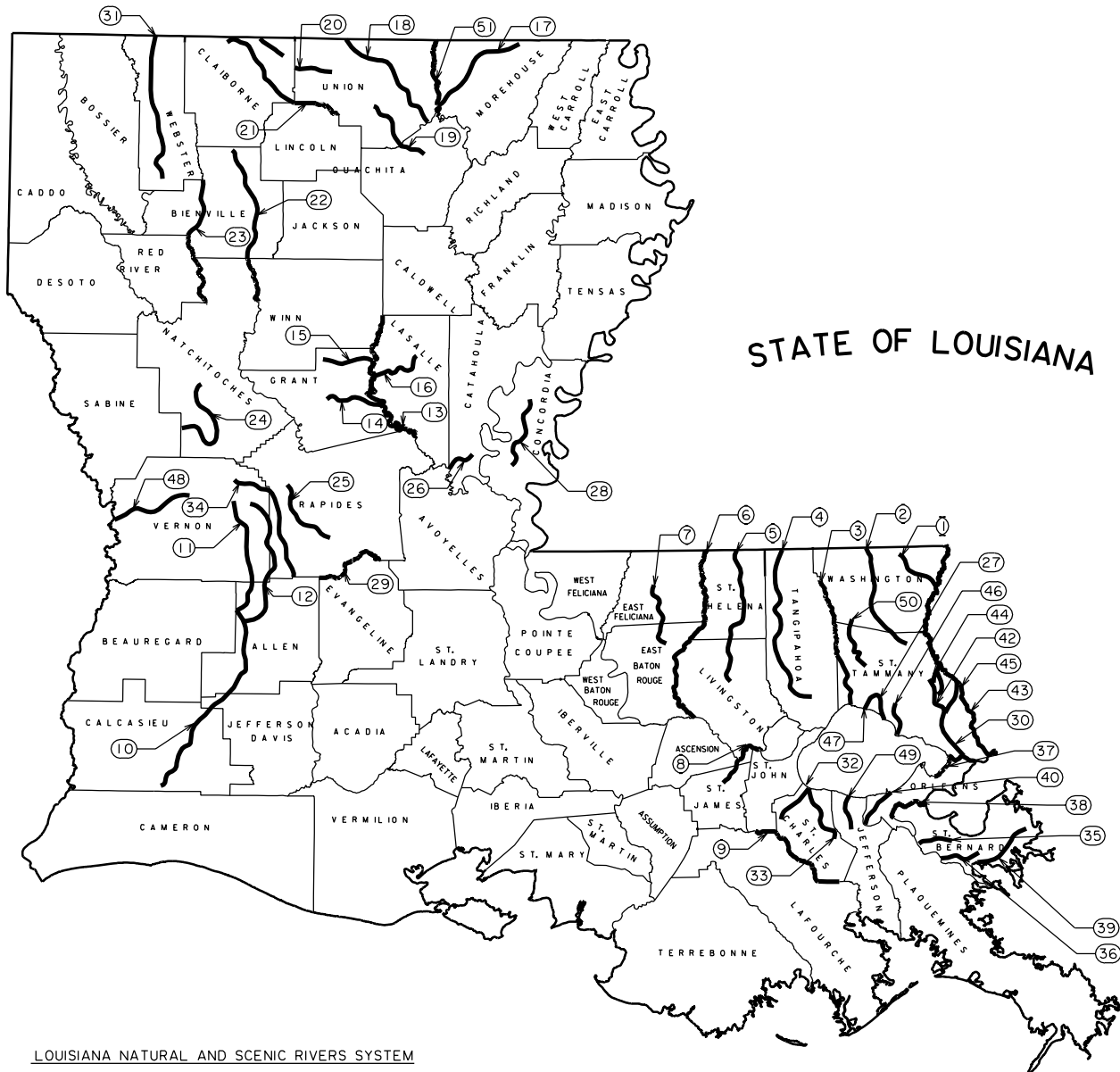
#### Water Quality Certification (Clean Water Act of 1977 (P.L. 95-217))

The Louisiana Department of Environmental Quality, Office of Water Resources has been designated to determine whether construction in a Louisiana waterway will violate the Water Quality Standards of the State pursuant to Public Law 92 - 500 or the Clean Water Act of 1977 (P.L. 95-217).

## **LOUISIANA DEPARTMENT OF WILDLIFE AND FISHERIES PERMIT**

### **CLASS B SCENIC STREAMS PERMITS**

The Louisiana Natural And Scenic River Act established the Louisiana Natural and Scenic River System which is one of the Nation's largest, oldest, most diverse and unique State river protection initiatives. The streams in the system vary from fast flowing upland streams with riffles and waterfalls, through sluggish swamp bayous flanked by Spanish moss draped cypress trees to brackish water, tidal creeks in the coastal marshes. The Act established a regulatory program and delegated the authority to administer the program to the Louisiana Department of Wildlife and Fisheries. Figure on page 20 shows a list of Natural and Scenic Rivers. Since this list changes from time to time a current list should be obtained from the Environmental Section. The Environmental Section processes the Class B Permit application.



LOUISIANA NATURAL AND SCENIC RIVERS SYSTEM

- |                          |                                 |                       |                        |
|--------------------------|---------------------------------|-----------------------|------------------------|
| 1. PUSHEPATAPA RIVER     | 16. TROUT CREEK                 | 31. BAYOU DORCHEAT    | 46. BAYOU LACOMBE      |
| 2. BOGUE CHITTO RIVER    | 17. BAYOU BARTHOLOMEW           | 32. BAYOU TREPAGNIER  | 47. BAYOU CANE         |
| 3. TCHEFUNCTE RIVER      | 18. BAYOU L'OUTRE               | 33. BAYOU LABRANCHE   | 48. PEARL CREEK        |
| 4. TANGIPAHOA RIVER      | 19. BAYOU D'ARBONNE             | 34. CALCASIEU RIVER   | 49. BAYOU ST. JOHN     |
| 5. TICKFAW RIVER         | 20. CORNEY BAYOU                | 35. BAYOU DUPRE       | 50. BOGUE FALAYA RIVER |
| 6. AMITE RIVER           | 21. MIDDLE FORK BAYOU D'ARBONNE | 36. LAKE BORGNE CANAL | 51. OUACHITA RIVER     |
| 7. COMITE RIVER          | 22. SALINE BAYOU                | 37. BASHMAN BAYOU     |                        |
| 8. BLIND RIVER           | 23. BLACK LAKE BAYOU            | 38. TERRE BEAU BAYOU  |                        |
| 9. BAYOU DES ALLEMANDS   | 24. BAYOU KISATCHIE             | 39. PIROGUE BAYOU     |                        |
| 10. WHISKEY CHITTO CREEK | 25. SPRING CREEK                | 40. BAYOU BIENVENUE   |                        |
| 11. SIX MILE CREEK       | 26. SALINE BAYOU                | 41. BAYOU CHAPERON    |                        |
| 12. TEN MILE CREEK       | 27. BAYOU CHINCHUBA             | 42. HOLMES BAYOU      |                        |
| 13. LITTLE RIVER         | 28. BAYOU COCODRIE (CONCORDIA)  | 43. BRADLEY SLOUGH    |                        |
| 14. BIG CREEK            | 29. BAYOU COCODRIE (EVANGELINE) | 44. WILSON SLOUGH     |                        |
| 15. FISH CREEK           | 30. WEST PEARL RIVER            | 45. MORGAN RIVER      |                        |

**STATE OF LOUISIANA  
SCENIC RIVERS MAP**

## **ENVIRONMENTAL PROTECTION AGENCY**

### **GENERAL**

The National Pollution Discharge Elimination System (NPDES) was developed as a function of the 1987 Clean Water Act (CWA). The Environmental Protection Agency (EPA) is required to develop an approach to regulating storm water discharges under this Act.

The NPDES program stipulates several regulations that apply to all construction projects that disturb over five acres. Among the more important items is the requirement to file a Notice of Intent with the EPA, the development of a Storm Water Pollution Prevention Plan for the project and a certification by the Department and the contractor to abide by the terms of these regulations.

In order to comply with these mandates, the attached items should be included in the contract document for every project that qualifies under this program.

Section 405 of the Water Quality Act of 1987 (WOA) added Section 402(p) of the Clean Water Act (CWA) which requires the Environmental Protection Agency (EPA) to develop an approach to regulating storm water discharges under the National Pollution Discharge Elimination System (NPDES). The NPDES General Permit requires that discharges from construction sites will be managed to prevent pollutants from entering waters of the United States.

These specifications cover work designed to provide temporary erosion control on construction projects and in areas outside the right-of-way where work is accomplished in conjunction with the project to prevent pollution of water. These measures shall control features shown on the plans or as directed.

Installation of temporary erosion control features shall be coordinated with construction of permanent erosion control features to the extent necessary to ensure economical, effective and continuous control of erosion and water pollution throughout the life of the contract.

## **FEDERAL AVIATION AUTHORITY (FAA) PERMIT**

### **GENERAL**

For projects that are near airports coordination with the FAA will be required.

For all projects passing within two miles of an airport, a sketch map showing airway-highway clearances is prepared and is signed by the Chief Engineer. A print is sent to the Office of Aviation. On federal-aid projects, a print is sent to the Project Control Section, which handles the correspondence necessary for obtaining approvals from the Federal Highway Administration and the Federal Aviation Authority. On state projects, a print is sent directly to the FAA office in Houston, Texas, for approval. The project coordinator retains the original tracing of the sketch map. A sample sketch map is shown in Figure 1-4.

There are additional requirements, which prohibit construction from occurring within the glide paths of aircraft. These requirements can be found in the document titled Federal Aviation Regulations (Objects Affecting Navigable Airspace) Part 77.

### **SCOPE OF FAA AS REGULATORY AUTHORITY**

1. Any construction or alternation of more than 61 m in height above the ground level at its site.
2. Any construction or alternation of greater height than an imaginary surface extending outward and upward at one of the following slopes: of each airport specified in subparagraph (5) of this paragraph with at least one runway more than 980 meters in actual length, excluding heliports,
  - A) 1v to 100h for a horizontal distance of 6,100 m from the nearest point of the nearest runway.
  - B) 1v to 50h for a horizontal distance of 930 m from the nearest point of the nearest runway of each airport specified in subparagraph (5) of this paragraph with its longest runway no more than 975 meters in actual length, excluding heliports.
  - C) 1v to 25h for a horizontal distance of 1524 meters from the nearest point of the nearest landing and takeoff area of each heliport specified in subparagraph (5) of this paragraph.
3. Any highway, railroad, or other traverse way for mobile objects, of a height which, if adjusted upward 5.2 meters for an Interstate Highway that is part of the National System of Military and Interstate Highways where overpasses are designed for a minimum of 5.2 meters vertical distance, 4.6 meters for any other public roadway, three (3) meters or the height of the highest mobile object that would normally traverse the road, whichever is greater, for a private road, 7.2 meters for a railroad,

and for a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it, would exceed a standard of subparagraph (1) or (2) of this paragraph.

4. When requested by the FAA, any construction or alteration that would be in an instrument approach area (defined in the FAA standards governing instrument approach procedures) and available information indicates it might exceed a standard of subpart C of this section.
5. Any construction or alteration on any of the airports (including heliports):
  - A) An airport that is available for public use and is listed in the Airport Directory of the current Airman's Information Manual
  - B) An airport that is under construction, that is the subject of a notice of proposal on file with the FAA, and except for military airports, it is indicated that that airport will be available for public use.
  - C) An airport that is operated by an armed force of the United States.

## **RAILROAD REQUIREMENTS**

### **GENERAL**

Whenever possible at-grade Railroad crossings should be avoided. This may be accomplished by underpassing or overpassing the railroad. Overpasses are designed and constructed to carry highway loads. Underpasses are designed and constructed to carry railroad loads. Clearances, geometrics, utilities, provisions for future tracks, and maintenance road requirement for off-track equipment will involve coordination with the railroad company.

### **HORIZONTAL AND VERTICAL CLEARANCES**

The horizontal and vertical clearances vary with the different railroad companies. Furthermore, the clearances required by a single company may vary because of different uses of the tracks or future plans for the tracks. The minimum clearance shown herein are to be used strictly for general information and are not a set criteria. For actual design, the clearance for the specific tracks involved must be acceptable to the railroad company involved and should be resolved early in project development.

A note should be added to the profile stating: "The elevations of the existing top-of-rail profile shall be verified before beginning construction. All discrepancies shall be brought to the attention of the Railroad. Final plans, erection clearances, and specification must be approved by the railroad company concerned.

Figure on page 26 shows the shoring requirements for excavations adjacent to railroads. This sketch is intended to be used as a guideline in determining shoring requirements in the absence of other railroad specific guidelines.

### **DRAINAGE**

Track drainage must be maintained and overpass drainage must be clear of the tracks and railroad bed area. No scuppers or other deck drains, roadway drainage, catch basins, inlets or outlets are permitted to drain onto Railway property. Columns, piles, and footings should be kept out of the Railroad ditch to prevent obstruction of drainage.

## **CRASH WALLS**

Crash walls are required for all bridges over railroads in which any part of the substructure above the ground is constructed closer than 7.6 meters measured from the centerline of the track perpendicular to the track. However, the preferred horizontal clearance should be provided to avoid the need for crash walls unless extenuating circumstances dictate otherwise. Crash walls shall meet the following criteria:

1. The crash wall shall be constructed to be integral with the pier or bent and shall have a smooth face.
2. Crash walls shall have a minimum thickness of 600 mm.
3. Crash walls shall have a minimum height of 3.6 meters above the track.
4. Crash walls shall connect with the columns and extend a minimum of 300 mm beyond the face of the column parallel to the track.
5. The face of the crash wall shall extend at least 150 mm beyond the face of the pier on the side adjacent to the track .
6. The bottom of the crash wall shall be a minimum of one (1) meter below the lowest surrounding grade.


## **PROCEDURES TO FOLLOW TO OBTAIN RAILROAD AGREEMENTS**

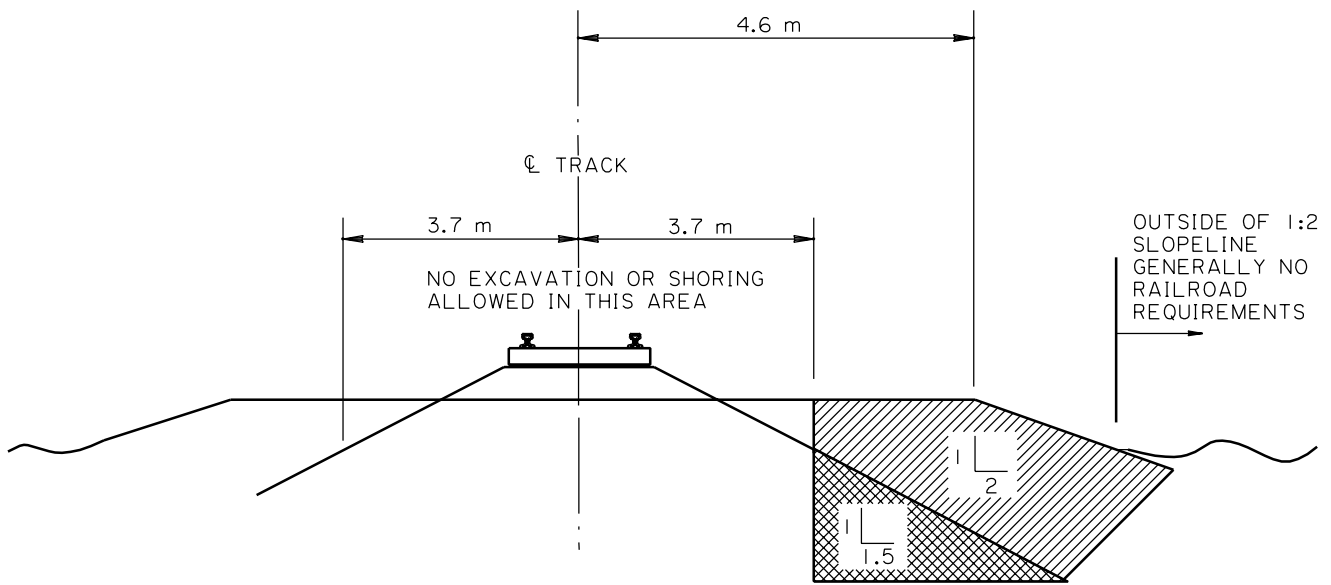
The railroad should be included in the plan-in-hand distribution. Submit preliminary bridge plans to railroad companies through the Department's Rail/Highway Engineer in the Maintenance Section. Show all clearances and request their tentative approval. An agreement between DOTD and the railroad is necessary. This agreement is a document, which will be included in the construction contract. The railroad will specify if off-track maintenance clearance will be required and on which side if required.

The following is a list of questions that should be asked of the Railroad prior to any alignment studies:

1. Do they have any future tracks planned at this site ?
2. Do they have any plans to adjust the ballast on this track at this location in the next ten years ?
3. What type of tracks are located at this site ?
4. What are the general shoring requirements of this Railroad ?

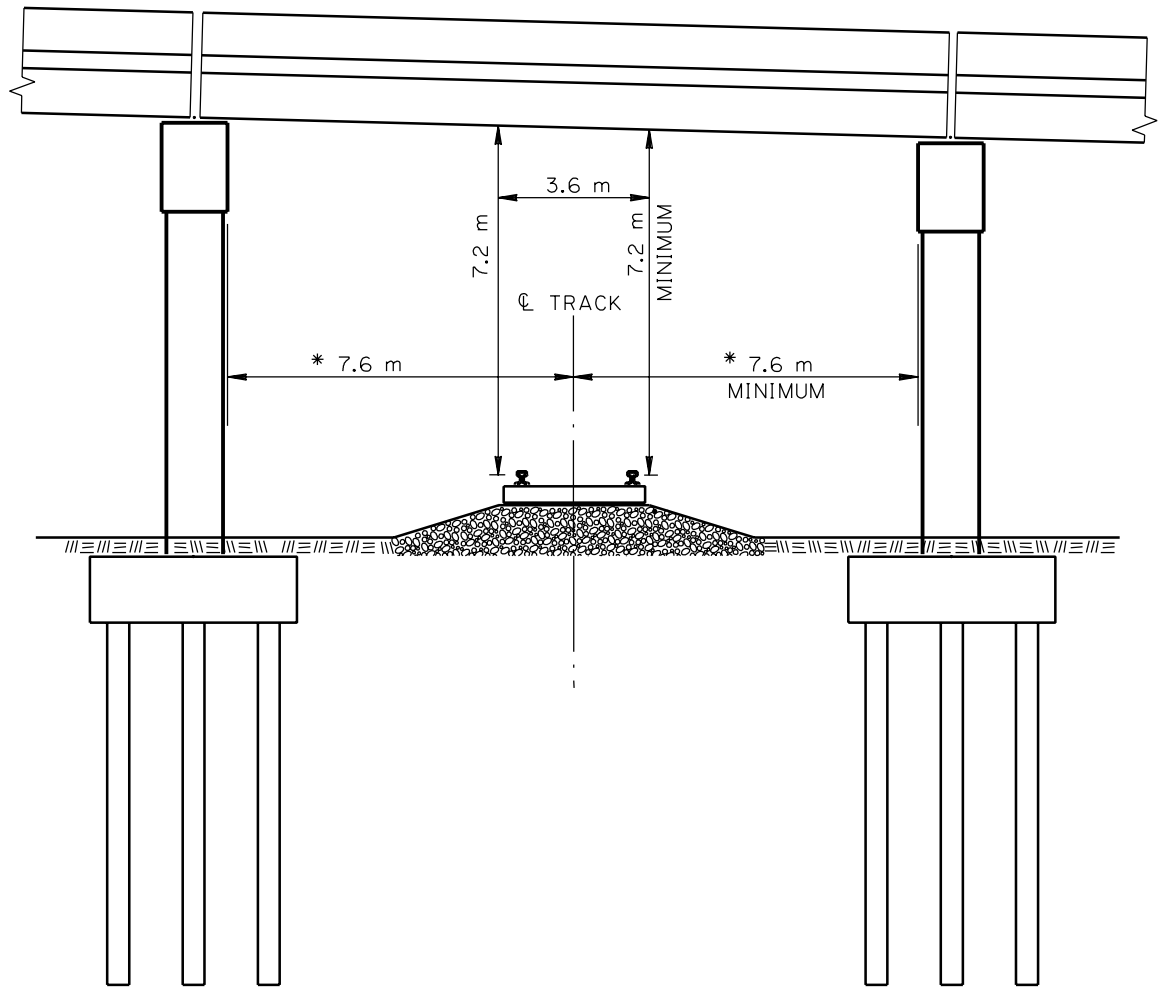


-  — SHORING REQUIRED PER OSHA SPECIFICATIONS
-  — SHORING REQUIRED PER OSHA SPECIFICATIONS AND DESIGNED FOR RAILROAD LIVE LOAD



SHORING REQUIREMENTS

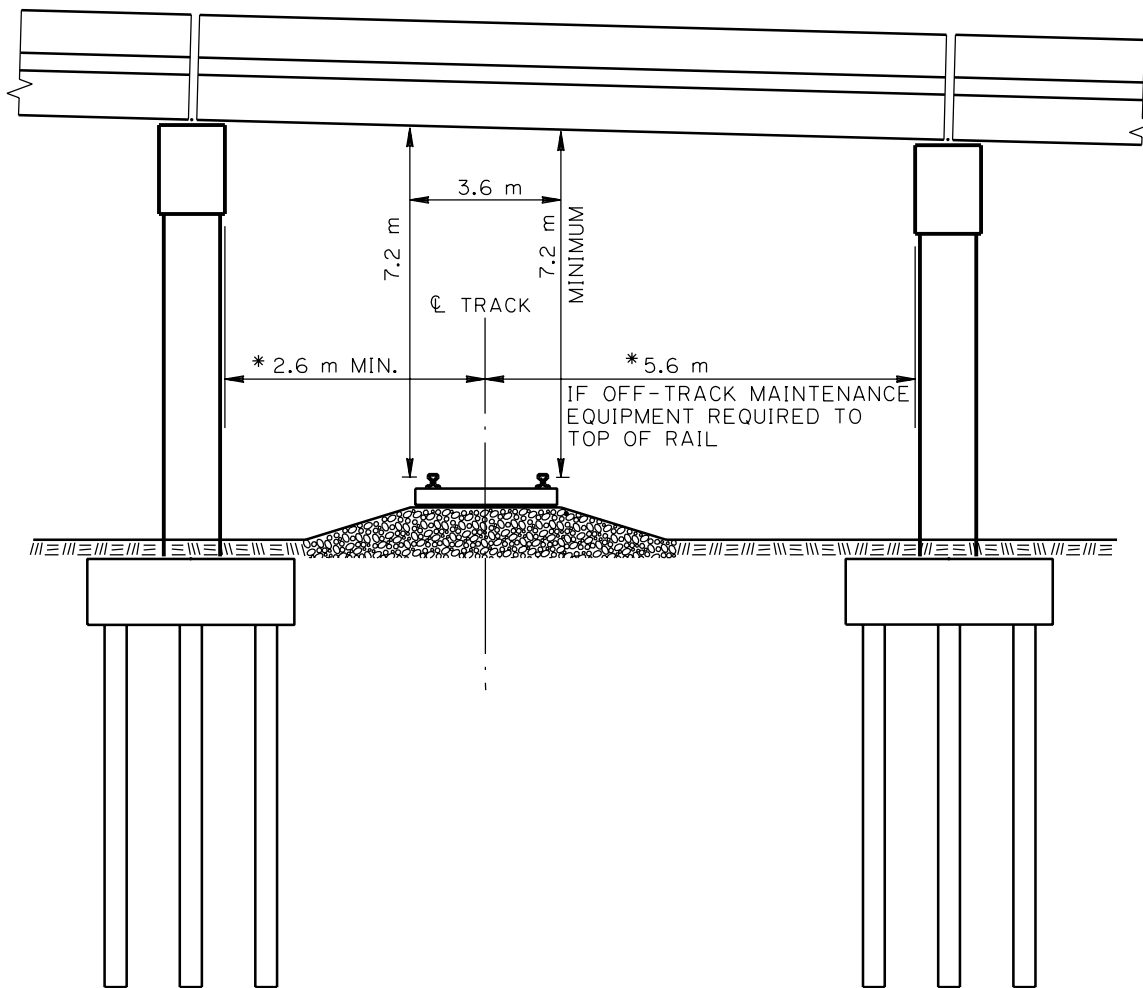
**GENERAL RAILROAD  
SHORING REQUIREMENTS**



**RECOMMENDED VERTICAL AND HORIZONTAL CLEARANCES**

\* CLEARANCES MUST BE APPROVED BY THE RAILROAD.

**RECOMMENDED RAILROAD  
CLEARANCE REQUIREMENTS**



MINIMUM VERTICAL AND HORIZONTAL CLEARANCES

\* CLEARANCES MUST BE APPROVED BY THE RAILROAD.  
 USE MINIMUM CLEARANCES IF RECOMMENDED IN CASES  
 WHERE HORIZONTAL CLEARANCES CANNOT BE MET.

**MINIMUM RAILROAD  
 CLEARANCE REQUIREMENTS**

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## **SHOP DRAWINGS**

### Introduction

The fabricator prepares shop drawings and erection drawings by interpreting the engineering drawings in the contract plans. The engineer who prepares the engineering drawings shall generally be responsible for checking of the corresponding shop drawings.

### Scope

This article covers the responsibilities of the Engineer regarding shop drawings review. The Engineer's responsibilities include two requirements, expediency and completeness, in checking the shop drawings for conformity to contract plans, specifications and special provisions.

### Commentary

An engineer charged with checking shop drawings for the first time often asks or wonders, "How complete or to what detail should the drawings be checked? The answer to this question is as variable as are the details prepared by the engineer. As the engineer gains experience in checking shop details, he acquires working knowledge of what must be checked and what may be scanned over. The remainder of this article may serve as a guide to the inexperienced checker and a reminder to the experienced engineer.

### Guidelines, Shop Drawing Review

1. Always check shop drawings to the extent you are satisfied that the structure described can be fabricated and erected according to the governing plans and specifications.
2. Shop details shall have top priority unless you are otherwise instructed. This rule is needed to avoid costly delays in the bridge construction.
3. The amount of time to be spent checking shop details should be proportional to their complexity and quantity of sheets involved.

ASTM DESIGNATION	YEAR	SHAPE OR DIMENSIONS	GRADE	MINIMUM F <sub>y</sub>
A-7	1924	-	Structural	30 ksi
A-7	1924	Rivet	Structural	25 ksi
A-7	1934	-	Structural	33 ksi
A-8	1924	Rivet	Structural	45 ksi
A-8	1924	Plates, Shapes, Bars	-	50 ksi
A-8	1924	Eyebar Flats & Rollers	Unannealed	55 ksi
A-8	1924	Eyebar Flats & Pins	Annealed	52 ksi
A-8	1938	Eyebar Flats	Unannealed	55 ksi
A-8	1938	Full Size Tested Eyebars	Annealed	48 ksi
A-15	1914	Plain & Deformed	Structural	33 ksi
A-15	1914	Plain & Deformed	Intermediate	40 ksi
A-15	1914	Plain & Deformed	Hard	50 ksi
A-15	1914	Cold Twisted	-	55 ksi
A-16	1914	Plain, Deformed, Hot-Twisted	-	50 ksi
A-16	1959T	Plain & Deformed	Normal	50 ksi
A-16	1959T	Deformed	Special	60 ksi
A-36	1960T	Plates, Shapes, Bars	Structural	36 ksi
A-94	1927	-	Structural	45 ksi
A-141	1933	Rivet	Structural	28 ksi
A-195	1939T	Rivet	Structural	38 ksi
A-242	1941T	$\frac{3}{16}'' < t \text{ (thickness)} < \frac{3}{4}''$	Structural	50 ksi
A-242	1941T	$\frac{3}{4}'' < t < 1\frac{1}{2}''$	Structural	45 ksi
A-242	1941T	$1\frac{1}{2}'' < t < 2''$	Structural	40 ksi
A-242	1955	$t < \frac{3}{4}''$	Structural	50 ksi
A-242	1955	$\frac{3}{4}'' < t < 1\frac{1}{2}''$	Structural	46 ksi
A-242	1955	$1\frac{1}{2}'' < t < 4''$	Structural	42 ksi
A-373	1954T	Plates, Shapes, Bars	Str. Welding	32 ksi
A-406	1957T	Rivet	Structural	50 ksi

"T" denotes a tentative ASTM designation approved by the sponsoring committee.

## BRIDGE STEEL

ASTM DESIGNATION	YEAR	SHAPE OR DIMENSIONS	GRADE	MINIMUM F <sub>y</sub>
A-440	1959T	t (thickness) < 3/4"	Structural	50 ksi
A-440	1959T	3/4" < t < 1 1/2"	Structural	46 ksi
A-440	1959T	1 1/2" < t < 4"	Structural	42 ksi
A-441	1960T	t < 3/4"	Structural	50 ksi
A-441	1960T	3/4" < t < 1 1/2"	Structural	46 ksi
A-441	1960T	1 1/2" < t < 4"	Unannealed	42 ksi

"T" denotes a tentative ASTM designation approved by the sponsoring committee.

- A-7 · - Structural steel ( discontinued, replaced by A-36, A-283  
· · A-663, & A-675 ).
- A-8 · - Structural nickel steel ( discontinued ).
- A-15 · - Billet-steel for reinforcing bars ( discontinued, replaced by  
· · A-615 ).
- A-16 · - Rail-steel for reinforcing bars ( discontinued, replaced by  
· · A-616 ).
- A-36 · - Structural steel.
- A-94 · - Structural silicon steel ( discontinued ).
- A-141 · - Structural rivet steel ( discontinued, replaced by A-502 ).
- A-195 · - High-strength structural rivet steel ( discontinued, replaced  
· · by A-502 ).
- A-242 · - High-strength low-alloy structural steel.
- A-373 · - Structural steel for welding ( discontinued, combined with  
· · A-36 ).
- A-406 · - High-strength structural alloy rivet steel ( discontinued ).
- A-440 · - High-strength structural steel ( discontinued ).
- A-441 · - High-strength low-alloy structural manganese vanadium steel  
· · ( discontinued, replaced by A-572 ).

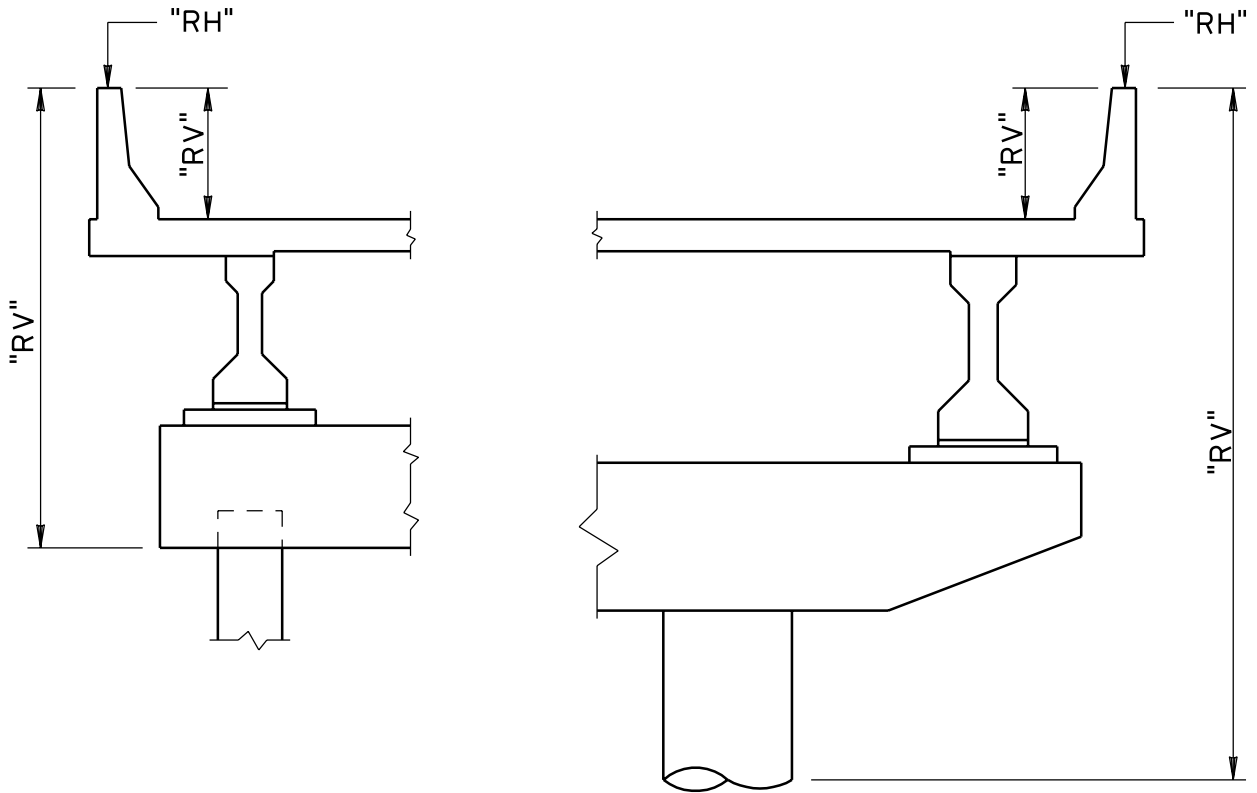
## BRIDGE STEEL

Table Showing Materials Unit Weight .

The following unit weights shall be used in computing dead load and for estimating pay quantities where payment for material is to be made on the basis of weight:

<b>MATERIAL</b>	<b>UNIT WEIGHT (kg/m<sup>3</sup>)</b>
<b>Steel,:</b> Rolled, cast, <i>copper bearing</i> , silicon, nickel and stainless	7850
<b>Iron,</b> cast	7130
<b>Iron,</b> malleable	7530
<b>Iron,</b> wrought	7800
<b>Aluminum,</b> cast or wrought	2770
<b>Copper,</b> alloy	8590
<b>Copper,</b> sheet	8940
<b>Bronze,</b> cast	8590
<b>Lead,</b> sheet	11320
<b>Zinc</b>	7210
<b>Timber,</b> treated	960
<b>Timber,</b> untreated	770
<b>Concrete,</b> plain or reinforced	2400
<b>Brick,</b> common	1920
<b>Asphalt plank</b>	1730
<b>Macadam or gravel,</b> rolled	2240
<b>Embankment fills,</b> rammed sand or gravel	1920
<b>Loose sand and earth</b>	1600
<b>Cinder filling</b>	960





NOTES:

"RV" denotes vertical and sloping faces and chamfers, as seen in elevation, which are to receive a class 2A special surface finish. "RH" denotes horizontal surfaces which are to receive a class 2A special surface finish.

The following surfaces shall receive a class 2A special surface finish:

1. Visually exposed faces of wingwalls, cast-in-place retaining walls, railings and parapets.
2. Outside faces of exterior concrete girders, slabs, brackets, curbs, headwalls, parapets, and vertical faces of caps and columns.

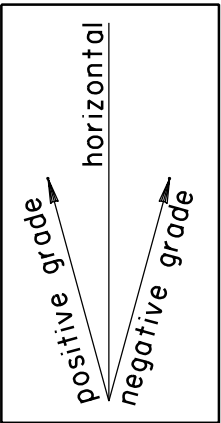
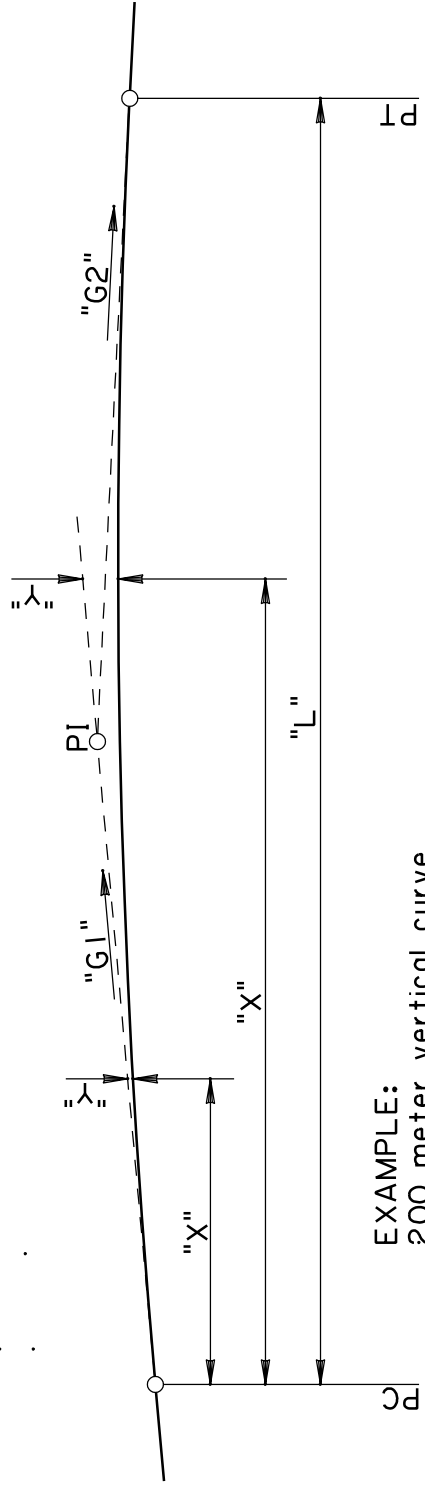
Bridge deck surfaces shall receive a class 6, Bridge Deck Finish except for sidewalks which are to receive a class 7, Sidewalk Finish. All other surfaces are to receive a class 1, Ordinary Surface Finish.

**SURFACE FINISHING**

- Let: L = total length of vertical curve in meters
- G1 = grade left of PI in decimals
- G2 = grade right of PI in decimals
- Y = correction for any point on curve in meters
- X = distance of that point from PC in meters

Then :  $Y = \frac{0.5(G2-G1)(X)^2}{L}$

Curve elev. = PC elev. + X(G1) + Y



EXAMPLE:  
 200 meter vertical curve  
 L=200 m, G1=+4.5%=+0.045, G2=-2.5%=-0.025  
 PC = Sta.10+000.000, Elev. 10.000 m

STATION	TANGENT ELEV.	CORRECTION	CURVE ELEV.
10+025.000	11.125	0.109 375 m	11.016
10+050.000	12.250	0.437 500 m	11.813
10+075.000	13.375	0.984 375 m	12.391
10+100.000 (PI)	14.500	1.750 000 m	12.750
10+125.000	15.625	2.734 375 m	12.891
10+150.000	16.750	3.937 500 m	12.813
10+175.000	17.875	5.359 375 m	12.516
10+200.000 (PT)	19.000	7.000 000 m	12.000

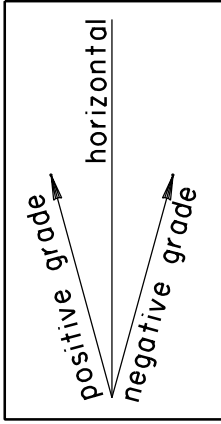
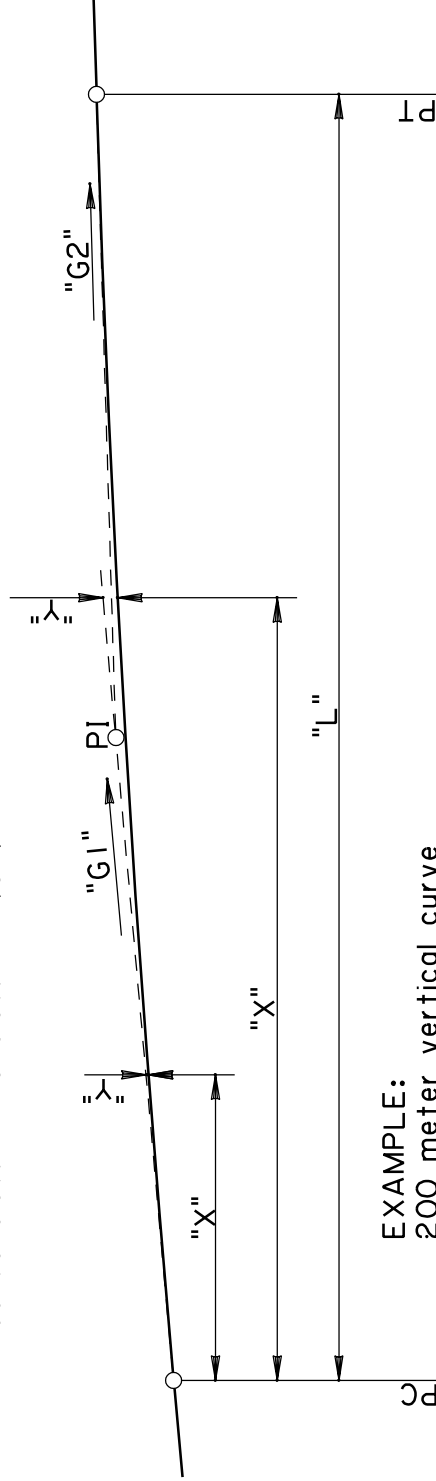
In the above example, Y = -0.000175(X)<sup>2</sup>.  
 The negative sign implies a downward measurement from tangent G1.

## VERTICAL CURVES

- Let: L = total length of vertical curve in meters  
 G1 = grade left of PI in decimals  
 G2 = grade right of PI in decimals  
 Y = correction for any point on curve in meters  
 X = distance of that point from PC in meters

$$\text{Then : } Y = \frac{0.5(G2-G1)(X)^2}{L}$$

$$\text{Curve elev.} = \text{PC elev.} + X(G1) + Y$$



EXAMPLE:  
 200 meter vertical curve  
 L=200 m, G1=+4.5%=+0.045, G2=+1.5%=0.015  
 PC = Sta.10+000.000, Elev. 10.000 m

STATION	TANGENT ELEV.	CORRECTION	CURVE ELEV.
10+025.000	11.125	0.046 875 m	11.078
10+050.000	12.250	0.187 500 m	12.063
10+075.000	13.375	0.421 875 m	12.953
10+100.000 (PI)	14.500	0.750 000 m	13.750
10+125.000	15.625	1.171 875 m	14.453
10+150.000	16.750	1.687 500 m	15.063
10+175.000	17.875	2.296 875 m	15.578
10+200.000 (PT)	19.000	3.000 000 m	16.000

In the above example, Y = -0.000075(X)<sup>2</sup>.  
 The negative sign implies a downward measurement from tangent G1.

## VERTICAL CURVES

Let: L = total length of vertical curve in meters

G1 = grade left of PI in decimals

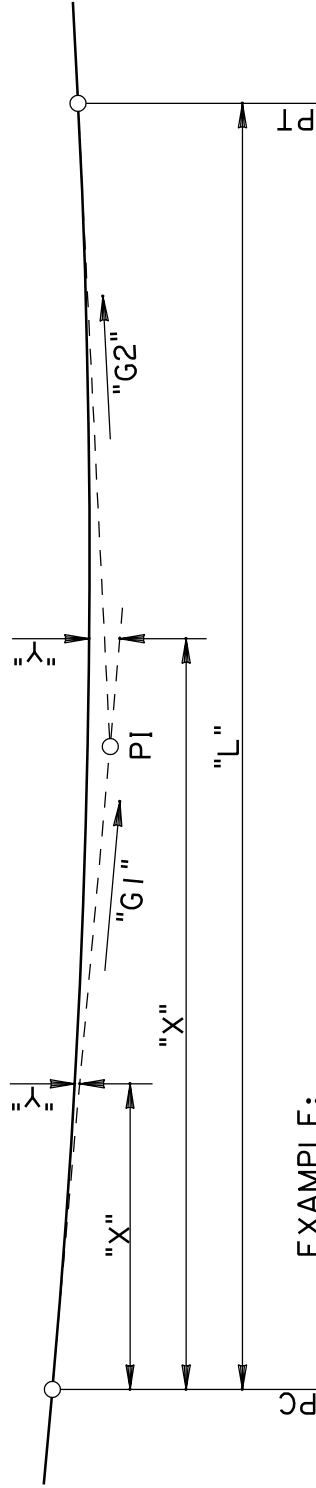
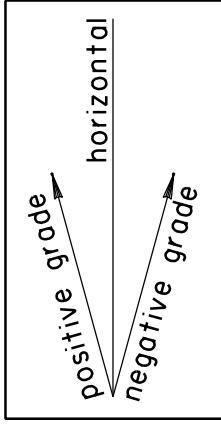
G2 = grade right of PI in decimals

Y = correction for any point on curve in meters

X = distance of that point from PC in meters

$$\text{Then : } Y = \frac{0.5(G2-G1)(X)^2}{L}$$

$$\text{Curve elev.} = \text{PC elev.} + X(G1) + Y$$



**EXAMPLE:**

200 meter vertical curve

L=200 m, G1=-4.5%=-0.045, G2=+2.5%=+0.025

PC = Sta.10+000.000, Elev. 10.000 m

STATION	TANGENT ELEV.	CORRECTION	CURVE ELEV.
10+025.000	8.875	0.109 375 m	8.984
10+050.000	7.750	0.437 500 m	8.188
10+075.000	6.625	0.984 375 m	7.609
10+100.000 (PI)	5.500	-1.750 000 m	7.250
10+125.000	4.375	2.734 375 m	7.109
10+150.000	3.250	3.937 500 m	7.188
10+175.000	2.125	5.359 375 m	7.484
10+200.000 (PT)	1.000	7.000 000 m	8.000

In the above example,  $Y = +0.000175(X)^2$ .

The positive sign implies an upward measurement from tangent G1.

**VERTICAL CURVES**

Let: L = total length of vertical curve in meters

G1 = grade left of PI in decimals

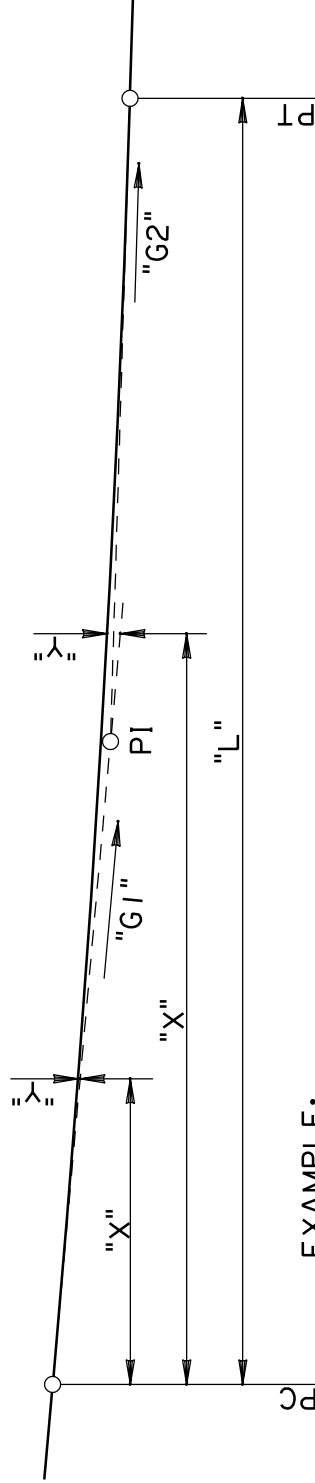
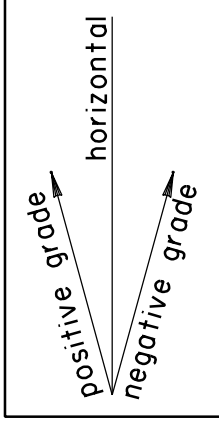
G2 = grade right of PI in decimals

Y = correction for any point on curve in meters

X = distance of that point from PC in meters

$$\text{Then : } Y = \frac{0.5(G2-G1)(X)^2}{L}$$

$$\text{Curve elev.} = \text{PC elev.} + X(G1) + Y$$



**EXAMPLE:**

200 meter vertical curve

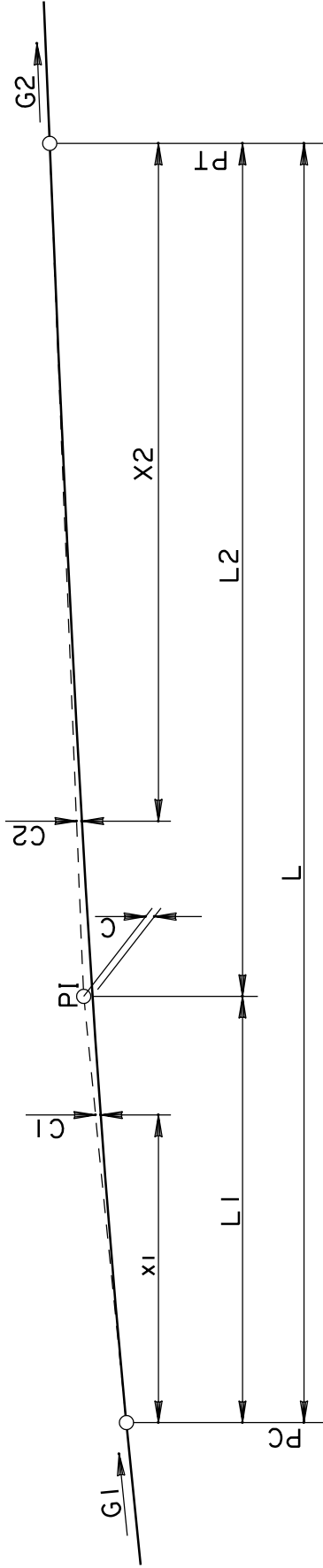
L=200 m, G1=-4.5%=-0.045, G2=-1.5%=-0.015

PC = Sta.10+000.000, Elev. 10.000 m

STATION	TANGENT ELEV.	CORRECTION	CURVE ELEV.
10+025.000	8.875	0.046 875 m	8.922
10+050.000	7.750	0.187 500 m	7.938
10+075.000	6.625	0.421 875 m	7.047
10+100.000 (PI)	5.500	0.750 000 m	6.250
10+125.000	4.375	1.171 875 m	5.547
10+150.000	3.250	1.687 500 m	4.938
10+175.000	2.125	2.296 875 m	4.422
10+200.000 (PT)	1.000	3.000 000 m	4.000

In the above example, Y = +0.000075(X)<sup>2</sup>.  
 The positive sign implies an upward measurement from tangent G1.

**VERTICAL CURVES**



### EXAMPLE

300 meter eccentric vertical curve,  $L_1=100$  m,  $L_2=200$  m  
 $G_1=+5.00\%$ ,  $G_2=+2.00\%$ ,  $PI=sta.10+100$ , elev.=15.000 m

$$C = \frac{(100)(200)(0.02 - 0.05)}{2(300)} = -1.000 \text{ m}$$

$$C_1 = \frac{(-1)(X_1)^2}{(100)^2} = -0.0001(X_1)^2$$

$$C_2 = \frac{(-1)(X_2)^2}{(200)^2} = -0.000025(X_2)^2$$

### FORMULAS

Let  $L$  = total length of vertical curve

$L_1$  = length of vertical curve back of PI

$L_2$  = length of vertical curve ahead of PI

$G_1$  = first grade of curve back of PI

$G_2$  = second grade of curve ahead of PI

$X_1$  = distance from PC of any point back of PI

$X_2$  = distance from PT of any point ahead of PI

$C_1$  = correction for any point back of PI

$C_2$  = correction for any point ahead of PI

$C$  = center correction at PI

$$\text{Then } C = \frac{(L_1)(L_2)(G_2 - G_1)}{2L}$$

$$C_1 = \frac{(C)(X_1)^2}{(L_1)^2}$$

$$C_2 = \frac{(C)(X_2)^2}{(L_2)^2}$$

All dimensions in meters.

All grades in decimals.

STATION	DISTANCE		TANGENT ELEV.	CORRECTION		CURVE ELEV.
	$X_1$	$X_2$		$C_1$	$C_2$	
10+050	50 m	N/A	12.500	-0.25 m	N/A	12.250
10+100	100 m	N/A	15.000	-1.00 m	N/A	14.000
10+150	N/A	150 m	16.000	N/A	-0.5625 m	15.438
10+200	N/A	100 m	17.000	N/A	-0.25 m	16.750
10+250	N/A	50 m	18.000	N/A	-0.0625 m	17.938
10+300	N/A	0 m	19.000	N/A	0 m	19.000

## ECCENTRIC VERTICAL CURVES

290 m SSD, 120 km/h DES. SPEED				250 m SSD, 110 km/h DES. SPEED				210 m SSD, 100 km/h DES. SPEED				140 m SSD, 80 km/h DES. SPEED			
GRADE A/2 %	Lc=209A (meters)	Ls= 38A (meters)	"H" (meters)	GRADE A/2 %	Lc=155A (meters)	Ls= 32A (meters)	"H" (meters)	GRADE A/2 %	Lc=110A (meters)	Ls= 26A (meters)	"H" (meters)	GRADE A/2 %	Lc= 49A (meters)	Ls= 16A (meters)	"H" (meters)
1.0	418	76	1.425	1.0	310	66	1.105	1.0	220	60	0.850	1.0	98	48	0.485
1.5	627	114	3.206	1.5	465	96	2.464	1.5	330	78	1.823	1.5	147	48	0.911
2.0	836	152	5.700	2.0	620	128	4.380	2.0	440	104	3.240	2.0	196	64	1.620
2.5	1045	190	8.906	2.5	775	160	6.844	2.5	550	130	5.063	2.5	245	80	2.531
3.0	1254	228	12.825	3.0	930	192	9.855	3.0	660	156	7.290	3.0	294	96	3.645
3.5	1463	266	17.456	3.5	1085	224	13.414	3.5	770	182	9.923	3.5	343	112	4.961
4.0	1672	304	22.800	4.0	1240	256	17.920	4.0	880	208	12.960	4.0	392	128	6.480
4.5	1881	342	28.856	4.5	1395	288	22.174	4.5	990	234	16.403	4.5	441	144	8.201
5.0	2090	380	35.625	5.0	1550	320	27.375	5.0	1100	260	20.250	5.0	490	160	10.125
5.5	2299	418	43.106	5.5	1705	352	33.124	5.5	1210	286	24.503	5.5	539	176	12.251
6.0	2508	456	51.300	6.0	1860	384	39.420	6.0	1320	312	29.160	6.0	588	192	14.580

120 m SSD, 70 km/h DES. SPEED				110 m SSD, 65 km/h DES. SPEED				90 m SSD, 60 km/h DES. SPEED							
GRADE A/2 %	Lc= 36A (meters)	Ls= 14A (meters)	"H" (meters)	GRADE A/2 %	Lc= 30A (meters)	Ls= 12A (meters)	"H" (meters)	GRADE A/2 %	Lc= 20A (meters)	Ls= 10A (meters)	"H" (meters)	GRADE A/2 %	Lc= 13A (meters)	Ls= 7A (meters)	"H" (meters)
1.0	72	42	0.390	1.0	60	39	0.345	1.0	40	36	0.280	1.0	30	30	0.225
1.5	108	42	0.720	1.5	90	39	0.630	1.5	60	36	0.495	1.5	39	30	0.371
2.0	144	56	1.280	2.0	120	48	1.080	2.0	80	40	0.800	2.0	52	30	0.560
2.5	180	70	2.000	2.5	150	60	1.688	2.5	100	50	1.250	2.5	65	35	0.844
3.0	216	84	2.880	3.0	180	72	2.430	3.0	120	60	1.800	3.0	78	42	1.215
3.5	252	98	3.920	3.5	210	84	3.308	3.5	140	70	2.450	3.5	91	49	1.654
4.0	288	112	5.120	4.0	240	96	4.320	4.0	160	80	3.200	4.0	104	56	2.160
4.5	324	126	6.480	4.5	270	108	5.468	4.5	180	90	4.050	4.5	117	63	2.734
5.0	360	140	8.000	5.0	300	120	6.750	5.0	200	100	5.000	5.0	130	70	3.375
5.5	396	154	9.680	5.5	330	132	8.168	5.5	220	110	6.050	5.5	143	77	4.084
6.0	432	168	11.520	6.0	360	144	9.720	6.0	240	120	7.200	6.0	156	84	4.860

NOTES: THE MINIMUM LENGTH OF A VERTICAL CURVE = 0.6V, EXCEPT IN SPECIAL CASES SUCH AS IN RURAL SECTIONS WHERE THE MINIMUM LENGTH = 100 m.

"H" ON THE PLANS MUST NOT BE LESS THAN WHAT IS SHOWN ON THIS SHEET.

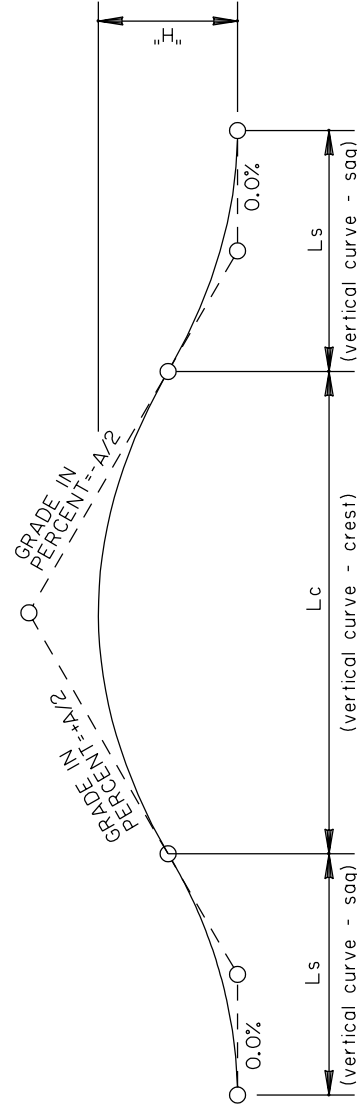
FORMULAS:  
 $L_c = KAc = \frac{A(S)^2}{404}$

$L_s = KAs = \frac{0.5A(S)^2}{120+3.5S}$

$L_c(\min) = L_s(\min) = 0.6V$

where S = SSD (in meters), and V is speed (in km/h).

⊗ SEE NOTES ABOVE.



## VERTICAL CURVES (DESIRABLE LENGTHS)

210 m SSD, 120 km/h DES. SPEED			180 m SSD, 110 km/h DES. SPEED			160 m SSD, 100 km/h DES. SPEED			120 m SSD, 80 km/h DES. SPEED						
GRADE A/2 %	Lc=110A (meters)	Ls= 26A (meters)	"H" (meters)	GRADE A/2 %	Lc= 81A (meters)	Ls= 22A (meters)	"H" (meters)	GRADE A/2 %	Lc= 64A (meters)	Ls= 19A (meters)	"H" (meters)	GRADE A/2 %	Lc= 36A (meters)	Ls= 14A (meters)	"H" (meters)
1.0	220	72	0.910	1.0	162	66	0.735	1.0	128	60	0.620	1.0	72	48	0.420
1.5	330	78	1.823	1.5	243	66	1.406	1.5	192	60	1.170	1.5	108	48	0.765
2.0	440	104	3.240	2.0	324	88	2.500	2.0	256	76	2.040	2.0	144	56	1.280
2.5	550	130	5.063	2.5	405	110	3.906	2.5	320	95	3.188	2.5	180	70	2.000
3.0	660	156	7.290	3.0	486	132	5.625	3.0	384	114	4.590	3.0	216	84	2.880
3.5	770	182	9.923	3.5	567	154	7.656	3.5	448	133	6.248	3.5	252	98	3.920
4.0	880	208	12.960	4.0	648	176	10.000	4.0	512	152	8.160	4.0	288	112	5.120
4.5	990	234	16.403	4.5	729	198	12.656	4.5	576	171	10.328	4.5	324	126	6.480
5.0	1100	260	20.250	5.0	810	220	15.625	5.0	640	190	12.750	5.0	360	140	8.000
5.5	1210	286	24.503	5.5	891	242	18.906	5.5	704	209	15.428	5.5	396	154	9.680
6.0	1320	312	29.160	6.0	972	264	22.500	6.0	768	228	18.360	6.0	432	168	11.520
100 m SSD, 70 km/h DES. SPEED			90 m SSD, 65 km/h DES. SPEED			80 m SSD, 60 km/h DES. SPEED			60 m SSD, 50 km/h DES. SPEED						
GRADE A/2 %	Lc= 25A (meters)	Ls= 11A (meters)	"H" (meters)	GRADE A/2 %	Lc= 20A (meters)	Ls= 10A (meters)	"H" (meters)	GRADE A/2 %	Lc= 16A (meters)	Ls= 8A (meters)	"H" (meters)	GRADE A/2 %	Lc= 9A (meters)	Ls= 6A (meters)	"H" (meters)
1.0	50	42	0.335	1.0	40	39	0.295	1.0	36	36	0.270	1.0	30	30	0.225
1.5	75	42	0.596	1.5	60	39	0.518	1.5	48	36	0.450	1.5	30	30	0.225
2.0	100	44	0.940	2.0	80	40	0.800	2.0	64	36	0.680	2.0	36	30	0.480
2.5	125	55	1.469	2.5	100	50	1.250	2.5	80	40	1.000	2.5	45	30	0.656
3.0	150	66	2.115	3.0	120	60	1.800	3.0	96	48	1.440	3.0	54	36	0.945
3.5	175	77	2.879	3.5	140	70	2.450	3.5	112	56	1.960	3.5	63	42	1.286
4.0	200	88	3.760	4.0	160	80	3.200	4.0	128	64	2.560	4.0	72	48	1.680
4.5	225	99	4.759	4.5	180	90	4.050	4.5	144	72	3.240	4.5	81	54	2.126
5.0	250	110	5.875	5.0	200	100	5.000	5.0	160	80	4.000	5.0	90	60	2.625
5.5	275	121	7.109	5.5	220	110	6.050	5.5	176	88	4.840	5.5	99	66	3.176
6.0	300	132	8.460	6.0	240	120	7.200	6.0	192	96	5.760	6.0	108	72	3.780

NOTES: THE MINIMUM LENGTH OF A VERTICAL CURVE = 0.6V, EXCEPT IN SPECIAL CASES SUCH AS IN RURAL SECTIONS WHERE THE MINIMUM LENGTH = 100 m.

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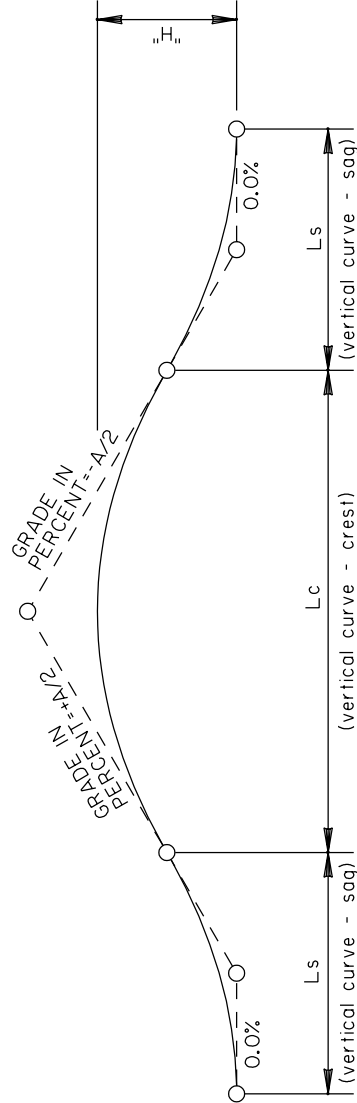
FORMULAS:  
 $L_c = KAc = \frac{A(S)^2}{404}$

$L_s = KAs = \frac{0.5A(S)^2}{120+3.5S}$

$L_c(\text{min}) = L_s(\text{min}) = 0.6V$

where S = SSD (in meters), and V is speed (in km/h).

⊗ SEE NOTES ABOVE.



## VERTICAL CURVES (MINIMUM LENGTHS)





## STANDARD PLANS AND STANDARD DETAILS

### Introduction

This section is intended to provide a list of available standard plans and standard details in order to prevent duplication of work. As these standard plans and standard details are continually being revised, it is the responsibility of the consultant or the in-house engineer to check with the project coordinator that the appropriate standard plans and standard details are included in the plans. Consultant manhours should not be included for details already covered on standard plans or standard details. All standard plans are listed on the title sheet along with its call number and latest revision date. Drawings for standard plans and standard details maintained by the Bridge Design Section are included in Appendix "A". All other standard plans (roadway, hydraulic, traffic control) may be obtained through the Department's General Files Section or the appropriate Department section.

### Definitions

**Standard plan:** An independent design detail (or series of details) that is routinely incorporated into the construction plans without modification and has been designated by the Chief Engineer as a standard plan. Official Department standard plans are signed by the Chief Engineer and described by a call number on the drawing ( i.e., GR-200 (M)).

**Standard detail:** Details maintained by the Bridge Design Section and are not signed by the Chief Engineer. These details are not official Department standards, and may require supplemental information for specific projects. These details are normally used on bridge related projects only.

### Policy for Adoption, Revision and Distribution of Standard Plans

The Contracts and Specifications Engineer Administrator will be responsible for the administering of all Standard plans. Proposed additions, deletions, and revisions must be submitted to his office in order to obtain the approval of the Chief Engineer. See E.D.S.M. I.1.1.2 for further information.

### Use of Standard Plans and Standard Details by entities other than DOTD

1. The Department will furnish a blue-line print of a Standard Plan or Detail stamped "**For Informational Purposes Only**".
2. The Department will furnish a reproducible copy of a Standard Plan or Detail if the requesting entity submits a formal, hold-harmless resolution, signed by someone with authority to accept responsibility. The letter for this request shall specify the project name and location for which the plans will be applied.

3. The reproducible will be furnished to the consultant working for the requesting entity on a project specific basis.

#### Standard Plans Maintained by the Bridge Design Section

##### Guardrail:

1. GR-200 (M), Guardrail For Bridge Ends, T-intersections
2. GR-201 (M), Guardrail For Median & Roadside Obstacles
3. GR-202 (M), Guardrail For Box Culvert
4. GR-203 (A) (M) and GR-203( B) (M), Guardrail For Off-System Bridges

##### Miscellaneous:

1. SWBS-100 (M), Steel Wire Bar Supports
2. RW-01 (M), Retaining Wall

#### Standard Details maintained by the Bridge Design Section

##### Concrete Slab Spans (Superstructure, Substructure and Approach Slabs)

1. 6 m and 20 ft. Cast-In-Place Slab Spans (On-System Bridges)
2. 6 m and 19 ft. Precast Slab Spans (Off-System Bridges)

### Span and Girder Details:

1. Miscellaneous Span and Girder Details, Prestressed Girders
2. Optional Span Details Concrete, (precast panels)
3. Optional Span Details Steel, (precast panels)
4. Strip Seal Joint
5. GF-1, Open Steel Grid Floor
6. GF-2, Open Steel Grid Floor (Heavy Duty)
7. Bridge End Drain Details

### Revetment:

1. CR-1 (M), Cast-In-Place Revetment
2. FR-01 (M), Flexible Revetment and Rip-Rap

### Piling:

1. CS-216 (M), Precast-Prestressed Piling
2. Prestressed Cylinder Pile
3. Alternate Pile Splice, Dyna-A-Splice
4. Pile Splice, Cement Dowel
5. Concrete Pile Alternates

### Approach Slab Drainage:

1. ASD-SS, Underdrains for Approach Slabs (Slab Spans)
2. ASD-SA, Underdrains for Approach Slabs (Girder Spans)

### Barrier Railing:

1. BR-01 (M), Barrier Railing (Girder Spans)
2. BR-02 (M), Barrier Railing (Slab Spans)
3. BR-03 (M), Barrier Railing (Low Speed Urban Transition)
4. BR-04A (M), Barrier Railing (Precast Slab Spans, Bolted Barrier)
5. BR-04B (M), Barrier Railing (Precast Slab Spans, Cast w/Panel)
6. BR-05 (M), Barrier Railing Transition

### Guardrail:

1. MELT, Guardrail End Treatment
2. New Jersey Bridge Rail Retrofit
3. Anchor Block Retrofit
4. Approach Guardrail & Bridge Rail Rehabilitation (Misc. Details)

### Detours:

1. Bridge Detour (Precast Concrete Panel)
2. Bridge Detour Substructure (Acrow Panel)
3. Temporary Precast Barrier

### Signing:

1. Permanent Signing (Overhead & Ground Mounted Signs)

### Lighting:

1. High Mast Tower Details

### Miscellaneous:

1. YP-01(M), year plates

Typically used Standard Plans maintained by other sections

1. SD-50,100,150,200 - 50 ft. to 200 ft. Spur Dike Details, (Hydraulics Section)
2. RS-31, Hazard Markers, (Road Design Section)
3. HS-01, Construction Signs and Barricades, (Traffic and Planning Section)
4. PM-01 (M), Raised Traffic Markers and Pavement Markings, (Traffic and Planning Section)

Other standard plans not listed may be obtained through the DOTD General Files Section. These include: roadway, hydraulic and traffic standard plans.

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## **GENERAL**

CAD is the most common method used to prepare bridge plans; however, manual drafting is sometimes utilized to produce bridge details. The instructions given in this chapter are sometimes only applicable to one of the two methods of plan preparation. Many of the principles necessary to produce quality bridge apply to both the manual and the computer aided method.

The purpose of an engineering or technical drawing is to convey complete instructions with clarity and simplicity. Complex projections, excessive detail, artistic flourishes and other unnecessary drafting frills should be avoided. They add nothing to the value of the drawing and defeat the objectives of simplicity and clarity that are so important to the plan production process. Show only what is necessary to clearly describe the detail.

A good quality drawing is easily recognized by its clean appearance, sharp line work, clear and uniform lettering, well-selected views and simple presentation. The importance of careful presentation cannot be over-emphasized as a prime factor in contributing to good quality reproductions. One cannot expect to achieve the same good results with a soiled, wrinkled drawing with light lines and lettering that one can with a clean drawing, using black opaque lines and lettering.

## **INSTRUCTIONS IN DETAILING FOR REDUCTION OF PLANS**

The Louisiana Department of Transportation and Development has a policy of reducing all plans that are to be let to contract. This process means that the drawings are reduced, using photography, to a plate 50 percent smaller than the original. Because this reduction works both horizontally and vertically, a plan sheet approximately one-fourth the size of the original plan sheet will result. The result is not always completely satisfactory in that the line work on the reduction may appear somewhat "fuzzy" or light if care is not used in preparing the drawings. These reduced prints will be the plans from which the contractor computes his bid and will also be used for construction of the bridge. Within a reasonable time after the bridge has been constructed, the original sheets will be microfilmed to one-thirteenth of the original size and kept as a permanent record of the contract plans. Prints can be made at any time in the future from the microfilm if it becomes necessary to do additional work on the bridge. Legibility is clearly of great importance.

What is considered "normal detailing practice" may not always apply to drawing that is to be reduced. This task requires a constant awareness on the part of the drafter, who should consider the question, "How will this drawing appear when it is reduced?" The size of lettering, spacing between lines of lettering, and spacing between object lines are all affected by plan reduction. The drafter should pay close attention to these concerns; otherwise, the plans will not be suitable for reduction. One must conclude that drawing plans for reduction requires not only technical skill, but an attention to detail not necessary when drawing for full-size reproductions.

## **LETTERING**

Due to nature of engineering work and the time element involved, it is often necessary to employ more than one drafter in the preparation of the plan sheets that go together to make up a final set of contract drawings. Such a procedure dictates that drafting practices should be consistent to ensure a reasonably uniform appearance for all sheets in the plan set. The greatest source of inconsistency is in the plan lettering. No two drafters will letter exactly alike, but if both are using the same basic style, then the result should be generally suitable. When work is being done on a drawing that has lettering already on it, whether it is hand type, Leroy, or other mechanical means, every effort should be made to match the additional lettering to the existing lettering on that sheet. All letters and numbers shall be created with an open, non-compressed style. The prints generated from microfilm or half-size copies are reduced from the original size, making clear, open lettering, uniform and properly spaced, essential for legibility. Lettering shall be vertical style, uppercase lettering, however, slanted lettering will not be prohibited for hand lettered drawings or drawings produced prior to this publication. Some type of guideline system shall be used, either a mechanical lettering guide or a prepared guideline sheet. Freehand lettering should never be attempted without using guidelines.

The body of letters, numbers, and symbols shall be no smaller than 140 Leroy size, except in unusual cases where available space is inadequate. If lettering is reduced to a size smaller than 140 Leroy, it must be reasonably readable at 50% reduction. The 120 Leroy size will usually meet these criteria. See the examples below for the size and type of lettering required. Sizes indicated as minimum are also the recommended sizes for most applications.

## **SCALE**

Drawing scale is an important consideration when setting up a detail sheet. Scales should be appropriate for the application, not too big and not too small. Legibility is the key consideration. Small-scale, crowded plans, elevations, views, and sections are not acceptable, so consideration should be given to moving views and sections to other sheets, separate from plan and elevation views, when necessary to avoid overcrowded and under-scaled details. Materials lists, summary of quantities and large notes may also be placed on separate sheets.

Obviously it is difficult to make proper topography drawings and plan-and-profile sheets to a large scale without utilizing additional time and materials; however, it is possible to greatly clarify a drawing without enlarging the scale by careful placement of dimensions, descriptions, and notes.

Details shall be drawn to standard scales where practical. If the detail is to scale, show the scale under the detail title. In special cases a detail may be scaled to fit available space. In these cases indicate that details are not to scale by noting "NTS" below the sheet title. Traditionally certain details, such as reinforcing bar details and superelevation transition details, have been drawn in schematic format. It is not necessary to mark schematic details "NTS."

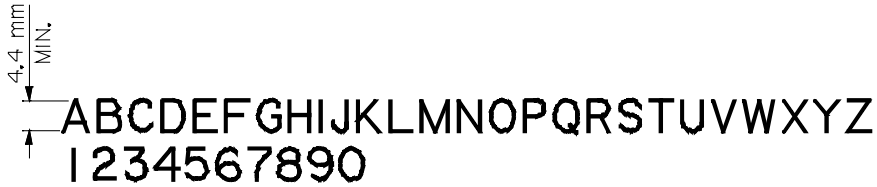
## TEXT

### PEN AND PENCIL TEXT SIZE AND LINE WEIGHTS

#### Detail Titles

Lettering Guide - # 5 1/2 Ames or # 175 Leroy

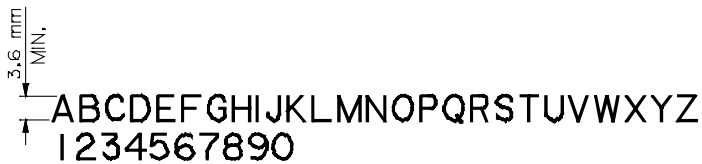
Line Weight - H lead or # 2 Technical pen



#### Dimensions, Notes and Callouts

Lettering Guide - # 4 1/2 Ames or # 140 Leroy

Line Weight - 2H lead or # 1 Technical pen



### CAD TEXT EQUIVALENCE

Text heights shown above are equivalent to the Leroy size or guideline spacing indicated, and are measured to the outside of stroke, whereas CAD text heights are measured to center of stroke. Therefore, a reduction in CAD text height values from the text heights shown above is required to achieve equivalent CAD text output. CAD text height values are as follows: 3.2 mm for 140 Leroy equivalence and 4.0 mm for 175 Leroy equivalence. CAD lines for text shall be equal in width to the technical pen specified above.

## **LINE WORK**

To ensure good half-size and microfilm reproductions, lines must be properly drawn. Ink is recommended as the best reproducing agent, however, dark concise pencil lines are acceptable. The outline of the object should stand out sharply, with reinforcing lines somewhat less prominent. Dimension lines, centerlines, cross-hatching, and existing structure lines shall be lighter still. Guidelines shall be scarcely visible. Closely drawn lines should be avoided as they tend to run together to make one (1) heavy line when the drawing is reduced. Some exaggeration of scale may be used in areas where this might occur. Lines of any type should never be placed on the back of drawings because they are almost impossible to reproduce with LA DOTD methods.

A steady pressure should be exerted to ensure lines of constant density throughout the drawing. Consistent line width and black opacity are essential. When making changes on a drawing, every effort should be made to match the original line density. A good gauge of the opacity of pencil line is whether it shines or not. A black shiny line will reproduce much better than a dull, fuzzy one.

### **PEN AND PENCIL LINE WORK**

1. Object or Concrete Lines (# 2 Technical Pen or 2H Lead - Minimum)
2. Reinforcing Steel or Metalwork Lines (# 1 Technical Pen or 3H Lead - Minimum)
3. Hidden Lines (# 0 Technical Pen or 3H Lead - Minimum)
4. Ground Lines (# 0 Technical Pen or 3H Lead - Minimum)
5. Dimension Lines and Arrow Heads (# 00 Technical Pen or 4H Lead - Minimum)
6. Centerlines (# 00 Technical Pen or 4H Lead - Minimum)
7. Existing Features Lines (# 00 Technical Pen or 4H Lead - Minimum)
8. Cross-Hatching (# 00 Technical Pen or 4H Lead - Minimum)
9. Break Lines (# 00 Technical Pen or 4H Lead - Minimum)
10. Cutting Plane or Section Lines (# 3 Technical Pen or H Lead - Minimum)

### **CAD LINE WORK EQUIVALENCE**

CAD lines shall be equal in width to the technical pens specified above. Software pen widths shall be adjusted to ensure a match that is as close as possible.

## **BRIDGE DESIGN CAD STANDARDS**

The following requirements assume that details are generated with MicroStation software. Currently submittal of consultant plans is not required in electronic format; however, this may become a requirement in the future. Users of other software should read this section as a guide to output symbology and quality expectations, and the general types of standardization expected.

### **CELL FILES**

Cell files are indexed graphically in the Bridge Design Cell Libraries booklet. This is a separate document and may be obtained upon request from the Bridge Design Section. Bridge Design cell libraries are as follows:

ENGLISH	METRIC
common.cel	general.cel
bent.cel	struct.cel
span.cel	struct.cel
gp.cel	plan.cel
steel.cel	metal.cel
mec.cel	mech.cel
ele.cel	elect.cel

Cell libraries are useful because they enable frequently used details to be accessed in a standardized format and placed without having to redraw. The above cell files should be used whenever possible by Bridge Design drafters. Personal versions of Standard Bridge Design cells are not recommended. Individuals creating useful cells should see to it that these cells are included in the appropriate cell library, and make sure that the library keeper is informed. Cells should be carefully constructed. Cells of limited long-term value, such as those to be used on a specific job only, shall be included in personal or project cell libraries. Consultants will not be required to use Bridge Design cell libraries; however, they should strive to achieve similar standardized details. Bridge Design cell libraries will be made available to consultants upon request.

### **TEXT REQUIREMENTS**

Fonts: Text shall be Font 103, a vertical, open, non-compressed style similar to Leroy. All text shall be uppercase unless there is a special need for lowercase such as the metric symbol, "mm." Actual text sizes shall be equal to mechanical Leroy sizes. For consistency and convenience, it is recommended that the sidebar menu, bridge-m.sbm, be used to set text size, line spacing and line weights.

## FILE NAMING CONVENTIONS

Users of Windows NT, Windows 95 or Macintosh operating systems may take advantage of the long filename capability. The filename "Bents2-5wb.dgn," for instance, is permissible; however, filenames that are overly descriptive are not recommended. A keyword, such as "Bent" or "Span," should start long filenames so that they will be grouped properly in the file manager.

Users of DOS or Unix type operating systems or mixed systems including either of these should use filenames conforming to DOS conventions. Maximum length of DOS filenames is 8 characters + 3 character extension. DOS filenames are permissible for all common operating systems. Unix allows two additional characters, but this is not enough to enable useful long filenames. A detail representative of several elements in a design, such as "bents 2-5 and 9", shall be specified using the first element number (i.e., bpil2.dgn). Standardized DOS filenames are listed below.

Files shall be limited to one sheet each. Filenames for details that require more than one sheet, such as end bents, shall be given a letter designation (e.g., bpil1a.dgn and bpil1b.dgn). Standard plan files shall be named according to historical conventions. The standard design file extension is ".dgn" and shall be used except where specified otherwise.

### Mechanical and Electrical Filenames

Files shall be named according to the "M" or "E" number whenever applicable. Examples: M04.dgn and E07.dgn.

### Structural Filenames (DOS convention)

1.	GENERAL ITEMS
FILENAME	DESCRIPTION
<b>plangb.dgn</b>	plan, general bridge
<b>plangr.dgn</b>	plan, general ramp
<b>plangd.dgn</b>	plan, general detour bridge
<b>channel.dgn</b>	channel relocation and improvements
<b>laygen.dgn</b>	layout, general
<b>layseq.dgn</b>	layout , sequencing or phasing
<b>notes.dgn</b>	general notes
<b>qsum.dgn</b>	quantities, summary of
<b>qbrsum.dgn</b>	quantities, bridge summary of
<b>signp.dgn</b>	signing, permanent
<b>signc.dgn</b>	signing, construction
<b>eltb.dgn</b>	elevation table

<b>2. BRIDGE SUBSTRUCTURE</b>	
<b>FILENAME</b>	<b>DESCRIPTION</b>
layfnd.dgn	layout, foundation
col.dgn	columns
drshaft.dgn	drilled shaft
pierprt.dgn	pier protection (fender system, dolphin, etc.)
fender.dgn	fender system
footing.dgn	footings
bgate.dgn	bent with traffic gates for movable bridge
bpier.dgn	bent, pier
bcol.dgn	bent, column
bpil.dgn	bent, pile
btbar.dgn	bent with traffic barrier for movable bridge
bppier.dgn	bent, pivot pier
pilepc.dgn	pile, precast
pilest.dgn	pile, steel
pileti.dgn	pile, timber
pilett.dgn	pile, treated timber
pidattb.dgn	pile data table

<b>3. BRIDGE SUPERSTRUCTURE</b>	
<b>FILENAME</b>	<b>DESCRIPTION</b>
planf.dgn	plan, framing
super.dgn	superelevation transition
railhn.dgn	rail, handrail
railbr.dgn	rail, barrier
wallrtn.dgn	wall, retaining
floorgr.dgn	flooring, grid
gicb.dgn	girder, concrete box
gicsb.dgn	girder, curved steel box
gicsi.dgn	girder, curved steel I-beam
gippc_.dgn	girder, ppc (type), e.g., gippc3 = type 3
gisi.dgn	girder, steel I-beam
gisb.dgn	girder, steel box
gidgntb.dgn	girder design table
gilentb.dgn	girder length table
ssi.dgn	span, steel I-beam girder
sppcb.dgn	span, precast-prestressed concrete box girder



<b>3. BRIDGE SUPERSTRUCTURE</b>	
sppci.dgn	span, precast-prestressed concrete I-girder
scslab.dgn	span, cast-in-place slab
spslab.dgn	span, precast slab
sctb.dgn	span, cast-in-place T-beam
slift.dgn	span, lift
sswing.dgn	span, swing
sccb.dgn	span, cast-in-place concrete box girder
sptcb.dgn	span, post-tensioned concrete box girder
sptci.dgn	span, post-tensioned concrete I-girder
ssb.dgn	span, steel box girder
postdet.dgn	post-tensioning details
postlay.dgn	post-tensioning layout
postqnt.dgn	post-tensioning quantities

<b>4. BRIDGE APPROACHES</b>	
FILENAME	DESCRIPTION
appr.dgn	approach slab
apprps.dgn	approach slab, pile supported

<b>5. SPECIALTY ITEMS</b>	
FILENAME	DESCRIPTION
access.dgn	access opening
caisson.dgn	caisson
cntwt.dgn	counterweight
drainbr.dgn	drainage, bridge
drainsc.dgn	drain, scupper
deckco.dgn	deck coordinates
erctsch.dgn	erection scheme, casting machine schematic
jtexp.dgn	joint, expansion and stress relief joint
jtfng.dgn	joint, finger
jacking.dgn	jacking details
operh.dgn	operator house
portal.dgn	portal
bearn.dgn	bearing, neoprene
bearp.dgn	bearing, pot
bearr.dgn	bearing, rocker

5.	SPECIALTY ITEMS
beart.dgn	bearing, Teflon
segbulk.dgn	segment bulkhead
seg.dgn	segment details
seglay.dgn	segment layout
strut.dgn	strut
subshaft.dgn	subshaft
tower.dgn	tower
portalt.dgn	portal, tower
truss.dgn	truss
swbrace.dgn	sway bracing
willowm.dgn	willow mattress
windanc.dgn	wind anchorage
windlnk.dgn	wind link

### SEED FILE SETTINGS

SETTING CATEGORY	SETTING TYPE	ENGLISH FILE SEEDBDE	METRIC FILE SEEDBDMD	METRIC FILE SEEDBDMP
1. Text	font size	103	103	103
	space	0.1280	96.0	0.960
		0.0768	58.0	0.576
2. Working unit names	master units	'	blank (mm)	_m
	sub units	"	blank	blank (mm)
3. Resolution	sub units	12	1	1000
	positional units	8000 or 2000	80	80
4. Coordinate Readout	coord. format	master	master	master
	ang. accuracy	.1234	.12	.1234
	angle format	dd.dddd	dd.dddd	dd mm ss
	angle mode	conventional	conventional	bearing
	ang. accuracy	.1234	.1234	0.1 seconds
5. Cells	tpmode	delta	delta	delta
	cell library	common.cel	bridge.cel	bridge.cel
6. Grid	terminator cell	LT101	LT101A	LT101A
	master grid	0.0833	0.1	1.0
7. Level names	reference grid	12	10	10
	level name file	str.lvl	str.lvl	str.lvl
8. Dimensions	as in settings file	str.stg	str.stg	str.stg
	component	english detail	metric detail	metric plan
9. Sheet type	reference file	N/A	detsheet	plnsheet
	sheet cell	sh101n	N/A	N/A

Note: Settings not shown are generally as in seed2d.dgn.

## **OUTPUT QUALITY - NEATNESS AND COMPOSITION**

CAD affords a great opportunity to produce neat, well-composed drawings. Details can be corrected, revised, rearranged, moved, copied, scaled, and rotated with little difficulty. Object corners can be made to meet precisely with zero gap or overlap. Spacing between lines of text can be made consistent. Automated dimensioning enables consistent dimension styles. Symbology settings enable consistency in drawing appearance and readability. There is simply no excuse for shoddy work.

## **ACCURACY GUIDELINES**

The value of CAD drawings can be greatly extended if they are accurately drawn. Precise angles and distances can be derived directly from CAD drawings without unnecessary additional manual or cogo computation. For this reason drawing geometry shall be input with six decimal place accuracy (meters) and three decimal place accuracy (millimeters). Small design dimension changes or input errors sometimes have ramifications to the drawing as a whole that would require a disproportionate amount of time to fix. In this case, if there is no critical geometry to be derived from the drawing, corrections need not be made to the geometry. Conversely, if corrections to the accuracy of drawing geometry can be easily made, they should be made.

In the past MicroStation has not been able to generate drawings with geometric accuracy that rivals hand calculations or cogo program output. Effective with MicroStation SE, an "enhanced precision" option is available which provides accuracy superior to double-precision floating-point storage. This option is invoked for Bridge Design effective April 1, 1999. It will not affect the accuracy of previously drawn geometry.

## **CAD TOOL CHOICES**

As any experienced CAD operator knows, there are often many ways to get the job done. A dimension, for instance, can be drawn using separate lines, terminators and text as was necessary with now archaic software such as the IGDS system. Dimensions can now be placed as dimension elements using dimensioning tools with associated standard saved settings for symbology and formatting. Dimensioning tools can often cut time required for dimensioning by well over 90%. These tools can be frustrating to deal with in unusual situations, but the efficiency gained is well worth the time required to learn how to deal with such situations.

CAD operators must take the time to learn all applicable tools and keep updating their skills, as new tools become available. Not implementing new, more effective tools will cost considerable time, effort and money in the long term. Change is inevitable, so taking full advantage of the tools that are provided is imperative. Staying with the old, familiar ways is simply unacceptable. For this reason, if a checker notices the use of an archaic tool in design file creation, he/she should suggest more efficient methods.

## **STANDARDIZATION IMPORTANCE**

Effective with the implementation of the Metric System is a renewed emphasis on standardization of detailing practices. With manual drafting, the primary elements of standardization are lettering style, symbolization, line style, and line weight. With CAD drafting, the elements of standardization are more complex. The additional elements of level structure, color, element type, cells, reference files, preference files, configuration files, seed files, etc. have added to the possibility of inconsistency. Standardization of these CAD elements has often been spotty to non-existent. This is not acceptable.

One of the biggest advantages of CAD is the ease with which details can be modified, corrected or copied for use in other jobs. When a detail is copied for a new job, alterations are often needed to make it fit the situation. Often the job of correcting a drawing or altering it for a new job falls on a drafter other than the original one. This can be a frustrating experience for the new drafter. Basic environmental issues come into play. If seed file settings are non-standard (e.g., working unit format, dimensioning settings, etc.), they must be set properly. If colors and levels are non-standard, then the drafter must get used to them or undertake the time consuming task of correcting element attributes. If the drawing is inaccurate or non-standard, is it worth fixing? If it is not worth fixing, do I want to make-do and put my name on it? Maybe I should just start over.

Working in another person's drawing file can be likened to working in another person's office. Some kind of order and familiarity is necessary or inefficiency and discomfort will result. For this reason the standards presented in this chapter must be taken seriously.

## **INROADS OUTPUT REQUIREMENTS**

Project requirements generated through the InRoads roadway design software shall meet standards developed by the Road Design Section unless specified otherwise.

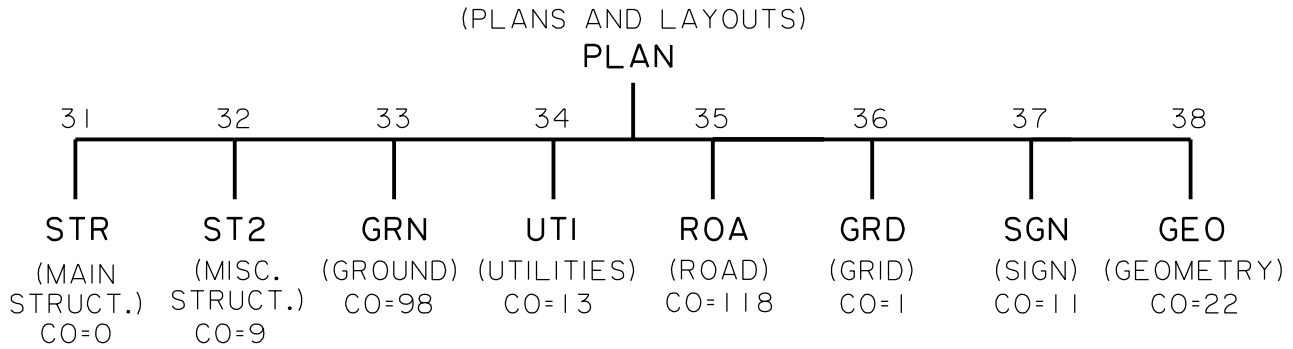
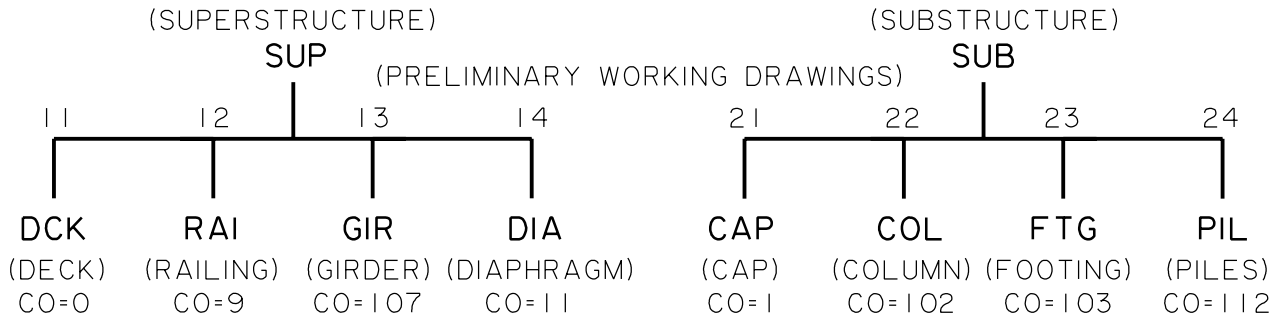
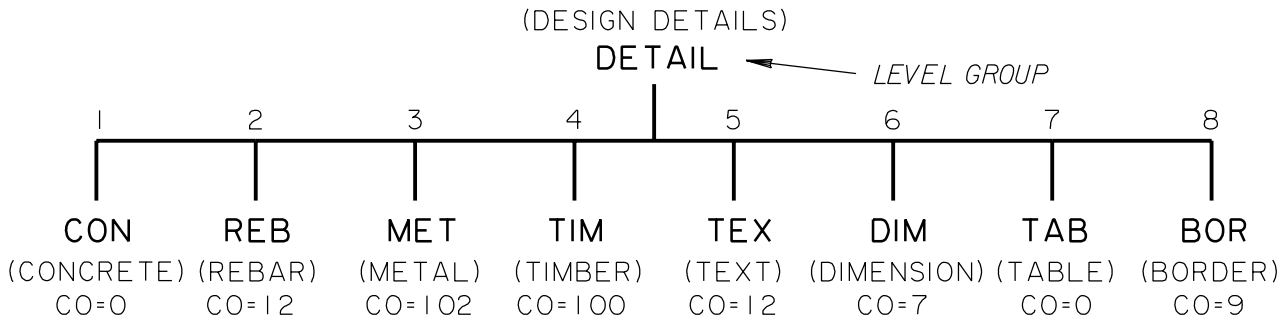
## **SURVEY DESIGN FILE TREATMENT**

Where survey data is to be part of a design, it shall be attached to the plan sheet as a reference. This reference file or reference view is an overlay to the design and is manipulated using clip bounding, clip masking and level display combinations.

## **SPECIAL CONSULTANT REQUIREMENTS**

Any special requirements for consultant jobs will be included in the contract or communicated through the project coordinator.

Occasionally, a consultant may be required to furnish drawings in MicroStation format, such as when the Department and one or more consultants share a job. In such cases the consultant should contact the Department, preferably before starting to detail the plans, to obtain information necessary for successful translation. This may include information such as font names, character mapping information and drawing symbology standards.

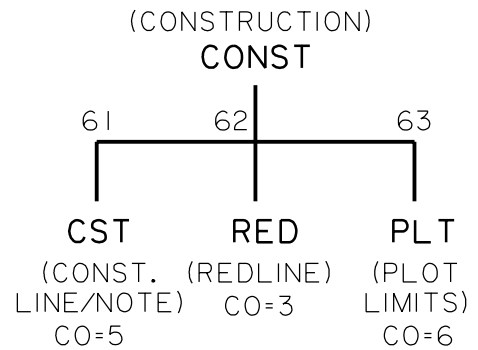


**NOTES:**

STANDARD SEED FILES CONTAIN LEVEL STRUCTURE. WHEN USING DESIGN FILES NOT CREATED FROM SEED FILES, LOAD THE STRUCTURAL LEVEL STRUCTURE FILE, STR.LVL, AND SAVE SETTINGS. ADDITIONAL LEVELS FOR MECHANICAL, ELECTRICAL, ARCHITECTURAL OR OTHER ELEMENTS MAY BE ADDED AS NEEDED. SAVE MODIFIED LEVEL STRUCTURES TO A ".LVL" FILE IN THE PROJECT DIRECTORY IF STRUCTURE WILL BE USED AGAIN.

FOR CONSISTENCY AND CONVENIENCE, IT IS RECOMMENDED THAT THE SIDEBAR MENU, BRIDGE-M.SBM, BE USED TO SET LEVEL AND COLOR.

TOPOGRAPHY LEVELS SHALL BE AS ADOPTED BY THE ROAD DESIGN SECTION. TOPOGRAPHY SHALL BE REFERENCED TO THE PLAN SHEET.



**STRUCTURAL LEVELS**



**KEYBOARD:**

ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz

@ # \$ % & \* ( ) + - = \ { } [ ] : " ; ' < > ? , . /

φ ( ) φ (~) Δ (!) ° (^) ℄ (:) 1 2 3 4 5 6 7 8 9 0

**FRACTIONS:** 1/2 1/4 1/8 1/16 1/32 (ALL) FORMAT FOR OTHER FRACTIONS =  
EXPONENT(S) / SUBSCRIPT(S) (/ = \250 )

EXPONENT	
0	\230
1	\231
2	\232
3	\233
4	\234
5	\235
6	\236
7	\237
8	\238
9	\239
MISC.	
ℙ	\163
•	\165
1	\167
1/2	\172
ℳ	\176
ℙ	\177
~	\190
`	\191
!	\192
^	\193
:	\194
△ '	\228
△ -	\229
△ /	\250
△ \	\253

SUBSCRIPT	
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f	\218
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y	\223
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II	\169
III	\170
IV	\171



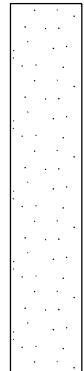
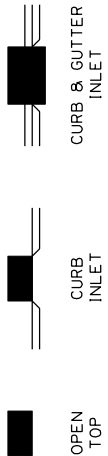
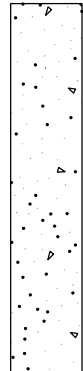
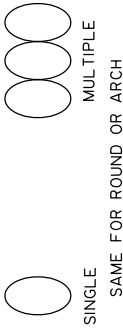
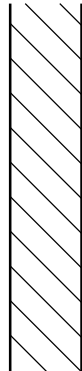
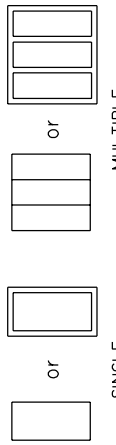
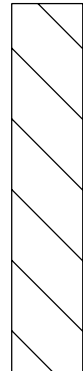

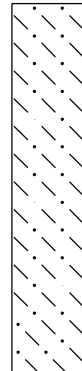






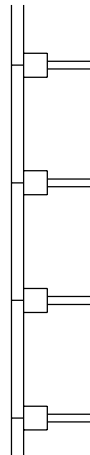
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β	\203
γ	\204
δ	\205
ε	\206
θ	\207
ν	\208
π	\209
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σ	\211
τ	\212
φ	\213
MATH	
÷	\195
≠	\196
≈	\197
≤	\198
≥	\199
±	\200
√	\201
∫	\251
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BUGS ⊗	
•	\162
⊕	\174
⊗	\175
⊗	\178
△	\179
⊖	\180
⊗	\181
⊗	\182
⊗	\183
△	\184
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⊗	\188
⊕	\189
√	\252
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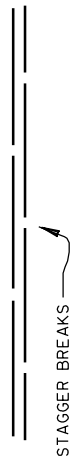

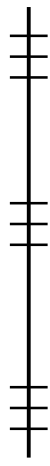


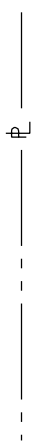


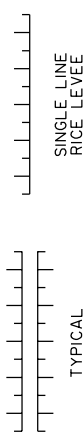
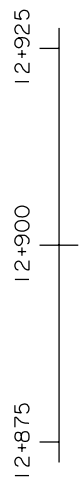
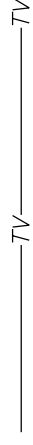

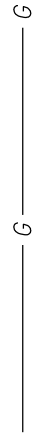


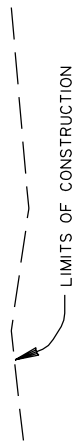
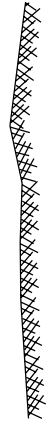
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HISTORIC IS FOR OLD DRAWINGS. USE KEYBOARD FOR NEW WORK.	
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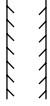


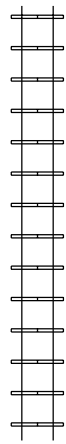



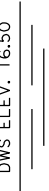













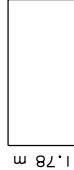

NOTE:  
CHARACTERS ARE SHOWN AT FULL SCALE PLAN SIZE.  
△ CHARACTER VERSION TO BE USED FOR SPECIAL CASES ONLY.  
⊗ ALL BUG CHARACTERS ARE TWO SPACE CHARACTERS WIDE EXCEPT FOR BULLET WHICH IS ONE SPACE CHARACTER WIDE.

**STANDARD HIGHWAY DESIGN FONT  
(FONT 103 CHARACTERS)**

<p>AGGREGATE SURFACING REQ'D.</p>  <p>OR</p>	<p>MANHOLE</p> 
<p>ASPHALTIC CONCRETE OR BITUMINOUS SURFACE TREATMENT REQ'D.</p> 	<p>CATCH BASIN</p> 
<p>CONCRETE</p> 	<p>CULVERTS REQ'D. IN PROFILE (PIPE)</p> 
<p>DRAINAGE EXCAVATION REQ'D.</p> 	<p>CULVERTS REQ'D. IN PROFILE (BOX)</p> 
<p>BRICK</p> 	<p>CULVERTS IN PLAN (PIPE OR BOX)</p> 
<p>BRASS, BRONZE OR COPPER</p> 	<p>LAKE, POND, ETC.</p> 
<p>STEEL</p> 	<p>RIVER, BAYOU, STREAM, ETC. (SMALL SCALE)</p> 
<p>CAST IRON</p> 	<p>RIVER, BAYOU, STREAM, ETC. (LARGE SCALE)</p> 
<p>BRIDGE IN PLAN</p> 	
<p>BRIDGE REQ'D. IN PROFILE</p> 	<p>CONVENTIONAL SYMBOLS</p>



<p>CUTTING PLANE LINE</p> 	<p>REINFORCING BARS</p>  <p>STAGGER BREAKS</p>
<p>DIMENSION LINE</p> 	<p>CONTROL OF ACCESS LINE</p> 
<p>BREAK LINE</p> 	<p>FENCE LINE</p> 
<p>PROPERTY LINE</p> 	<p>GATE OR WIRE GAP</p> 
<p>RIGHT OF WAY</p> 	<p>LEVEE</p> 
<p>CENTERLINE OF PROJECT OR SURVEY ☺</p> 	<p>CABLES</p> <p>LETTER DENOTES USAGE (E.G. TV-TELEVISION; P-POWER; T-TELEPHONE, ETC.)</p> 
<p>CENTERLINE (OTHER THAN ☺ PROJECT OR SURVEY ☺)</p> 	<p>PIPE LINES</p> <p>LETTER DENOTES USAGE (E.G., G-GAS, W-WATER, ETC.)</p> 
<p>HIDDEN LINE</p> 	<p>SCALE AS SHOWN</p> 
<p>LIMITS OF CONSTRUCTION</p> 	<p>CONVENTIONAL SYMBOLS</p>
<p>GROUND LINE</p> 	

ROAD (EXISTING DIRT OR GRAVEL)		GUY POLE	
ROAD (EXISTING PAVED)	 <p>IN PLACE</p>  <p>TO REMAIN</p>  <p>TO BE REMOVED</p>	GUY WIRE AND ANCHOR	
RAILROAD		POLES	 <p>POWER</p>  <p>TELEPHONE</p>  <p>COMBINATION</p>
WATER STAGE	 <p>DWS ELEV. 16.50</p>	FIRE HYDRANT	
SWAMP OR MARSH	 <p>SWAMP</p>  <p>MARSH</p>	WELL	 <p>GAS</p>  <p>OIL</p>  <p>WATER</p>
TREE		WATER VALVE	
HEDGE		METER	 <p>GAS</p>  <p>WATER</p>
WOODS EDGE		RIGHT OF WAY MARKER	
BUILDING	 <p>1.78 m</p> <p>3.72 m</p>		
GRAVE			

**CONVENTIONAL SYMBOLS**

## METRIC DETAILING CONVENTIONS

### NUMBERS

#### The International System of Units (SI)

In accordance with The International System of Units, numbers shall be divided into groups of three separated by spaces on either side of the decimal. Do not use a space for four digit numbers except for uniformity in tables. Do not use spaces for monetary values and formulas. Commas shall not be used except for monetary values (e.g., "\$3,000.00"). Include leading zero (e.g., 0.205).

Examples: 2 300 150    1234    4200.1234    44 200.123 45    625.22    0.205

#### Numbers in tables

If a table includes numbers with five digits or more, use spaces for consistency including all numbers of four digits or more so that columns line up properly. Otherwise, do not use spaces for four digit numbers.

Exception: Where tables are output by software that does not provide for unit separation by spaces, it is not necessary to edit to add spaces.

### DIMENSIONS

Dimensions shall be in millimeters unless otherwise noted.

#### Special format guidelines

1. Include the unit symbol for **dimensions included in notes** (e.g., "450 mm DIAMETER PILE"). Exception: Omit unit symbols for plates (e.g., "PL 15x200") and steel shapes (e.g., "L 102x102x9.5"). If length is shown, include the unit symbol (e.g., "L 102x102x9.5 x 800 mm")
2. For **dimensions and callouts, where text is included**, include the unit symbol. Exception: The unit symbol may be omitted where space is a problem, if the meaning is clear. For example:

Normal: "20 SPS. @ 300 mm = 6000 mm (B1501)"

Acceptable: "20 SPS. @ 300 = 6000 (B1501)" to save space.

Not acceptable: "20 300 SPS. = 6000 B1501"

Normal: "13 200 mm CLEAR ROADWAY"

Acceptable: "13 200 (CLEAR ROADWAY)" to save space.

Acceptable: "13 200" above dimension line and "CLEAR ROADWAY" below dimension line to save space.

Not acceptable: "13 200 CLEAR ROADWAY"

3. For **dimension lines and callouts where dimension stands alone**, omit the unit symbol (i.e., "6025" implies "6025 mm").
4. "When indicating the **size of an object**, show the unit symbol once in sequence (e.g., "10 x 25 m SLAB").
5. **Bolts, cap screws, studs and rods** shall be designated by the diameter preceded by the letter "M" (i.e., "M24" designates a metric 24 mm diameter bolt. Use only the standard metric diameters as shown in bolt data this chapter. Thread designations are normally covered by the Standard Specifications. Where length is shown, always include the unit designation, "mm" (e.g., "M24 x 300 mm bolt").
6. **Industry standards for size designations**, such as those published by ASTM or a manufacturer, shall be implemented for items not addressed by this document.
7. Include a space before and after **small "x"** (e.g. "M24 x 300 mm BOLT"). Exception: Omit spaces (except for length) for plates (e.g., "PL 15x200 x 800") and steel shapes (e.g., "L 102x102x9.5 x 800").

#### Exceptions to the millimeter standard

1. **Elevations, stations and survey curve data including PC and PT stations shall be expressed in meters.** Omit the "m" for stations and elevations. Examples: PC 22+850.320 PVI 23+150.320 ELEV. 23.872 R= 698.552 m
2. **Dimensions shown on general plans and general layouts shall be expressed in meters** (e.g., "20.710 m SPAN") except that pipe and pile diameters shall be expressed in millimeters (e.g., "600 mm x 60 m PIPE).

## **STATIONING**

Stations shall be expressed in kilometer format (e.g., "STA. 13+750"). Where plus (+) stations are shown, they shall be relative to the kilometer (e.g., "+025" or "+750"). Major tics shall be shown at 100 meter intervals with minor tics at 25 meter intervals.

## **ACCURACY**

Accuracy for proposed features including dimensions, stations and elevations will normally be to the nearest 1 mm or 0.001 m. Accuracy rules for other situations are indicated below:

1. All **ground line (profile) elevations** and associated stations shall be expressed with 0.01 m accuracy unless there is a need for greater accuracy. This includes existing pavement elevations.
2. **Topography location** (station, offset), where specified, shall be expressed in meters with 0.1 m accuracy (e.g., "+825.1, 45.1 m RT."). Use greater accuracy if necessary.

3. **Topography dimensions**, where specified, shall be expressed in meters with 0.01 m accuracy (e.g., "13.06 x 60.96 m CONCRETE BRIDGE"). Use greater accuracy if necessary.
4. **English system shapes designated in metric format** shall be according to ASTM A 6M (i.e., "L 102x102x9.5" describes "L 4x4x3/8").
5. **Gauge wire diameter and gauge plate thickness** shall be expressed with 0.1 mm accuracy.
6. **Survey angles, deltas and bearings** shall be expressed with 0.1" accuracy (e.g., "N 32° 13' 35.1" W"). This also applies to layout angles such as joint centerline angles.
7. **Detail angles**, such as for rebar bending and concrete forming, shall be expressed in decimal format with 0.0001° accuracy (e.g., "78.3042°").
8. **Mechanical dimensions** shall be expressed in millimeters. Accuracy required varies depending on the application.

If no decimal place is shown, then the normal accuracy for the situation is assumed (i.e., "50 m SPAN" is assumed to mean "50.000 m SPAN"). If the decimal is used, always include the specified number of decimal places for the situation.

Although 1 mm or 0.001 m is the normal accuracy for bridge details and stations, use increments of 10 mm or greater whenever possible, especially for control dimensions such as girder spacing and span lengths. For instance, "2510" or "2500" is preferred over "2512," and "STA. 21 + 25.400" is preferred over "STA. 21 + 25.443."

Decimal places may be added when the sum of rounded-off parts does not equal the overall dimension. For instance, rounded-off span lengths along the outside face of slab on a curved continuous unit sometime do not add up to the continuous unit length. Adding a decimal place to the span lengths will resolve this discrepancy. A 1-mm discrepancy is not considered significant enough to necessitate adding a decimal place.

Adding decimal places is not the answer for reinforcing steel spacing. A nominal spacing should be used whenever possible. It is easy to understand that it would be much easier in the field to place 998 bars at 150 mm spacing rather than 149.9 mm spacing. This can be accomplished by using an odd spacing for the last space at each end and/or the distance from the last bar to the edge of the concrete.

## PROFILE GRID

**Vertical grid lines** shall be shown at 25 or 100 meter intervals, and **horizontal grid lines** shall be shown at 5, 10 or 20 meter intervals, depending on scale.

Show **ground line elevations** at least every 25 meters and at notable grade break points. Interpolate if necessary. Include a note to indicate when elevations are derived from digital terrain modeling or manual interpolation.

## **SCALES**

Two metric scale versions are required with graduations as follows:

Scale 1: 2.5, 5, 10, 20, 50, 100

Scale 2: 100, 200, 300, 400, 500, 600

Scales that can be derived from these graduations represent acceptable scales, with one qualifier; scales used for full-size plans should have corresponding, acceptable, derived scales for half-size plans. For example, a scale of 1:30, which can be derived from the 300 graduation, is acceptable because, at a 50% reduction factor, the scale will become 1:60, which can be derived from the 600 graduation. It follows that scales derived from the 400 and 600 graduations (1:40, 1:60, 1:400, 1:600, 1:4000, 1:6000) are not normally acceptable for full-size plans that are to be reduced to half-size because the half-size scales cannot be derived from any of the standard graduations.

In special situations, where normally acceptable scales are impractical, scales derived from the 400 and 600 graduations may be used. In these situations, half-size plan scaling can be achieved by using the full-size scale and doubling the measurement. In addition, since there is a considerable disparity in scale between the 1:10 and 1:20 scales, a scale of 1:15 may be used if necessary. The scale becomes 1:30 at half-size. Full-size scaling is derived by dividing the 1:30 scale reading by 2.

Normally acceptable scales for full-size plans that are to be reduced to half-size are as follows:

Scale graduations: 2.5, 5, 10, 20, 50, 100, 200, 300, 500

Derived scales: 1:1, 1:2, 1:2.5, 1:3, 1:5, 1:10, 1:20, 1:25, 1:30, 1:50, 1:100, 1:200, 1:300, 1:500, 1:1000, 1:2000, 1:2500, 1:3000, 1:5000

**Guide for converting English to Metric scale:** English scales with their corresponding true scales (in parenthesis) are provided below as an aid in picking the appropriate metric scale. Normally pick the metric scale closest to the true English scale since metric scales are true scales.

Engineers Scale: 10 (1:120), 20 (1:240), 30 (1:360), 40 (1:480), 1:50 (1:600), 60 (1:720)

Architects Scale: 3/32 (1:128), 1/8 (1:96), 3/16 (1:64), 1/4 (1:48), 3/8 (1:32), 1/2 (1:24), 3/4 (1:16), 1 (1:12), 1 1/2 (1:8), 3 (1:4)

## SI SYMBOLS

Use standard SI symbols for metric dimensions. Since metric symbols are case sensitive, small characters must be used where applicable for dimension units in the plans (e.g., "50 m"). This is an exception to the "all caps" rule for Bridge Design details.

## BID ITEMS

Use standard SI symbols for bid items in detail quantity tables, plan notes and dimensions (e.g., "kg," "m<sup>3</sup>," etc.).

Spell out quantity units as defined in the Schedule of Bid Items (e.g., "cubic meter") in the Bridge Master summary table.

## STANDARD DETAIL SHEET

The standard detail sheet size shall be 560 x 915 mm (22" x 36"). The border size shall be 530 x 800 mm, which is a reduction in size from the previous standard. This will enable true 50% plotting, which will result in plans that can be scaled. The border shall be centered on the sheet from top to bottom and the right border shall be positioned 13 mm from the right edge of sheet.

## SLOPES

Profile grade slopes and roadway cross-slopes shall be expressed in percentage format (e.g., "2.5%").

Embankment side-slope and revetment fore-slope shall be expressed in ratio format, rise to run (e.g., "1:3").

## ABBREVIATIONS

Commonly used abbreviations, such as PPC, PC, PVI, SSD, GR-200 (M), etc., should be expressed consistently without periods (i.e., "PPC," not "P.P.C.").

## REINFORCING STEEL

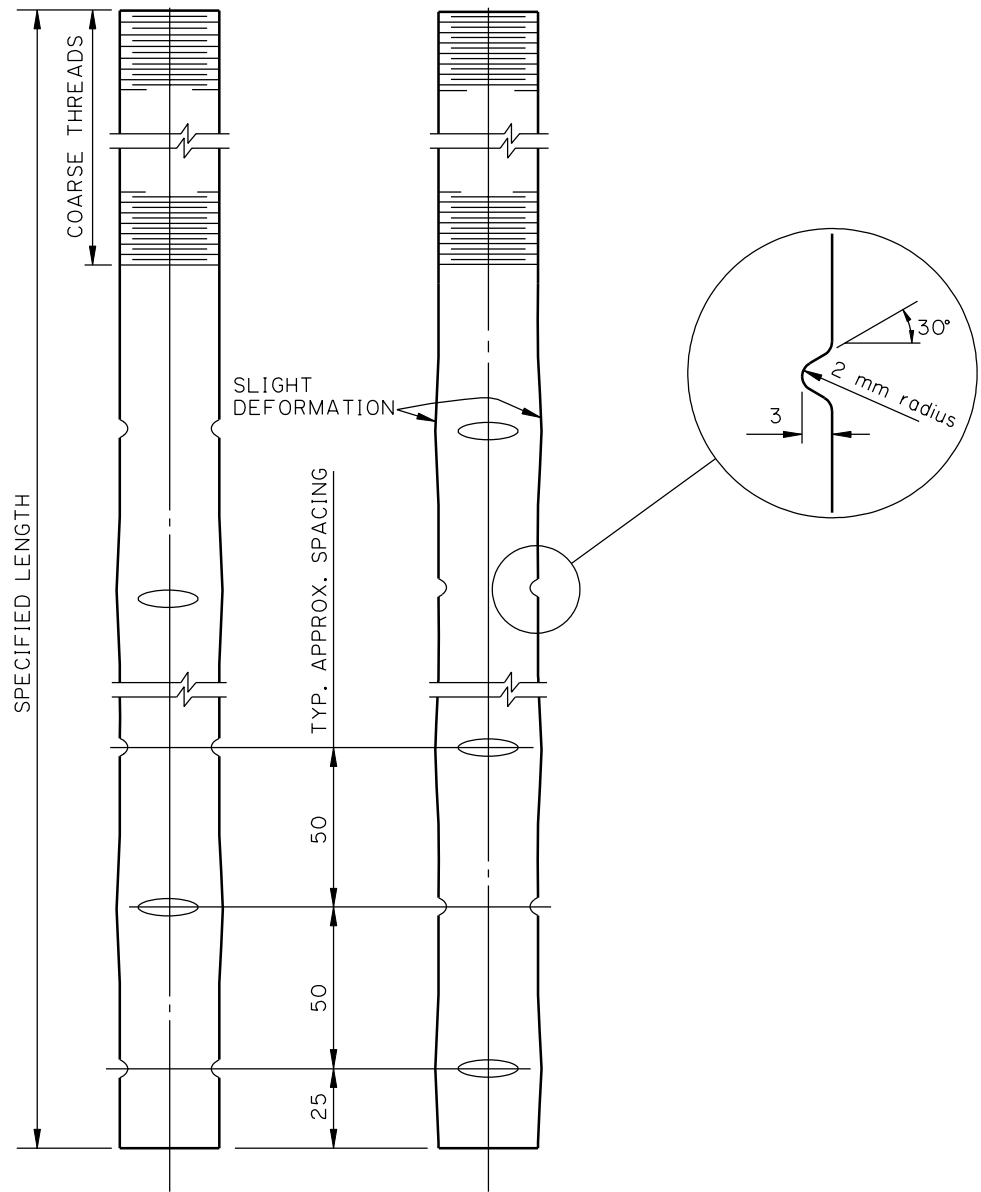
Bar designations shall be specified by the prefix "B" followed by the bar size and mark. For example, "B1502" designates a number 15 bar, mark 2.

## GENERAL NOTES REGARDING METRIC FORMAT

Include the following statements in the General Notes:

DETAILING CONVENTIONS: DETAIL DIMENSIONS ARE EXPRESSED IN MILLIMETERS (mm) UNLESS OTHERWISE NOTED (E.G., "6000" IMPLIES "6000 mm"). STATIONS AND ELEVATIONS ARE EXPRESSED IN METERS. SCALES SHOWN ARE FOR FULL-SIZE PLANS. DOUBLE THE SCALE GRADUATION FOR HALF-SIZE PLANS. WHERE SCALE IS NOT SHOWN, THE DETAIL IS NOT TO SCALE (NTS). EMBANKMENT SLOPES ARE EXPRESSED AS A RATIO OF RISE TO RUN.

REINFORCING STEEL: ALL REINFORCING STEEL IS DESIGNED AND DETAILED AS METRIC. BAR DESIGNATIONS ARE SPECIFIED WITH THE PREFIX "B" FOLLOWED BY THE BAR SIZE AND MARK. FOR EXAMPLE, "B1502" DESIGNATES A NUMBER 15 BAR WITH A MARK NUMBER OF 2.



PROPOSED METHOD FOR SWEDGING ANCHOR BOLTS

SWEDGED ANCHOR BOLTS



## GUIDELINES ON THE COMPUTATIONS OF CONCRETE VOLUME FOR PAYMENT

CONCRETE IS MEASURED AND PAID FOR BY VOLUME IN CUBIC METERS WITH TWO PLACE ACCURACY.

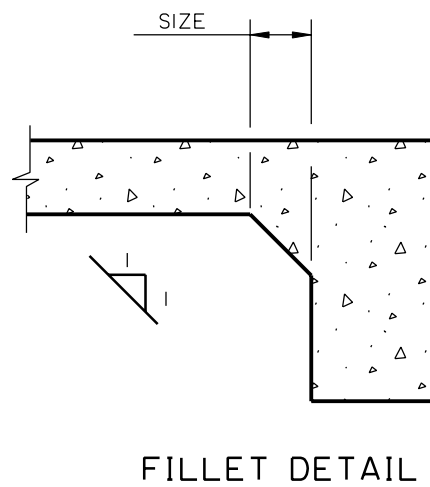
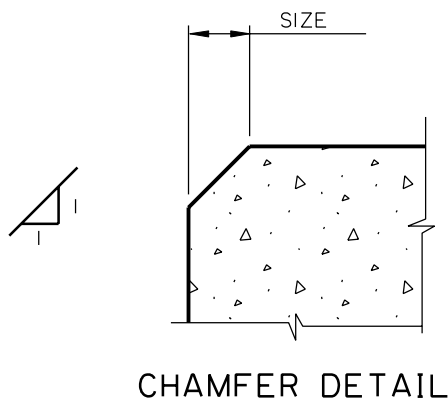
NO DEDUCTIONS ARE TO BE MADE FOR THE VOLUME DISPLACED BY:

1. REINFORCING STEEL
2. STRUCTURAL STEEL PLATES, ANGLES AND APPURTENANCES USED FOR DECK EXPANSION JOINTS AND END DAMS
3. CHAMFERS MEASURING 40 mm OR LESS
4. 150 mm PVC PIPE DRAINS
5. WEEP HOLES, SMALL PIPES AND CONDUITS
6. SHEAR CONNECTORS

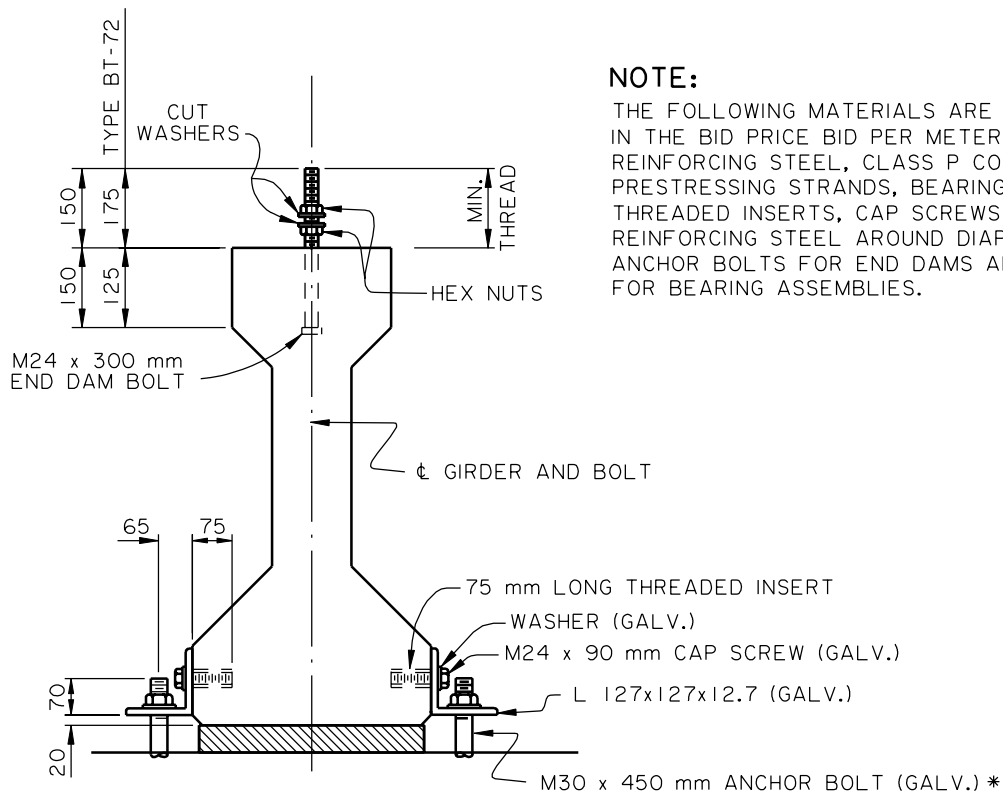
DEDUCTIONS MUST BE MADE FOR VOLUME OF CONCRETE DISPLACED BY:

1. STRUCTURAL STEEL MEMBERS, EXCEPT THOSE LISTED ON ITEM 2 ABOVE
2. CHAMFERS GREATER THAN 40 mm IN SIZE
3. VOLUME OF EMBEDDED PILES (ASSUME A 300 mm BUTT DIAMETER FOR TIMBER PILES)
4. ALL EXPANSION JOINTS

THE COMPUTED VOLUME OF CONCRETE SHALL INCLUDE FILLETS OVER 40 mm IN SIZE.



**CONCRETE QUANTITIES  
MEASUREMENT**



**NOTE:**

THE FOLLOWING MATERIALS ARE TO BE INCLUDED IN THE BID PRICE BID PER METER OF GIRDER: REINFORCING STEEL, CLASS P CONCRETE, PRESTRESSING STRANDS, BEARING PADS, THREADED INSERTS, CAP SCREWS & WASHERS, REINFORCING STEEL AROUND DIAPHRAGM HOLE, ANCHOR BOLTS FOR END DAMS AND ANGLES FOR BEARING ASSEMBLIES.

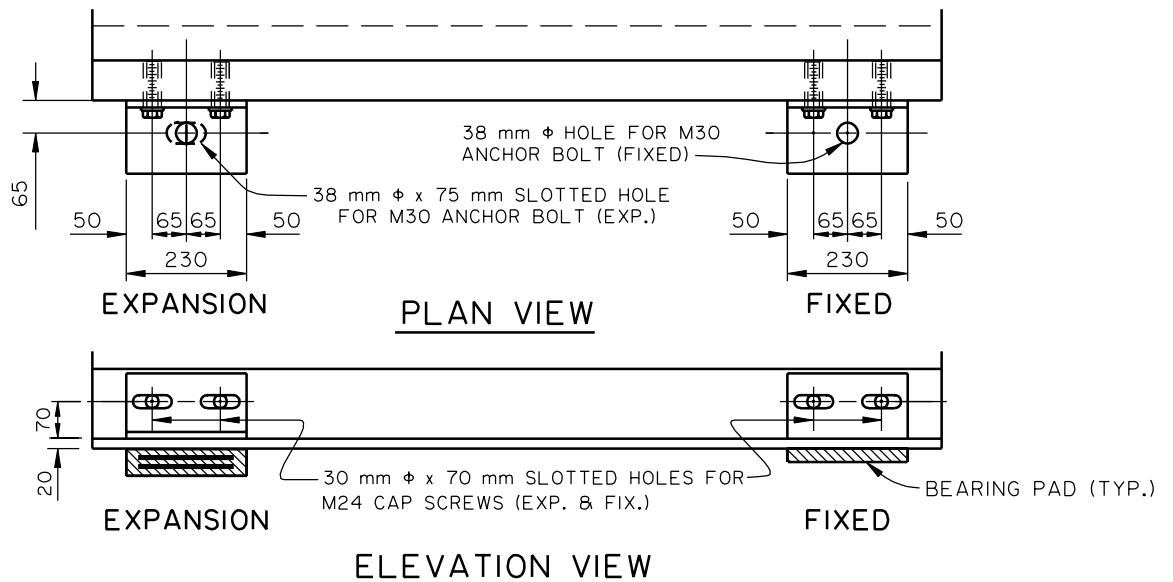
**GIRDER END VIEW**

**NOTES:**

AT THE CONTRACTORS OPTION THE THREADED INSERT MAY BE ELECTRO-PLATED AND COATED WITH GREASE OR GALVANIZED.

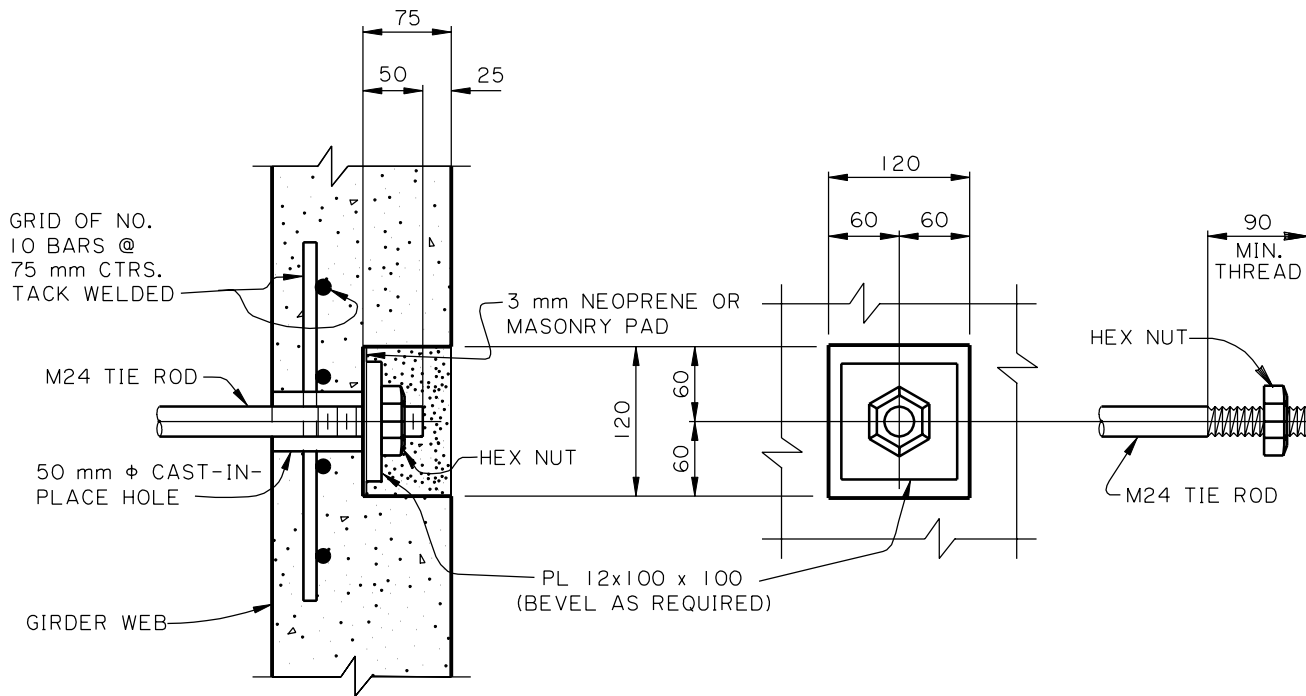
\* M30 x 450 mm ANCHOR BOLT WITH ONE (1) HEX NUT & ONE (1) WASHER (CLIP FOR NECESSARY CLEARANCE). A DEFORMED REINFORCING BAR OF THE SAME SIZE AND LENGTH MAY BE SUBSTITUTED FOR THIS ANCHOR BOLT. ANCHOR BOLTS TO BE PAID FOR AS STRUCTURAL METALWORK AND INCLUDED IN BENT QUANTITIES (FOR ESTIMATION PURPOSES ONLY).

THE NUMBER OF GIRDERS PER SPAN TO BE ANCHORED VARIES WITH THE SPAN CONFIGURATION.



**ELEVATION VIEW**

**GIRDER HARDWARE**



### TIE ROD ASSEMBLY

**NOTES:**

HAND TIGHTEN NUT AGAINST PLATE BEFORE POURING DIAPHRAGM. AFTER DIAPHRAGM AND SLAB ARE IN PLACE FOR 48 HOURS, TIGHTEN NUT FIRMLY. PAINT ALL EXPOSED SURFACES OF WELL, STEEL PLATE, ROD AND NUT WITH AN APPROVED EPOXY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS AND GROUT FLUSH WITH EDGE OF BEAM. (NO DIRECT PAYMENT)

INSIDE FACE OF PL 12x100 x 100 mm SHOULD BE BEVELED AS REQUIRED TO PROVIDE FULL AND EVEN BEARING. IN CASES WHERE EXTERIOR GIRDER IS FLARED, A SECOND BEVEL PLATE MAY BE NEEDED. SHOP DRAWINGS WILL BE REQUIRED FOR ALL CASES.

DIAPHRAGM TIE RODS, NUTS, BEVELED PLATES AND MASONRY PADS ARE TO BE PAID FOR AS STRUCTURAL METALWORK AND INCLUDED IN SPAN QUANTITIES (ESTIMATION PURPOSES ONLY).

## GIRDER HARDWARE

## STRUCTURAL METALWORK

### APPROACH SLABS:

END DAM PLATE (PL 12x130) . . . . .	12.25 kg/m
ANCHOR STUDS (M16 x 200 mm) . . . . .	0.36 kg EACH
CLIP ANGLE (L 203x102x12.7 x 130) . . . . .	3.80 kg EACH

### END BENTS:

#### ANCHOR BOLTS (STRIP SEAL OR END DAM)

ANCHOR BOLTS (M24 x 510 mm) . . . . .	1.95 kg EACH
HEX NUTS (2 PER BOLT) . . . . .	0.18 kg EACH
CUT WASHERS (2 PER BOLT) . . . . .	0.09 kg EACH

#### ANCHOR BOLTS (BEARING ASSEMBLY)

ANCHOR BOLTS (M30 x 450 mm) . . . . .	2.50 kg EACH
HEX NUTS (1 PER BOLT) . . . . .	0.34 kg EACH
CUT WASHERS (1 PER BOLT) . . . . .	0.12 kg EACH

### INTERMEDIATE BENTS:

#### ANCHOR BOLTS (BEARING ASSEMBLY)

ANCHOR BOLTS (M30 x 450 mm) . . . . .	2.50 kg EACH
HEX NUTS (1 PER BOLT) . . . . .	0.34 kg EACH
CUT WASHERS (1 PER BOLT) . . . . .	0.12 kg EACH

### SPANS:

#### END DAM ASSEMBLY (WHEN USED)

END DAM PLATE (PL 12x130) . . . . .	12.25 kg/m
ANCHOR STUDS (M16 x 200 mm) . . . . .	0.36 kg EACH
CLIP ANGLE (L 152x102x12.7 x 130) . . . . .	3.13 kg EACH

### GIRDERS:

#### BEARING ASSEMBLY

THREADED INSERTS (2 PER ANGLE) . . . . .	0.40 kg EACH
CAP SCREWS (M24 x 90 mm) (2 PER ANGLE) . . . . .	0.40 kg EACH
WASHERS (2 PER ANGLE) . . . . .	0.09 kg EACH
ANGLE (L 127x127x12.7 x 230) . . . . .	5.54 kg EACH

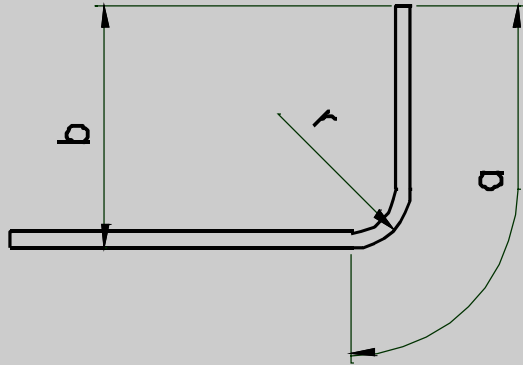
#### ANCHOR BOLTS (STRIP SEAL OR END DAM)

ANCHOR BOLTS (M24 x 300 mm) . . . . .	1.20 kg EACH
HEX NUTS (2 PER BOLT) . . . . .	0.18 kg EACH
CUT WASHERS (2 PER BOLT) . . . . .	0.09 kg EACH

**STRUCTURAL METALWORK WEIGHTS  
(SUMMARY)**

## REINFORCEMENT BAR DATA

90 DEGREE HOOK FOR STIRRUPS & TIES (SOFT METRIC)				
BAR SIZE	PIN DIAMETER	RADIUS R	a	b
#10	40	30		110
#13	50	40		120
#16	65	50		160
#19	115	80		310
#22	135	90		360
#25	155	100		410
90 DEGREE HOOK FOR STIRRUPS & TIES (HARD METRIC)				
#10	45	35		100
#15	65	50		145
#20	120	80		310
#25	150	100		400



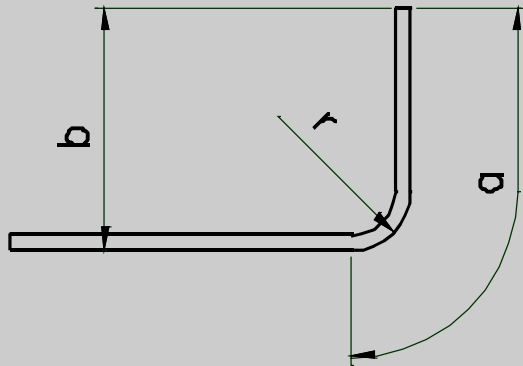
## REINFORCEMENT BAR DATA

135 DEGREE HOOK FOR STIRRUPS & TIES (SOFT METRIC)					
BAR SIZE	PIN DIAMETER	RADIUS r	a	b	c
#10	40	30	125	50	90
#13	50	40	180	65	120
#16	65	49	230	95	160
#19	115	80	310	115	220
#22	135	90	360	130	260
#25	155	100	410	150	300
135 DEGREE HOOK FOR STIRRUPS & TIES (HARD METRIC)					
#10	45	35	150	60	110
#15	65	50	210	85	150
#20	120	80	300	110	220
#25	150	100	400	140	280

## REINFORCEMENT BAR DATA

90 DEGREE STANDARD HOOKS (SOFT METRIC)				
BAR SIZE	PIN DIAMETER	RADIUS R	a	b
#10	60	39	170	150
#13	80	53	250	200
#16	95	63	300	250
#19	115	77	350	310
#22	135	89	410	360
#25	155	103	460	410
#29	230	148	570	490
#32	260	160	640	550
#36	290	180	710	610
#43	430	260	920	780
#57	580	350	1230	1030

90 DEGREE STANDARD HOOKS (HARD METRIC)				
BAR SIZE	PIN DIAMETER	RADIUS R	a	b
#10	70	46	210	180
#15	100	66	300	260
#20	120	80	360	320
#25	150	100	460	400
#30	240	150	590	500
#35	290	180	700	600
#45	440	264	930	780
#55	560	336	1200	1020



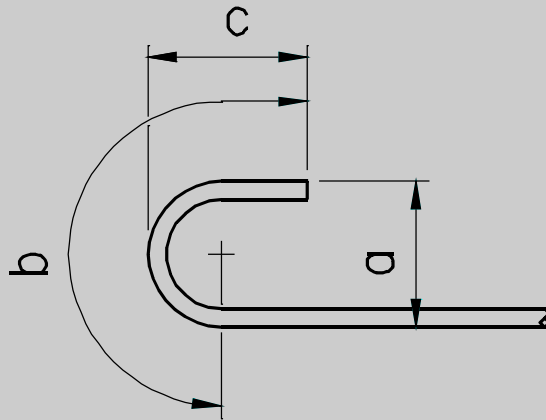
## REINFORCEMENT BAR DATA

### 180 DEGREE STANDARD HOOKS (SOFT METRIC)

BAR SIZE	PIN DIAMETER	a	b	c
#10	60	80	190	100
#13	80	110	200	120
#16	95	130	260	130
#19	115	160	320	150
#22	135	180	370	180
#25	155	210	420	200
#29	230	290	570	260
#32	260	330	640	300
#36	290	360	710	330
#43	430	520	990	450
#57	580	690	1310	590

### 180 DEGREE STANDARD HOOKS (HARD METRIC)

#10	70	90	200	110
#15	100	130	270	130
#20	120	160	330	160
#25	150	200	420	200
#30	240	300	590	270
#35	290	360	710	320
#45	440	520	1000	440
#55	560	680	1280	560





<b>REINFORCEMENT BAR PROPERTIES (SOFT METRIC)</b>				
<b>BAR SIZE DESIGNATION</b>	<b>MASS kg/m</b>	<b>DIAMETER (mm)</b>	<b>PERIMETER (mm)</b>	<b>AREA (mm<sup>2</sup>)</b>
#10	0.560	9.5	29.9	71
#13	0.994	12.7	39.9	129
#16	1.552	15.9	49.9	199
#19	2.235	19.1	59.8	284
#22	3.042	22.2	69.8	387
#25	3.973	25.4	79.8	510
#29	5.060	28.7	90.0	645
#32	6.404	32.3	101.3	819
#36	7.907	35.8	112.5	1006
#43	11.380	43.0	135.1	1452
#57	20.240	57.3	180.1	2581

<b>REINFORCEMENT BAR PROPERTIES (HARD METRIC)</b>				
<b>BAR SIZE DESIGNATION</b>	<b>MASS kg/m</b>	<b>DIAMETER (mm)</b>	<b>PERIMETER (mm)</b>	<b>AREA (mm<sup>2</sup>)</b>
#10	0.785	11.3	35.5	100
#15	1.570	16.0	50.3	200
#20	2.355	19.5	61.3	300
#25	3.925	25.2	79.2	500
#30	5.495	29.9	93.9	700
#35	7.850	35.7	112.2	1000
#45	11.775	43.7	137.3	1500
#55	19.625	56.4	177.2	2500

## BOLT DATA

<b>BOLT PROPERTIES FOR METRIC BOLTS AND ENGLISH BOLT SUBSTITUTIONS</b>					
<b>Metric Bolt Designation</b>	<b>Diameter (mm)</b>	<b>Area (mm<sup>2</sup>)</b>	<b>English Bolt Designation</b>	<b>Diameter (mm)</b>	<b>Area (mm<sup>2</sup>)</b>
M16	16	201.1	<sup>5</sup> / <sub>8</sub> "	15.9	197.9
M20	20	314.2	None	N/A	N/A
M22	22	380.1	<sup>7</sup> / <sub>8</sub> "	22.2	387.9
M24	24	452.4	1"	25.4	506.7
M27	27	572.6	1 <sup>1</sup> / <sub>8</sub> "	28.6	641.3
M30	30	706.9	1 <sup>1</sup> / <sub>4</sub> "	31.8	791.7
M36	36	1017.9	1 <sup>1</sup> / <sub>2</sub> "	38.1	1140.1
M48	48	1809.6	2"	50.8	2026.8
M64	64	3217.0	2 <sup>1</sup> / <sub>2</sub> "	63.5	3166.9
M72	72	4071.5	3"	76.2	4560.4

English bolts may be substituted for metric bolts as per the above table with the provision that, if any metric (A 325M) bolt is substituted for with the English (A 325) bolt, then all high-strength bolts shall be A 325. When substitutions are made, bolt hole size, minimum pitch and minimum clear distances shall be adjusted as required. Substitutions shall be at no additional cost to the Department.

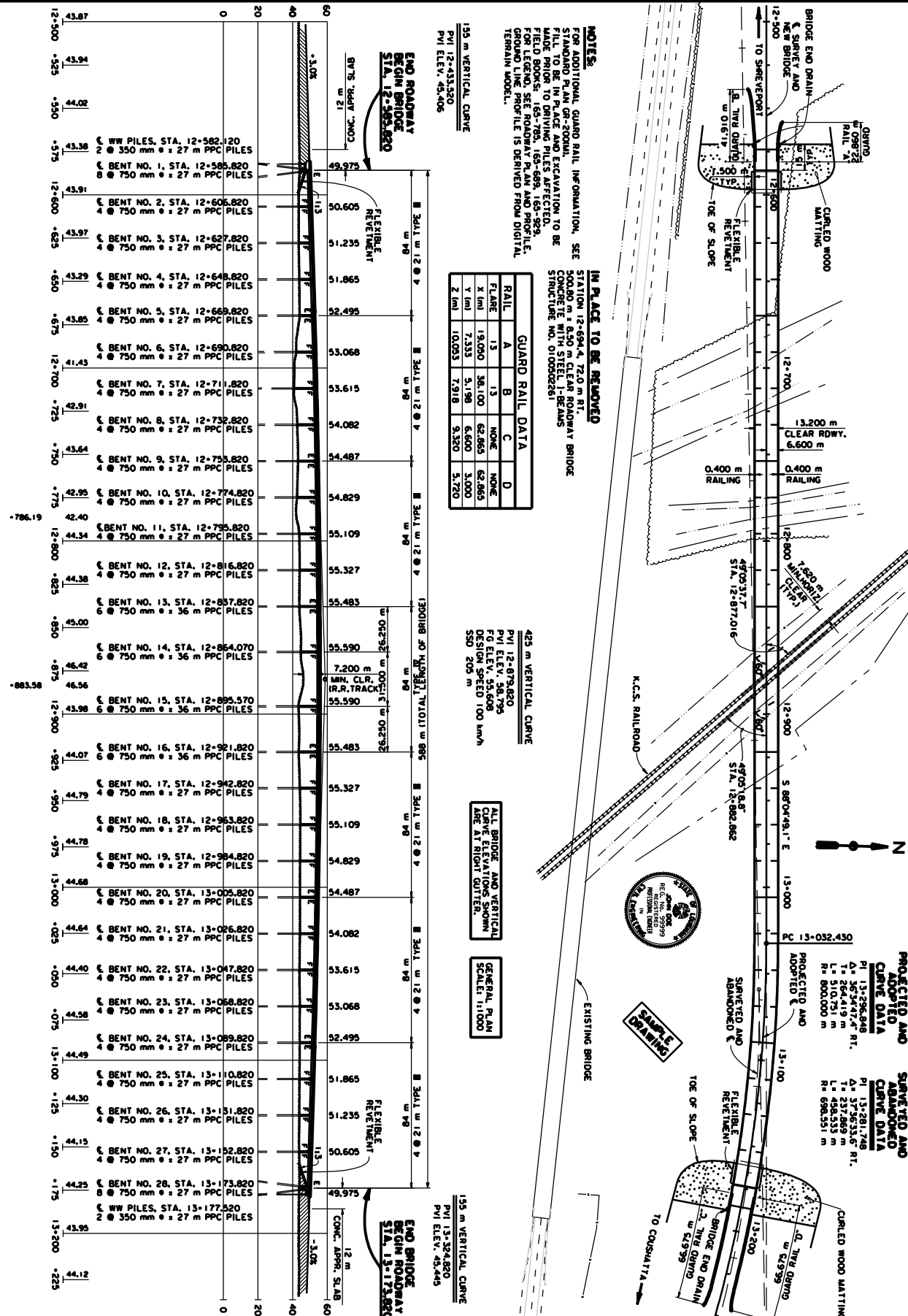
<b>BOLT EDGE DISTANCES</b>				
<b>Minimum Edge Distances (From AASHTO LRFD for M16-M36 Bolts)</b>			<b>Edge Distance Computation for Detailing - Rule of Thumb (Apply Multiplier to Diameter)</b>	
<b>Metric Bolt Designation</b>	<b>Sheared Edges (mm)</b>	<b>Rolled or Gas Cut Edges (mm)</b>	<b>Sheared Edges (Multiplier)</b>	<b>Rolled or Gas Cut Edges (Multiplier)</b>
M16	29	22	2.0	1.5
M20	32	25	2.0	1.5
M22	38	29	2.0	1.5
M24	44	32	2.0	1.5
M27	54	38	2.0	1.5
M30	57	41	2.0	1.5
M36	60	44	1.75	1.25
M48	84	60	1.75	1.25
M64	112	80	1.75	1.25
M72	126	90	1.75	1.25

<b>BOLT HOLE DIMENSIONS FOR METRIC BOLTS</b>				
<b>Bolt Designation</b>	<b>Standard Diameter (mm)</b>	<b>Oversize Diameter (mm)</b>	<b>Short-Slot Width x Length (mm)</b>	<b>Max. Long-Slot Width x Length (mm)</b>
M16	18	20	18 x 22	18 x 40
M20	22	24	22 x 26	22 x 50
M22	24	28	24 x 30	24 x 55
M24	26	30	26 x 32	26 x 60
M27	29	35	29 x 37	29 x 67
M30	32	38	32 x 40	32 x 75
M30 *	N/A	38	N/A	38 x 75
M36 *	N/A	44	N/A	44 x 90
M48 *	N/A	56	N/A	56 x 120
M64 *	N/A	74	N/A	74 x 160
M72 *	N/A	82	N/A	82 x 180
* Anchor bolts				

<b>BOLT HOLE DIMENSIONS FOR ENGLISH BOLT SUBSTITUTIONS</b>				
<b>Bolt Designation</b>	<b>Standard Diameter (mm)</b>	<b>Oversize Diameter (mm)</b>	<b>Short-Slot Width x Length (mm)</b>	<b>Max. Long-Slot Width x Length (mm)</b>
$\frac{5}{8}$ "	18	20	18 x 22	18 x 40
$\frac{7}{8}$ "	24	28	24 x 30	24 x 55
1"	27	31	27 x 33	27 x 60
1 $\frac{1}{8}$ "	31	35	31x 37	31 x 67
1 $\frac{1}{4}$ "	34	40	34 x 42	34 x 75
1 $\frac{1}{4}$ " *	N/A	40	N/A	40 x 75
1 $\frac{1}{2}$ " *	N/A	46	N/A	46 x 90
2" *	N/A	59	N/A	59 x 120
2 $\frac{1}{2}$ " *	N/A	74	N/A	74 x 160
3" *	N/A	86	N/A	86 x 180
* Anchor bolts				

## COMMON AND PREFERRED STEEL PLATE THICKNESSES

Common Plate Thicknesses	
Metric (mm)	Equivalent (in)
5	0.20
5.5	0.22
6	0.24
7	0.28
8	0.32
9	0.35
10	0.39
11	0.43
12	0.47
14	0.55
16	0.63
18	0.71
20	0.79
22	0.87
25	0.98
28	1.10
30	1.18
32	1.26
35	1.38
38	1.50
40	1.57
45	1.77
50	1.97
55	2.17
60	2.36
10 mm increments above 60 mm 50 mm increments above 200 mm	
Preferred thicknesses are shaded.	



**NOTES:**  
 FOR ADDITIONAL GUARD RAIL INFORMATION, SEE STANDARD PLAN GR-200M. FILL TO BE IN PLACE AND EXCAVATION TO BE MADE PRIOR TO DRIVING PILES APPLICABLE. FOR LEGEND, SEE ROADWAY PLAN AND PROFILE. GROUND LINE PROFILE IS DERIVED FROM DIGITAL TERRAIN MODEL.

**IN PLACE TO BE REMOVED**  
 STATION 12+694.4, 72.0 m RT.  
 30.00 m x 6.50 m CLEAR ROADWAY BRIDGE STRUCTURE NO. 01000261

**GUARD RAIL DATA**

RAIL	A	B	C	D
FLARE	13	13	NONE	NONE
X (m)	13.000	38.100	62.869	62.869
Y (m)	7.333	51.996	6.600	3.000
Z (m)	10.033	79.18	9.320	5.720

**425 m VERTICAL CURVE**  
 PVI 12+879.820  
 PVI ELEV. 58.799  
 I.R.R. TRACK  
 DESIRED SPEED 100 km/h  
 SSD 205 m

ALL BRIDGE AND VERTICAL CURVE ELEVATIONS SHOWN ARE AT RIGHT CENTER.

GENERAL PLAN SCALE: 1:1000

**155 m VERTICAL CURVE**  
 PVI 13+324.820  
 PVI ELEV. 45.445

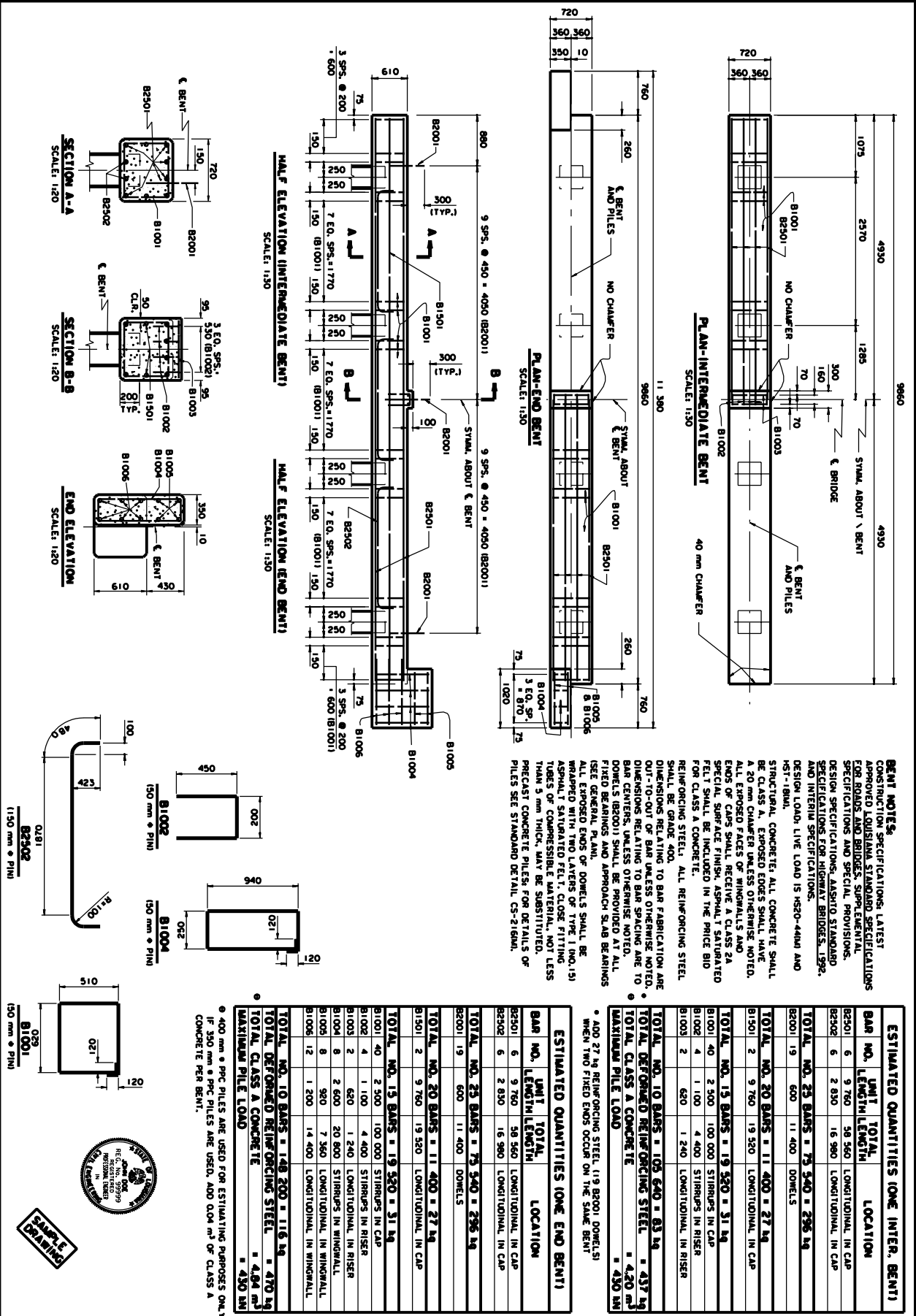
**PROJECTED AND ADOPTED CURVE DATA**

PC 13+052.430	PI 13+286.848	PT 13+521.248
L = 234.418 m	L = 234.418 m	L = 234.418 m
R = 800.000 m	R = 800.000 m	R = 800.000 m

**PROJECTED AND ADOPTED CURVE DATA**

PC 13+052.430	PI 13+286.848	PT 13+521.248
L = 234.418 m	L = 234.418 m	L = 234.418 m
R = 800.000 m	R = 800.000 m	R = 800.000 m

DESIGNED CHECKED DATE BY	DETAILED CHECKED DATE BY	BRIDGE AND STRUCTURAL CHECKED DATE BY		<b>K.C.S. RAILROAD OVERPASS</b> (MINOCK) US 71		PARISH PROJECT STATE PROJECT	BOSSIER 37-0701B1 010-05-0027	SHEET NO.	103
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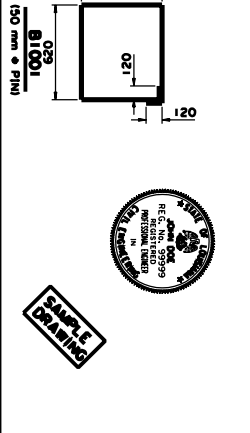


**BENT NOTES:**  
 CONSTRUCTION SPECIFICATIONS, LATEST APPROVED LOUISIANA STANDARD SPECIFICATIONS FOR ROADS AND BRIDGES, SUPPLEMENTAL SPECIFICATIONS AND SPECIAL PROVISIONS, DESIGN SPECIFICATIONS, ASHUTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 1992, AND INTERIM SPECIFICATIONS.  
 DESIGN LOAD: LIVE LOAD IS HS20-44MM AND HS-18MM.  
 STRUCTURAL CONCRETE: ALL CONCRETE SHALL BE CLASS A. EXPOSED EDGES SHALL HAVE A 20 mm CHAMFER UNLESS OTHERWISE NOTED. ALL EXPOSED FACES OF WALLS AND ENDS OF CAPS SHALL RECEIVE A CLASS 2A SPECIAL SURFACE FINISH. ASPHALT SATURATED FELT SHALL BE INCLUDED IN THE PRICE BID FOR CLASS A CONCRETE.  
 REINFORCING STEEL: ALL REINFORCING STEEL SHALL BE GRADE 400.  
 DIMENSIONS RELATING TO BAR FABRICATION ARE OUT-TO-OUT OF BAR UNLESS OTHERWISE NOTED. DIMENSIONS RELATING TO BAR SPACING ARE TO BAR CENTERS, UNLESS OTHERWISE NOTED.  
 DOWELS (B2001) SHALL BE PROVIDED AT ALL FIELD BEARINGS AND APPROACH SLAB BEARINGS (SEE GENERAL PLAN).  
 ALL EXPOSED ENDS OF DOWELS SHALL BE WRAPPED WITH TWO LAYERS OF TYPE 1 (NO. 15) ASPHALT SATURATED FELT, CLOSE FITTING TO THE DOWEL. THE FELT SHALL BE LESS THAN 3 mm THICK, MUST BE SUBSTITUTED, LESS THAN 3 mm THICK, MUST BE SUBSTITUTED, PRECAST CONCRETE PILES FOR DETAILS OF PILES SEE STANDARD DETAIL, CS-216AM.

ESTIMATED QUANTITIES (ONE INTER. BENT)		
BAR NO.	UNIT	TOTAL LOCATION
B2301	6	9 750 58 560 LONGITUDINAL IN CAP
B2302	6	2 830 16 990 LONGITUDINAL IN CAP
<b>TOTAL NO. 23 BARS = 75 540 = 295 kg</b>		
B2001	19	600 11 400 DOWELS
<b>TOTAL NO. 20 BARS = 11 400 = 27 kg</b>		
B1001	2	9 750 19 520 LONGITUDINAL IN CAP
<b>TOTAL NO. 15 BARS = 19 520 = 51 kg</b>		
B1001	40	2 500 100 000 STRIPBARS IN CAP
B1002	4	1 100 4 400 STRIPBARS IN CAP
B1003	2	650 1 240 LONGITUDINAL IN RISER
B1004	8	2 600 20 800 STRIPBARS IN WINDOW WALL
B1005	8	2 350 20 800 LONGITUDINAL IN WINDOW WALL
B1006	12	1 400 14 400 LONGITUDINAL IN WINDOW WALL
<b>TOTAL NO. 10 BARS = 148 200 = 116 kg</b>		
<b>TOTAL DEFORMED REINFORCING STEEL = 437 kg</b>		
<b>TOTAL CLASS A CONCRETE = 420 m³</b>		
<b>MAXIMUM PILE LOAD = 430 kN</b>		

ESTIMATED QUANTITIES (ONE END BENT)		
BAR NO.	UNIT	TOTAL LOCATION
B2301	6	9 750 58 560 LONGITUDINAL IN CAP
B2302	6	2 830 16 990 LONGITUDINAL IN CAP
<b>TOTAL NO. 23 BARS = 75 540 = 295 kg</b>		
B2001	19	600 11 400 DOWELS
<b>TOTAL NO. 20 BARS = 11 400 = 27 kg</b>		
B1501	2	9 750 19 520 LONGITUDINAL IN CAP
<b>TOTAL NO. 15 BARS = 19 520 = 51 kg</b>		
B1001	40	2 500 100 000 STRIPBARS IN CAP
B1002	4	1 100 4 400 STRIPBARS IN RISER
B1003	2	650 1 240 LONGITUDINAL IN RISER
B1004	8	2 600 20 800 STRIPBARS IN WINDOW WALL
B1005	8	2 350 20 800 LONGITUDINAL IN WINDOW WALL
B1006	12	1 400 14 400 LONGITUDINAL IN WINDOW WALL
<b>TOTAL NO. 10 BARS = 148 200 = 116 kg</b>		
<b>TOTAL DEFORMED REINFORCING STEEL = 437 kg</b>		
<b>TOTAL CLASS A CONCRETE = 430 m³</b>		
<b>MAXIMUM PILE LOAD = 430 kN</b>		

• 400 mm • PRC PILES ARE USED FOR ESTIMATING PURPOSES ONLY.  
 IF 350 mm • PRC PILES ARE USED, ADD 0.04 m³ OF CLASS A CONCRETE PER BENT.



DESIGNED: \_\_\_\_\_

CHECKED: \_\_\_\_\_

DATE: 2-25-97

SHEET: 1 OF 2

**CAST-IN-PLACE CONCRETE BENT**

9 m CLEAR ROADWAY  
90° CROSSING

STANDARD DETAIL: 40-BCSSR-90-9-TWT-GL

PARISH: \_\_\_\_\_

FEDERAL PROJECT: \_\_\_\_\_

STATE PROJECT: \_\_\_\_\_

9 (37)

<b>DEVELOPMENT LENGTH OF REINFORCING BARS IN TENSION, (mm)<sup>1</sup></b>											
<b><sup>2</sup>Bar No.</b>	<b>f'c=22 MPa, class A, S, X</b>					<b>f'c=24 MPa, class AA, S, X</b>					
	ld <sup>3</sup>	1.3ld	1.4ld	1.7ld	2.0ld	ld	1.3ld	1.4ld	1.7ld	2.0ld	
10M	300	370	400	490	570	300	370	400	490	570	
15M	410	540	580	700	820	410	540	580	700	820	
20M	540	710	760	920	1080	520	680	730	890	1040	
25M	900	1170	1260	1530	1800	860	1120	1210	1470	1720	
30M	1260	1640	1770	2150	2520	1210	1580	1700	2060	2420	
35M	1800	2340	2520	3060	3600	1720	2240	2410	2930	3440	
45M	2240	2920	3140	3810	4480	2150	2800	3010	3660	4300	
55M	3050	3970	4270	5190	6100	2920	3800	4090	4970	5840	

<b>Bar No.</b>	<b>f'c=26 MPa, class AA(M), A(M)</b>					<b>f'c=18 MPa, class D</b>				
	ld	1.3ld	1.4ld	1.7ld	2.0ld	ld	1.3ld	1.4ld	1.7ld	2.0ld
10M	300	370	400	490	570	300	370	400	490	570
15M	410	540	580	700	820	410	540	580	700	820
20M	500	650	700	850	1000	600	780	840	1020	1200
25M	830	1080	1170	1420	1660	990	1290	1390	1690	1980
30M	1160	1510	1630	1980	2320	1390	1810	1950	2370	2780
35M	1650	2150	2310	2810	3300	1980	2580	2780	3370	3960
45M	2480	3230	3480	4220	4960	2970	3870	4160	5050	5940
55M	4120	5360	5770	7010	8240	4950	6440	6930	8420	9900

<b>Bar No.</b>	<b>f'c=45MPa, class P(M)</b>					<b>F'c=40 MPa, class P</b>				
	ld	1.3ld	1.4ld	1.7ld	2.0ld	ld	1.3ld	1.4ld	1.7ld	2.0ld
10M	300	370	400	490	570	300	370	400	490	570
15M	410	540	580	700	820	410	540	580	700	820
20M	500	650	700	850	1000	500	650	700	850	1000
25M	640	840	900	1090	1280	670	880	940	1140	1340
30M	880	1150	1240	1500	1760	930	1210	1310	1590	1860
35M	1260	1640	1770	2150	2520	1330	1730	1870	2270	2660
45M	1880	2450	2640	3200	3760	2000	2600	2800	3400	4000
55M	3140	4090	4400	5340	6280	3330	4330	4670	5670	6660

<sup>1</sup> For epoxy reinforcing development length, see AASHTO LFD specs 8.25.2.3

<sup>2</sup> ASTM A 615M-95b (fy = 420 MPa)

<sup>3</sup> Refer to LRFD 5.11.2.1.1 for development of reinforcing

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## **INTRODUCTION**

The safety and efficiency of operation on a highway depends a great deal upon the placement of highway signing as a means of informing, warning and controlling drivers. The signing of highways requires both roadside ground mounted and overhead signs.

Normally the Geometric Design Section coordinates the design and details of permanent signing plans into the construction plans. This includes the signing quantity sheets and sign layout sheets. Permanent Signing Construction Plans can be let as a project by itself or can be placed in projects also containing roadway and bridge construction.

The Bridge Design Section's primary function is to maintain the standard structural sign details for roadside ground mounted and overhead signs to be placed in the construction plans. A written request must be made to the Bridge Design Engineer to obtain the standard structural signing details to be used in DOTD projects. This request should be coordinated with the Geometric Design Engineer. The standard sign details include the roadside ground mounted breakaway signs (sign panel and sign post details) and overhead signs (type II truss, cantilever truss and fascia details).

Location, reflectorization, and lighting of signs are important considerations in signing. For information regarding the design, location and application of sign reference should be made to the latest edition of the Manual of Uniform Traffic Control Devices (MUTCD).

Highway signs with the potential of being a hazard to motorists should be placed outside of clear zones, behind guardrail or barriers, or on structures. If these measures are not feasible, the roadside sign supports must be breakaway or for overhead sign supports, shielded by appropriate guardrail or barriers. The breakaway and structural design of roadside and overhead signs must comply with the latest edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

For additional general guidelines for breakaway supports and clear zone requirements, refer to the latest edition of the AASHTO Roadside Design Guide.

## **ROADSIDE GROUND MOUNTED SIGNS**

Roadside ground mounted signs generally consist of single post and multiple post-breakaway systems. The details for the breakaway systems generally follow research results developed by different national pooled fund studies. These signs must be designed for vehicle impact and wind loading.

Over the past decades, the vehicle fleet has changed size, configuration and construction. The standard vehicle of 25 years ago weighed 4500 lbs. or greater. There were very few lighter-weight vehicles. As time progressed smaller sedans entered the fleet. Presently 1800 lbs. sedans or mini cars are common place. Thus breakaway signs that were once acceptable for the larger, heavier cars must be adjusted for the smaller cars. The details of our current breakaway installations follow the crash test results performed by a national pool fund study in 1991 coordinated by FHWA to meet current vehicle weights and vehicle impact specifications.

The appropriate procedures for acceptance testing of breakaway supports are based on NCHRP report 350, "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

Most breakaway posts consist of rolled steel shapes, extruded aluminum shapes or timber. The Departments single and multiple post breakaway signs use a unidirectional or multidirectional slip base design. Multidirectional single breakaway posts are used when a vehicle can impact the sign from any direction. A unidirectional single or multiple post breakaway post is generally used when a vehicle can impact the sign in one direction.

Slip base mechanisms activate when two parallel plates slide apart when bolts are pushed out under impact. The upper hinge on unidirectional multi-post signs consists of a slotted fuse plate on the expected impact side and a saw cut through the web of the post to the near flange. The near flange then acts as a hinge when the post rotates up. Proper function of the slip and fuse plate design requires the proper torque of the bolts.

Attached on page 10 (6) is an example detail of a single post and multiple post breakaway slip base roadside ground mounted sign. Further information on ground mounted signs can be obtained from the standard sign details.

## **OVERHEAD SIGNS**

Overhead signs consist of ground or structure mounted type II trusses, cantilever trusses or fascia signs. The span ranges for the type II trusses can extend up to 36.5 meters. The span ranges for the cantilever trusses can extend up to 10 meters. The type II and cantilever trusses are space frames that consist of steel, aluminum tube, or pipe section. The type II trusses may come in incremental sections, which can be joined by means of a bolted splice. This process helps simplify the erection of the type II truss in the field.

The type II and cantilever trusses are supported by pile footings, drilled shaft footings or attached directly to a bridge or a retaining wall support. The structural supports on a bridge or retaining wall must be designed and detailed on an individual basis. The fascia signs are attached directly to the side of bridge, at the bridge barriers, or at the bottom flanges of the bridge girders. The designer is cautioned to check the design criteria for the overhead sign. The height and wind pressure of each overhead sign must be checked against the design criteria in the standard details. Any difference in criteria must be accounted for by an adjustment of the standard details.

A type II truss summary sheet is included with the standard details. The table on this summary sheet is to be filled out by the designer. The table includes information for the sign number; sign station, sign areas, trusses member sizes, truss camber and anchor bolt sizes. The structure design of the type II trusses is based on an in-house computer program. The computer output will give the most economical truss member sizes, the truss camber and the required anchor bolt diameters for spans ranging from 9 meters to 36.5 meters at increments of 1.8 meters. Member sizes given by the computer output must be checked for availability. The engineer should include a minimum additional 30% to the planned design sign area to account for any future signs placed on the truss. The program assumes the sign panel to be three (3) meters in height and the sign area will vary in increments of 9.3 m<sup>2</sup>. Normally the truss designs are provided upon written request to the Bridge Design Section.

For overhead cantilever signs, the Department maintains a ground mounted and structural mounted standard details. The engineer is required to check the site criteria to each cantilever to see if it matches our standard detail design criteria. This is especially true for cantilevers mounted on bridges at heights above our normal criteria. In cases not covered by our standard detail, individual design and details must be done.

Shop drawings for overhead signs are normally submitted to the design section by the fabricator for review and approval. The fabricator will sometimes request the use of a different diameter pipe or tube than what is called for in the plans, since certain sizes of tube or pipe may not be readily available.

Attached on page 10 (7) through page 10 (12) are examples of details of the type II cantilever trusses showing both structural and ground mounted details. Also attached on page 10 (13) is a sign truss design form to be used by the designer in identifying and designing overhead sign structures. The designer should fill out the top truss design data

table for each overhead sign. The Bridge Design Section will complete the type II truss member size table upon written request.

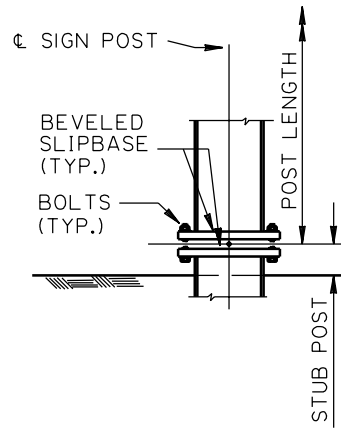
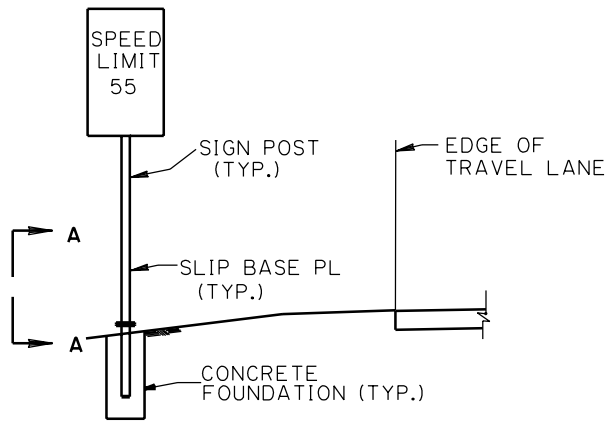
## ANALYSIS AND DETAIL INFORMATION

### Analysis

1. Ground mounted Multiple post sign supports are considered as cantilever beam-columns that are fully supported against lateral and torsional buckling at sill connections.
2. Ground mounted single post signs are designed as cantilever beam-columns that have unsupported length from the base to the center of pressure of the sign mounted on them.
3. A uniform soil bearing capacity of 143 Pa was used for ground mounted roadside signs.
4. Overhead type II sign trusses are designed as pin connected and simple supported for wind and dead load trusses. The columns for the overhead type II trusses are designed fixed at the base.
5. Structure mounted supports for type II or cantilever overhead sign trusses must be designed and detailed on an individual basis.

### Details

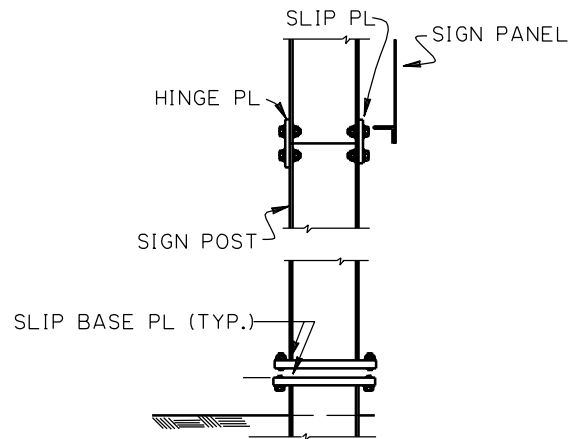
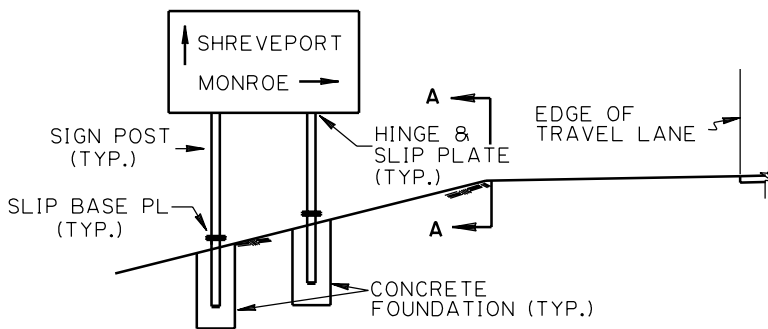
1. Ground mounted single-post signs have a breakaway slip base which is beveled such that the sign is given an upward component of acceleration when hit such that the sign will pass over the top of the colliding vehicle without further contact.
2. Ground mounted multiple-post signs have a breakaway slip base which are beveled such that the sign is given an upward component of acceleration when both posts are hit simultaneously. This probability is deemed to exist when the post spacing is 2.1 meters or less.
3. The directional slip bases should be placed such that their operational characteristics will be the most probable direction of high-speed collision where practical.



VIEW A-A

SINGLE-POST UNIDIRECTIONAL

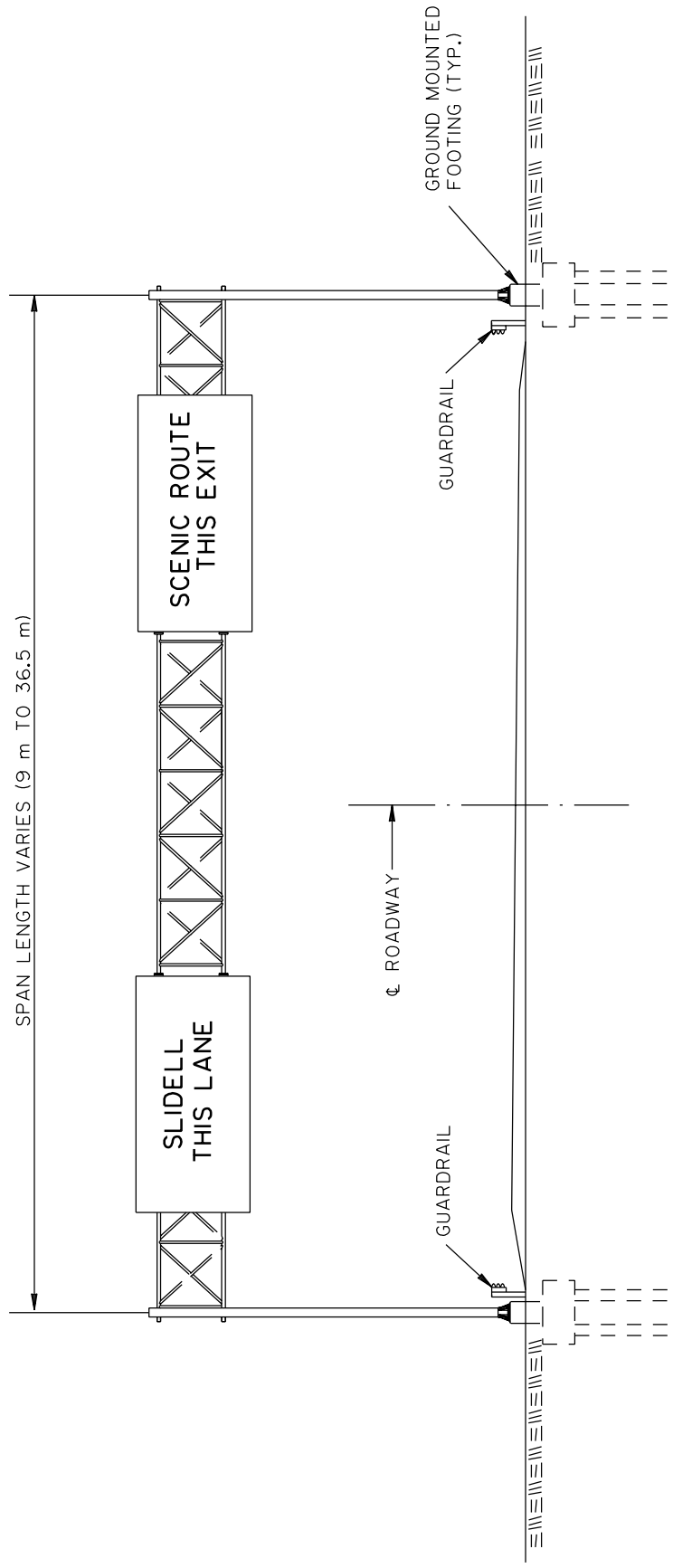
NOTE: FOR FURTHER INFORMATION,  
SEE STANDARD SIGNING DETAILS.



VIEW A-A

MULTIPLE-POST UNIDIRECTIONAL

**ROADSIDE GROUND MOUNTED SIGN  
TYPICAL DETAILS**



NOTE: FOR FURTHER INFORMATION,  
SEE STANDARD SIGNING DETAILS.

**TYPE II OVERHEAD SIGN TRUSS  
GROUND MOUNTED FOOTINGS**

SPAN LENGTH VARIES (9 m TO 36.5 m)

MORGAN CITY  
THIS LANE

GUIDRY DRIVE  
THIS EXIT

ROADWAY

MEDIAN BARRIER  
FOOTING

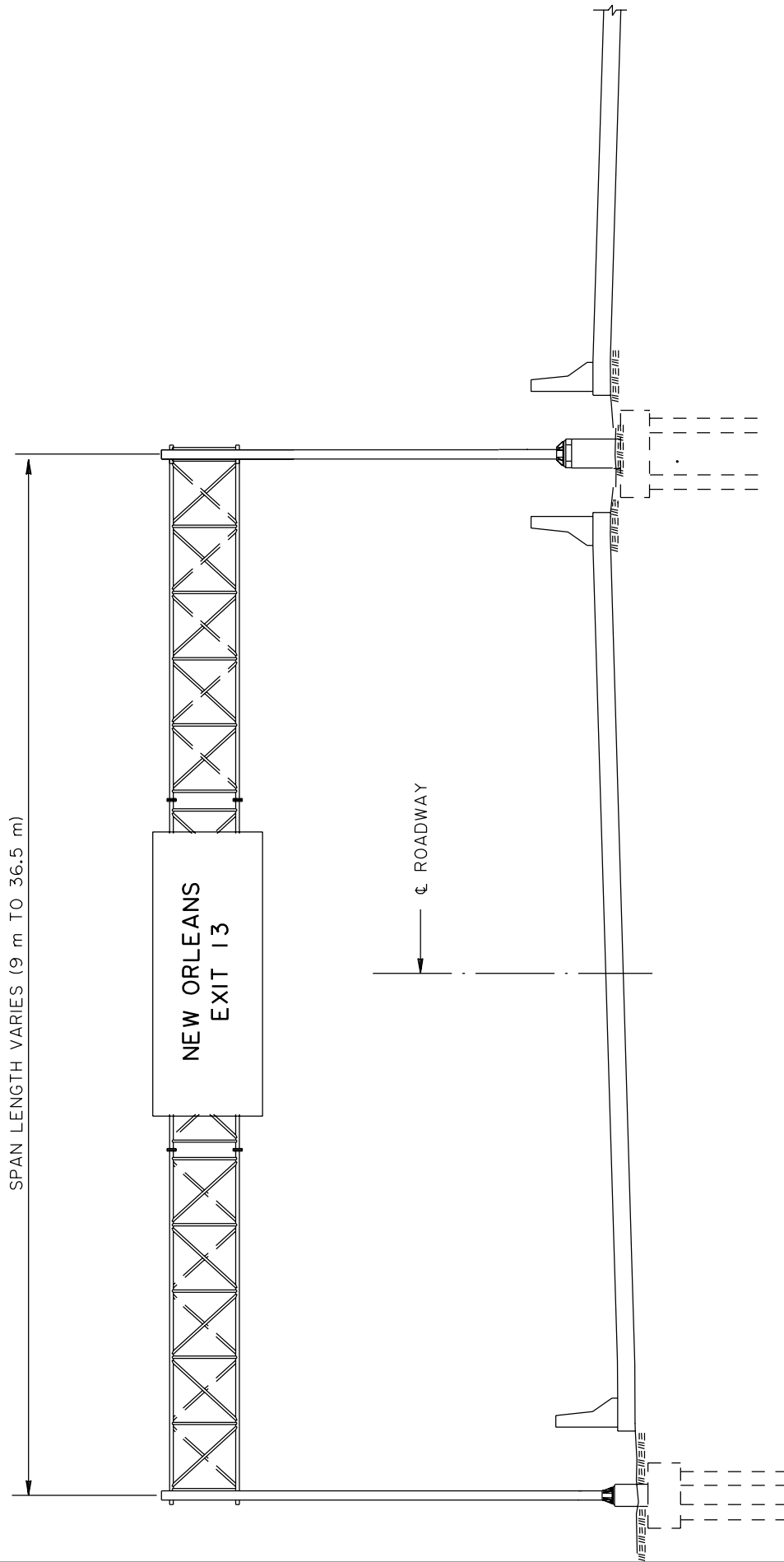
GUARDRAIL

NOTE: FOR FURTHER INFORMATION,  
SEE STANDARD SIGNING DETAILS.

**TYPE II OVERHEAD SIGN TRUSS  
GROUND MOUNTED AND MEDIAN  
BARRIER FOOTINGS**

3 OF 7





SPAN LENGTH VARIES (9 m TO 36.5 m)

NEW ORLEANS  
EXIT 13

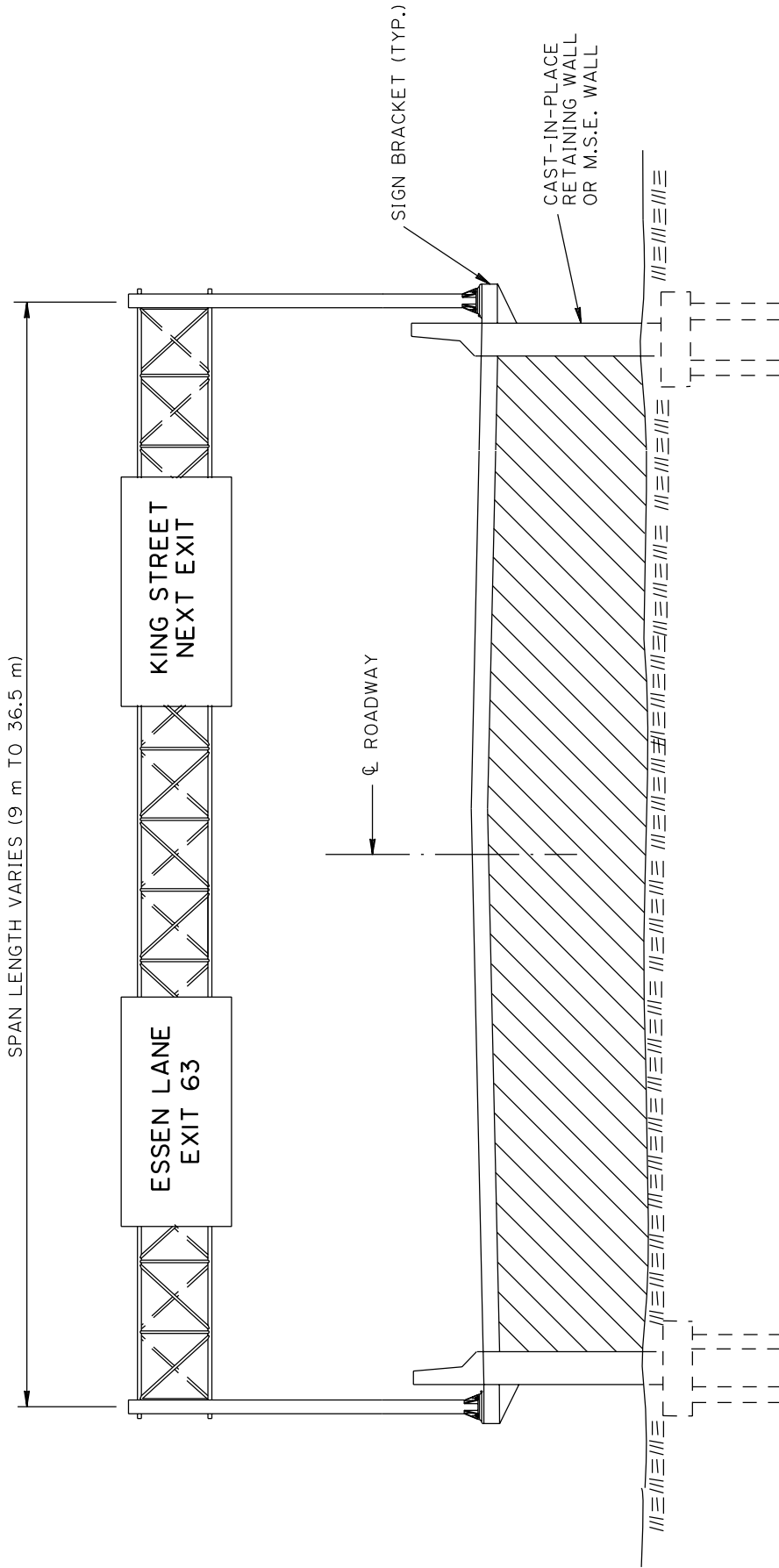
C ROADWAY

MEDIAN

MEDIAN

NOTE: FOR FURTHER INFORMATION,  
SEE STANDARD SIGNING DETAILS.

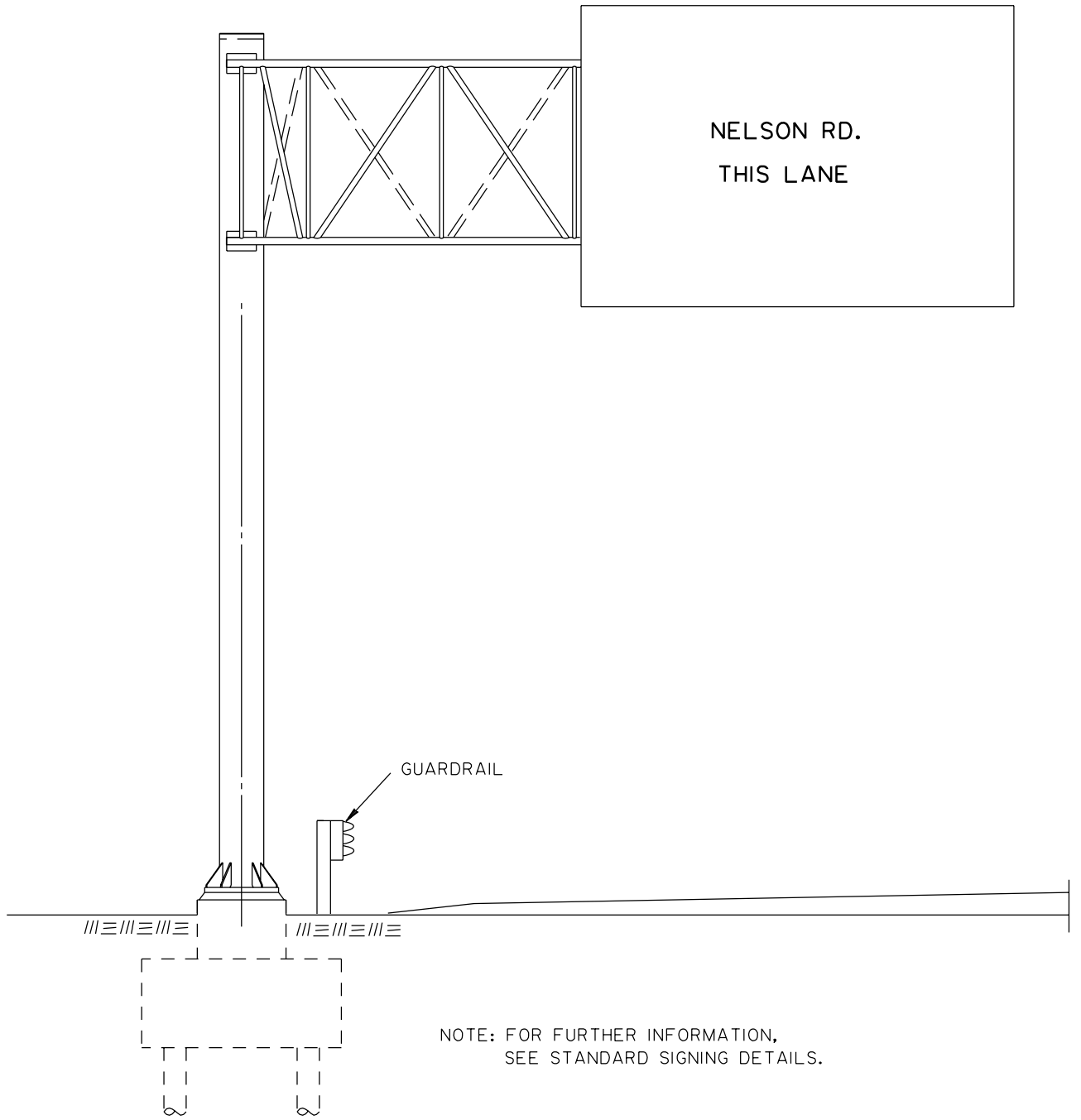
**TYPE II OVERHEAD SIGN TRUSS  
GROUND MOUNTED  
AND MEDIAN FOOTINGS**



NOTE: FOR FURTHER INFORMATION,  
SEE STANDARD SIGNING DETAILS.

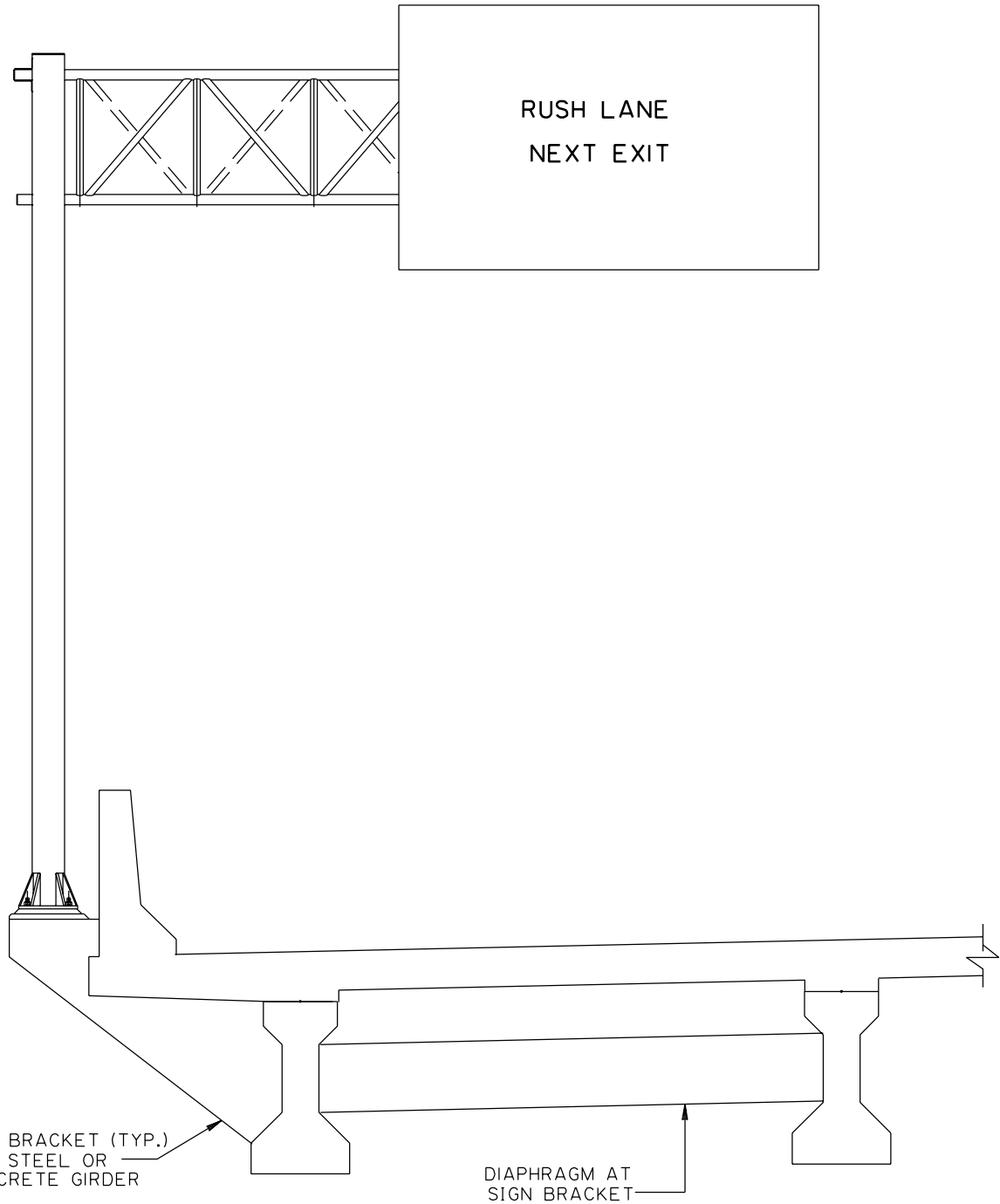
**TYPE II OVERHEAD SIGN TRUSS  
RETAINING WALL MOUNTED**

5 OF 7



**SINGLE-POST CANTILEVER SIGN  
TRUSS GROUND MOUNTED FOOTINGS**

6 OF 7



RUSH LANE  
NEXT EXIT

SIGN BRACKET (TYP.)  
FOR STEEL OR  
CONCRETE GIRDER

DIAPHRAGM AT  
SIGN BRACKET

NOTE: TYPE II TRUSS MOUNTING  
ARE SIMILAR TO THIS DETAIL

**DOUBLE-POST CANTILEVER SIGN  
TRUSS OR TYPE II TRUSS BRIDGE  
MOUNTED**

7 OF 7

## SIGN TRUSS DESIGN FORM

Please complete the following table as fully as possible

TRUSS DESIGN DATA			
PROJECT NO.		PARISH	
STATION		TRUSS NO.	
GUARDRAIL REQ'D	( ) YES ( ) NO	REQ'D SPAN (m)	
TRUSS TYPE ( ) EXISTING★ ( ) NEW	( ) OVERHEAD TYPE II ( ) SINGLE-POST CANTILEVER ( ) DOUBLE-POST CANTILEVER	MOUNTING ( ) EXISTING★ ( ) NEW	( ) GROUND FOOTING ( ) BRIDGE ( ) RETAINING WALL ( ) GROUND FOOTING - MEDIAN BARRIER
WIND VELOCITY	( ) 113 km/h ( ) 145 km/h ( ) 129 km/h ( ) 161 km/h	ACTUAL SIGN AREA (m <sup>2</sup> )	
DESIGN DATA SUBMITTED BY:			DATE:
COMMENTS:			
★ EXISTING MOUNTING OR TRUSS BUILT UNDER S.P. NO. _____ SHT NO. _____			

The following table is to be completed by the Bridge Design Section

TYPE II TRUSS MEMBER SIZES							
DESIGN SPAN (m)		DESIGN AREA (m <sup>2</sup> )			DESIGN WIND (Pa)		
<sup>1</sup> SIGN HEIGHT (m)		ALUMINUM			STEEL		
TRUSS MEMBER	<sup>2</sup> SEC. NO.	<sup>3</sup> O.D.x T (mm)	AVAIL. SIZE	<sup>2</sup> SEC. NO.	<sup>3</sup> O.D.x T (mm)	AVAIL. SIZE	
<sup>4</sup> POST							
POST STRUT							
POST DIAGONAL							
CHORD							
H. DIAGONAL							
CAMBER (mm)							
ANCHOR BOLT DIA.(mm)							
LOAD CASE							
COMPUTED BY:				CHECKED BY:		DATE:	
COMMENTS:							

<sup>1</sup> Sign height = sign height from the ground to centerline of sign panel

<sup>2</sup> SEC. NO. IS OBTAINED FROM BRIDGE DESIGN COMPUTER DESIGN TABLES

<sup>3</sup> o.d. x t (outside diameter x thickness)

<sup>4</sup> Design post spacing= 1848 mm + chord diameter + post diameter

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## **BARRIER AND END TREATMENT SYSTEMS**

### **OVERVIEW**

Crash tested and approved effective barrier systems, end treatments, and crash cushions, shall be used to achieve the highest levels of highway safety. Any highway safety appurtenance which do not meet the appropriate crash test requirements or are not considered as operational by FHWA and LA DOTD shall not be specified in any plans. This will include all generic as well as proprietary items. Prior to 1994 all highway safety devices were crash tested in accordance with the guide lines outlined in the National Cooperative Research Program 230 (NCHRP230). NCHRP 230 has been replaced by another publication, which is referred to as NCHRP 350 since early 1994. Although many safety appurtenances are crash tested to meet these new criteria, FHWA has not established a target date in which time the NCHRP 350 criteria will become mandatory. This is partially due to the fact that the more stringent criteria in this new document has made it very difficult for some widely used existing devices to pass the crash test. In fact a partial rewrite of NCHPR 350 may be necessary before it is mandated nationwide. Until such date, the NCHPR 230 will remain as the official criteria for approval of safety appurtenances. However, all items which have passed the test under NCHRP 350 shall be given favorable consideration for use on state highways.

Uses of proprietary items are generally not recommended unless a generic equal is not available. When proprietary items are specified, plans shall allow an equal substitute subject to the approval of the department and at no extra cost.

In selecting or working with any type of roadside safety appurtenance, consult the latest issue of AASHTO; Roadside Safety Guide for the Recommended Procedures, and design criteria.

### **HISTORY OF CRASH TESTING**

Procedures for full-scale vehicle crash testing of Roadway Barriers were first published in Highway Research Institute in 1973 to address the questions that were not covered in circular 782. Following this project the first report was published as "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances", NCHRRP Report 153. This 16-page document was based on technical input from more than 70 individuals and agencies as well as extensive deliberation by a special adhoc panel. This report later proved to be inadequate and NCHRP Project 22-2(4) was initiated in 1979 by Southwest Research Institute to address the major changes that had been recommended through a special committee action under TRB Circular 191. The final report of NCHRP Project 22-2(4) was published as NCHRP Report 230 "Recommended Procedures for the Safety Performance Evaluation of Highway Safety Appurtenances", in 1980.

This thirty-six-page document incorporated new procedures, updated the evaluation criteria and brought the procedures up to date with available technology and practices. This document served as the primary reference for full-scale crash testing of highway safety appurtenances in the United States and in many other parts of the world.

In 1987, AASHTO recognized that the evaluation of roadside safety concepts, technology, and practices necessitated an update to report 230. The reason included significant changes in the vehicle fleet, the new policies requiring the use of safety belt and advances in computer simulation and other evaluation methods.

Following this recognition, a team of experts from Texas Transportation Institute (TTI) and Dynatech Engineering began their effort in 1989 toward the creation of a new set of criteria to replace the NCHRP 230. The end result of their effort has been the creation of the NCHRP 350, which represents a comprehensive update of the procedures for safety performance evaluation.

Report 350 differs from report 230 in the following ways:

1. It is presented as all metric documents.
2. It provides a wider range of test procedures to permit safety performance evaluations for a wider range of barriers, terminals, crash cushions, breakaway support structures and utility poles, truck-mounted attenuators, and work zone traffic control devices.
3. It uses a pickup truck as the standard test in place of the 4500-lb. passenger car to reflect the fact that almost 25% of the passenger vehicles on U.S. roads are "light truck" category.
4. It defines other supplemental test vehicles including a mini-compact passenger car (700 kg), single unit cargo trucks (800 kg) and tractor-trailer vehicles (36 000 kg).
5. The three basic evaluation criteria categories remain the same. The occupant risk criteria retains the use of the flail space model, but defines preferred and maximum levels of occupant impact velocity and acceleration.
6. It provides optional criteria, established by others for side impact testing.



## LOUISIANA PRACTICE

### Barriers

Details of several crash- tested roadway barriers have been shown in this chapter. Among these barriers, the double-face thrie beam and the sloped-face concrete barriers are considered by FHWA as "Innovative Barrier". When required by FHWA, these barriers may be used in lieu of the more conventional type.

Barriers shown here are in two basic categories. First, the permanent barriers second the temporary barriers. Temporary barriers are commonly used in construction zone. When temporary barriers are utilized on bridge structures a positive connection to the bridge deck shall be provided, unless it is determined that a considerable lateral deflection of the barrier system can be tolerated. The blunt ends of temporary barriers shall be made crashworthy by means of either an end treatment device or by flaring away from traffic and carrying beyond the clear zone distance.

### Guardrail

Virtually all information pertaining to guardrail is contained in the Standard Plan G.R-200(M). This Standard provides information to the designers for the purpose of determining the "Length of Need" and to the contractors, for the purpose of constructing the guardrail.

In addition to G.R-200(M), Standard Plan G.R-201(M) and G.R-202(M) are provided to aid the designers with specific applications of guardrails. By using these particular standards the designers may show the dimensions which are unique to a specific condition on a simple

Sketch in the contract plans and make reference to a detail on the standard plan to provide the more generic information. Standard plans G.R-201(M) and G.R-202(M) shall always be used in conjunction with Standard Plan G.R-200(M).

Although guardrail standard plans adequately provide the necessary information to construct the guardrail system, it is very important that plans provide all information necessary for the specific site condition. For example, plans shall always show the total length, the length of each pay item, the location, the flare rate, the type of end treatment and any special notes or details.

When bridge construction is considered as "Spot Replacement", often there is little or no road construction, and in such cases minimum guard rail length shall be provided to make the bridge rail blunt ends crashworthy. In these situations, it is not necessary to design "length of need" to provide protection for the full "clear zone" distance behind the bridge rail. An exception to this is when the existing road in the vicinity of the structure provides the design "clear zone" distance, in which case the guardrail for the bridge ends shall provide protection consistent with that "clear zone" distance. The decision whether the minimum length or the standard length is to be utilized shall be made at the Plan-In-Hand

meeting after the road condition is examined. The final decision shall be included in the Plan-In-Hand report. When minimum guardrail lengths are utilized in "spot replacement" conditions, there will be no need for acquiring a design exception.

In all conditions, where the criteria within the standard plans can not be concurred, a design exception from the Chief Engineer shall be obtained and shall be stated in the plans. Statements of such design exceptions will provide easy reference to these exceptions when the department is challenged in litigation. End treatment of bridge railing located outside of the clear zone is recommended unless it is determined not feasible. End treatment of combination traffic and pedestrian railing when curbs and sidewalks are present is not recommended. The standard guardrail end treatment is "Modified Eccentric Loader Terminal" (MELT). This type of end treatment has a parabolic flare and is most suitable for when the line guardrail is flared away from the traffic. When the line guardrail has little or no flare, "MELT" can be used, however, under tight space condition, the placement of a parabolic end treatment may be difficult as well as undesirable. In such cases, a straight end treatment such as ET-2000 or equal may be utilized. When using this type of end treatment the line guardrail may be flared at a rate not to exceed 1:50.

For guardrails on existing roads and bridges see EDSM NO. 11.3.1.3. This EDSM outlines the procedures for guardrail design on existing conditions.

Bridge railing on all detour bridges shall be protected with a crashworthy end treatment. Flexible bridge railing can be adequately protected with a minimum guardrail length of 11 430 mm. However, when rigid barriers such as concrete safety shapes are used an additional 7620 mm transition guardrail section shall be included.

#### Guardrails for Off-System Projects

The guardrail standard plans applicable to off-system bridge projects are as follows:

GR-203A (M)

GR-203B (M)

BR-05 (M)

All standard plans for off-system projects shall be used in conjunction with Standard Plan GR-200 (M).

GR-203A (M) makes provisions for bridge end treatment on all classifications of off-system projects.

GR-203B (M) provides a shorter guardrail length than GR-203A (M), for when site conditions do not allow the installation of the standard length guardrail contained in GR-203A (M).

BR-05B (M) is a safety shape bridge barrier that is flared down within a 3000 mm length. These standards are applicable for situations where physical conditions do not allow the application of Standard Plans GR-203A (M) and GR-203B (M).

In addition to these standards, Standard Plan GR-200 (M) contains details for bridges near intersections. At the discretion of the Design Engineer, these details may be applied when it is geometrically appropriate.

### Crash Cushions (Impact Attenuators)

Crash cushions or impact attenuators are protective devices, which prevent errant vehicles impacting fixed object hazards.

Commonly, impact attenuators are in two categories:

1. Kinetic attenuators
2. Inertial attenuators

Kinetic attenuators are generally referred to as compression crash cushion. This type of attenuator needs a rigid backup wall to resist the impact loads. The kinetic attenuators work based on the absorption of the kinetic energy of a moving vehicle by crushable or plastically deformable materials placed in front of a hazard. Some of the energy is also dissipated by the crushing of the front end of the impacting vehicle.

The inertial attenuators work based on the conservation of momentum principle. The expandable mass usually consists of containers filled with sand or water. There is no need for a back wall. Momentum is equal to the mass of a body multiplied by its velocity. Application of the conservation of the momentum concept will not completely stop the vehicle; however, it will be adequate to reduce the velocity of the vehicle to about 15 km/hr after the last module has been impacted. The use of inertial attenuators such as sand barrel systems is not recommended for gore areas on elevated structures. However, for highway applications they can be effective and economical. Virtually all impact attenuators used in Louisiana are proprietary items. There are a number of proprietary attenuators in the market, most of which are manufactured by "Energy Absorption Systems, Inc."

The "Hex-Foam Sandwich" is among the most commonly used attenuators in our state. The designer using the manufacturer's design information shall determine its length and width. The construction and the installation of such devices shall always be in accordance with the manufacturer's recommended procedures.

The "Great" is another form of attenuator, which is compatible with "Hex-Foam" both in performance and cost. However, the use of this attenuator is generally reserved for very narrow locations as opposed to the "Hex-Foam" which is available in varying widths.

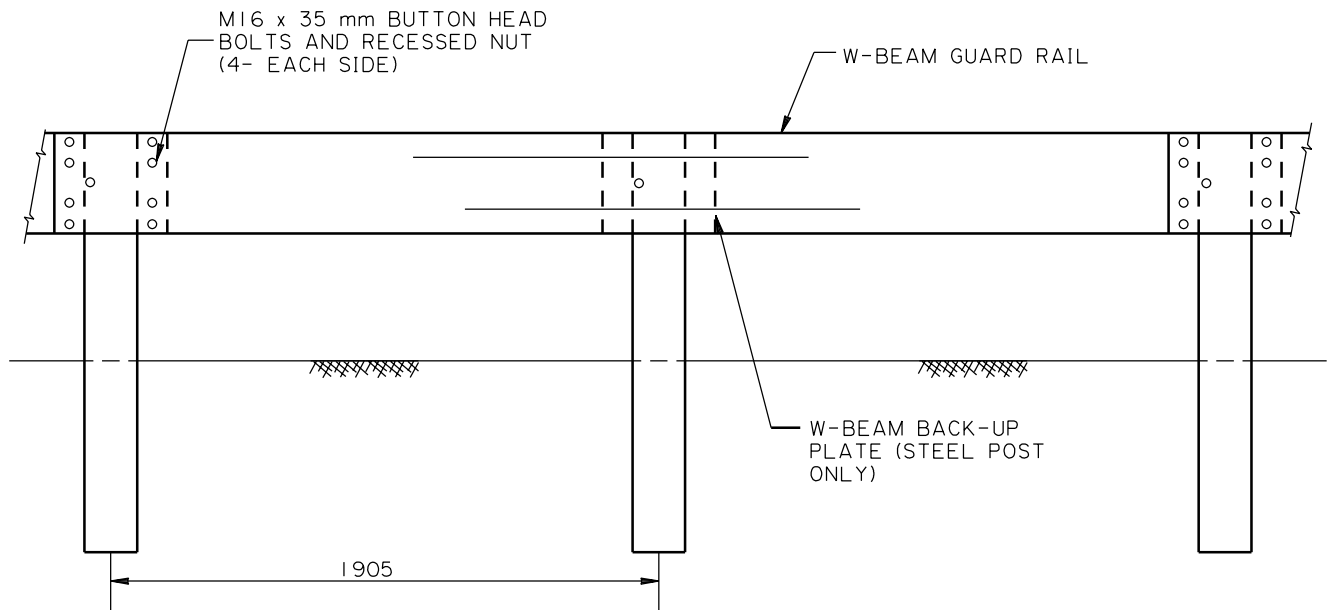
The "Construction Zone Great" is an attenuator commonly used in work zones and the only thing the designer needs to do is to specify its use on the plans.

The design of attenuators shall be in accordance with industry standards. Impact attenuators shall be designed for the maximum average deceleration level not exceeding approximately 7.0 g's.

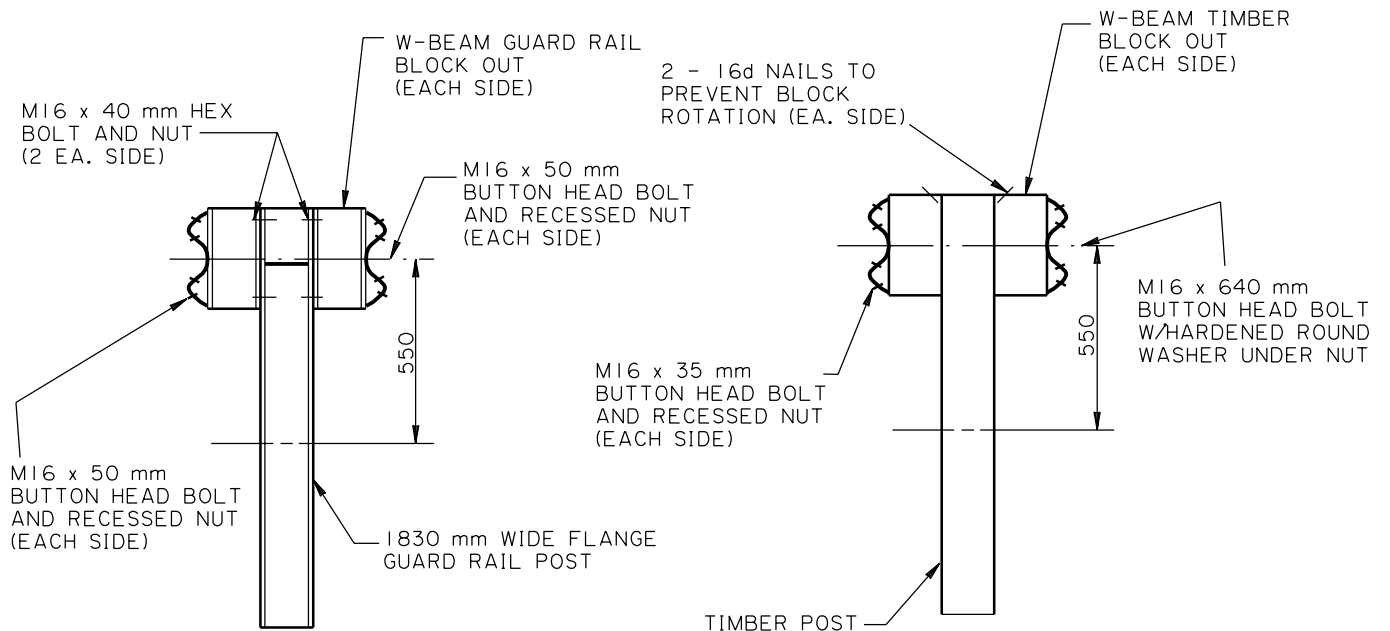
The reserve area for gores shall be designed and checked in accordance with the latest AASHTO geometric specification. These criteria are also available in the "Roadside Design Guide" under "Crash Cushions".

Although for many years, proprietary attenuators have been the primary source of attenuators, many state DOTs have made considerable progress in designing their own generic attenuator systems. There are many cost saving advantages in such devices, one of which arises from the fact they can be fabricated on a competitive basis.

The Bridge Design Section is working to provide better information regarding the generic attenuators, and as soon as fabrication plans are available, the use of these attenuators will be strongly recommended.



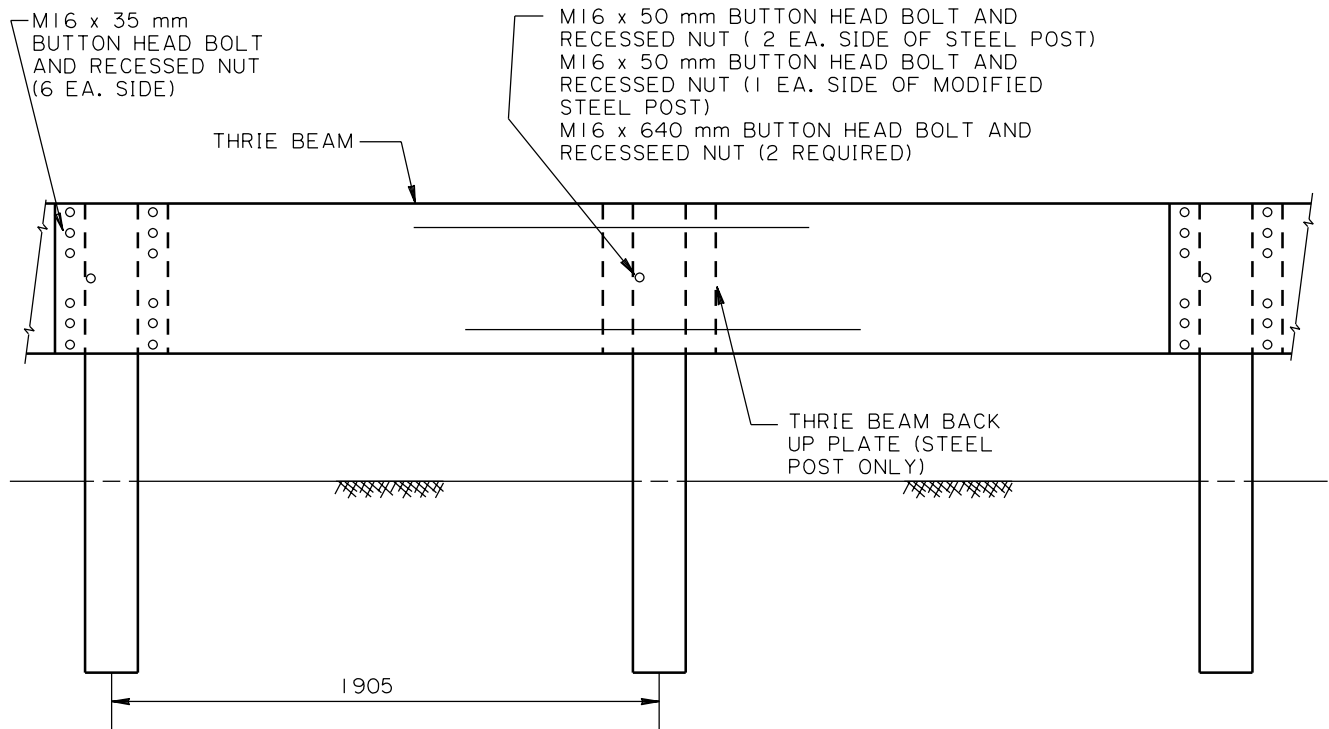
ELEVATION



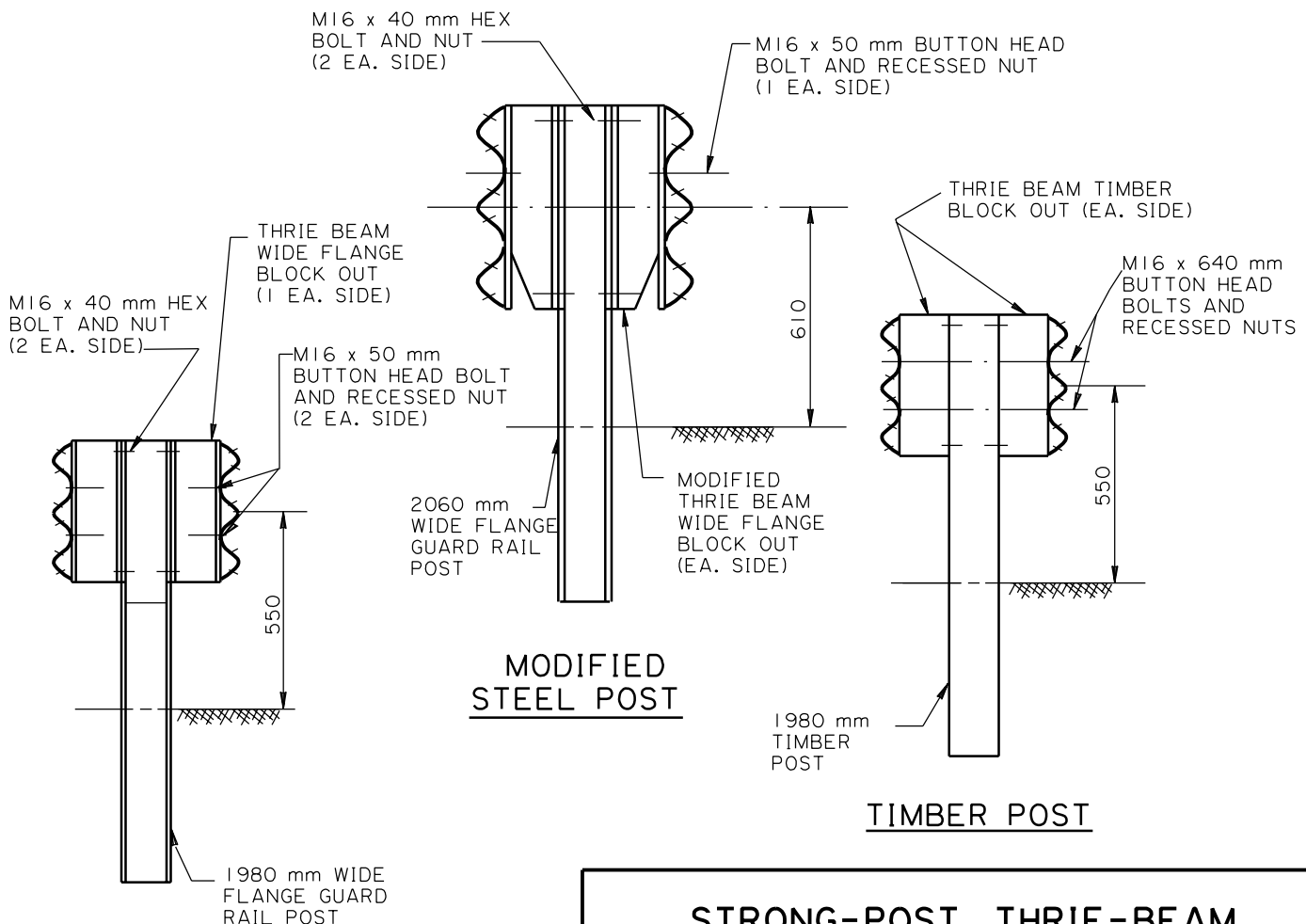
STEEL POST

TIMBER POST

**STRONG-POST, W-BEAM  
MEDIAN BARRIER**



**ELEVATION**



**MODIFIED STEEL POST**

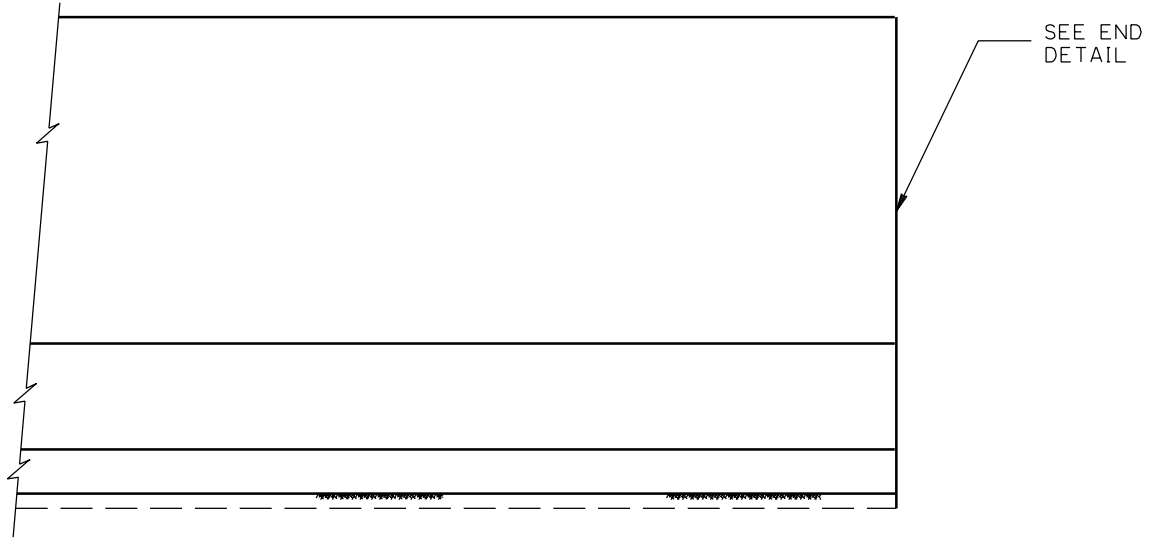
**TIMBER POST**

**STEEL POST**

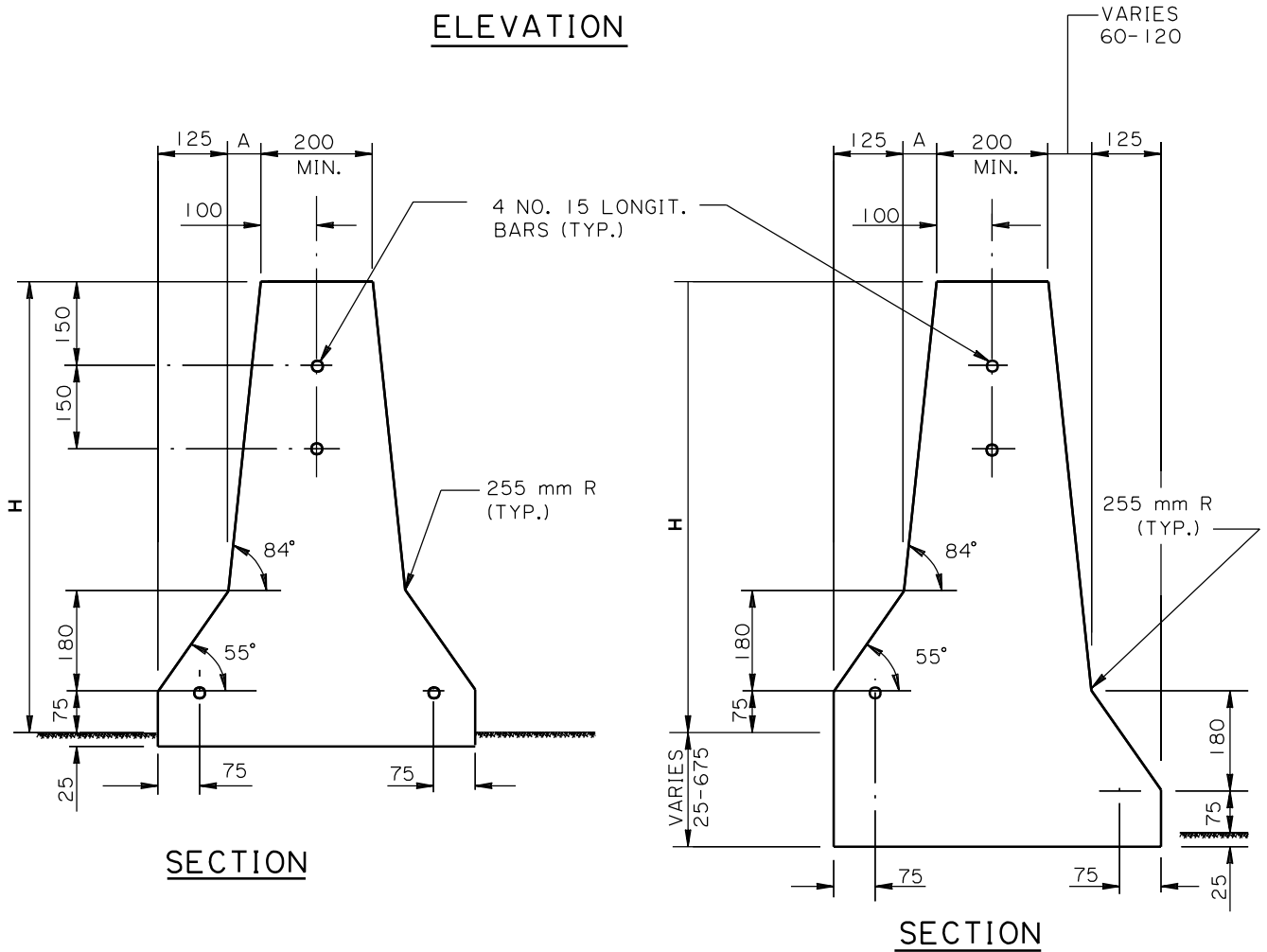
**STRONG-POST, THRIE-BEAM  
MEDIAN BARRIER**

**NOTES:**

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.



**ELEVATION**



**SECTION**

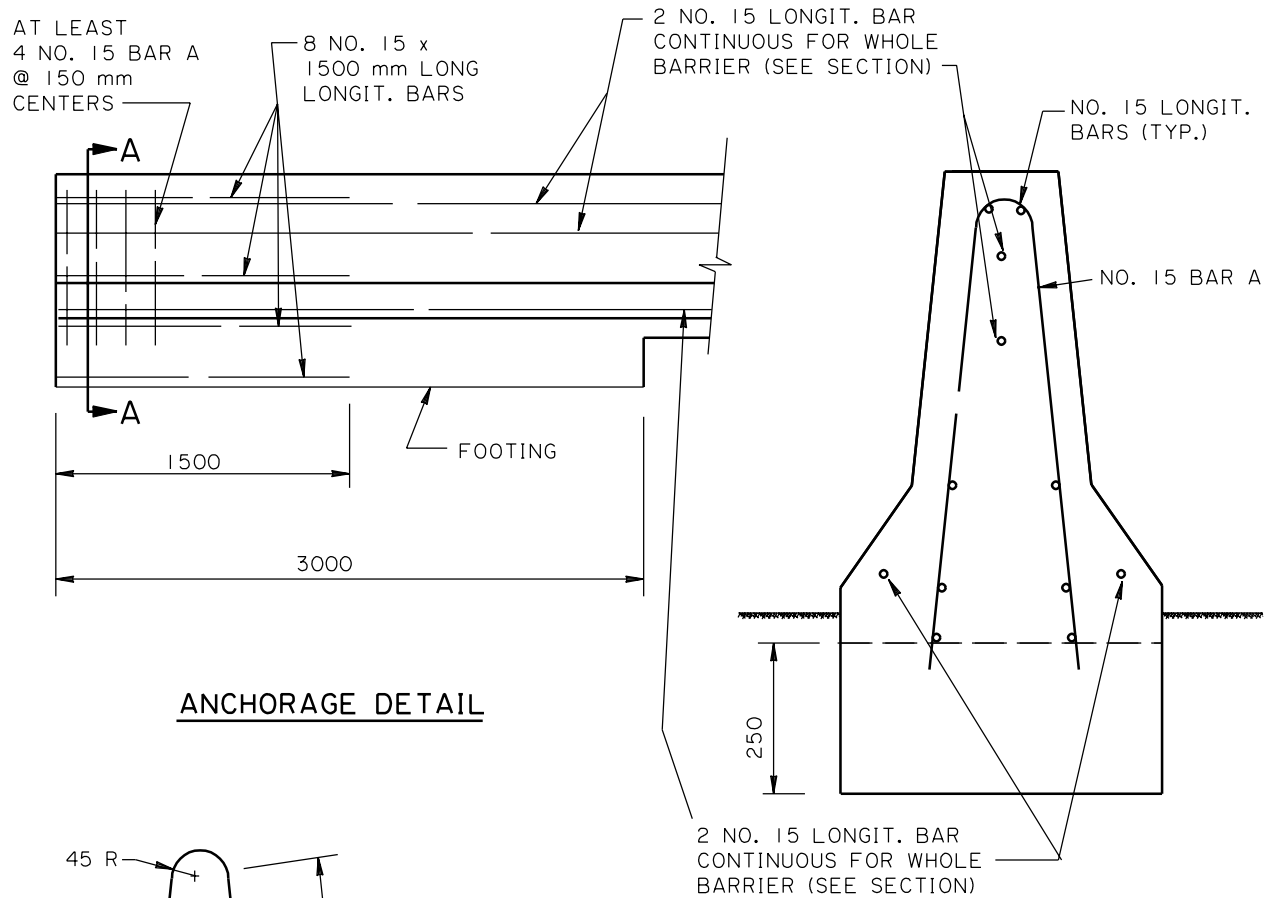
**SECTION**

SYSTEM	A	H
F-SHAPE (PL-2)	60	810
F-SHAPE (PL-3)	85	1070

**F-SHAPE MEDIAN BARRIER**

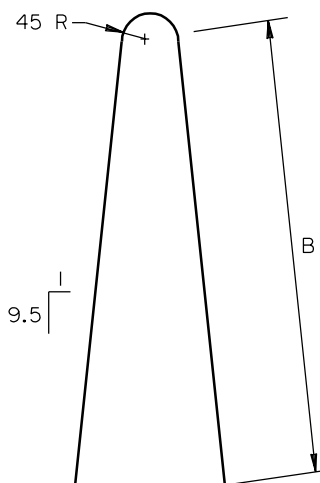
**NOTES:**

1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



ANCHORAGE DETAIL

SECTION A-A



BAR A (NO. 15)

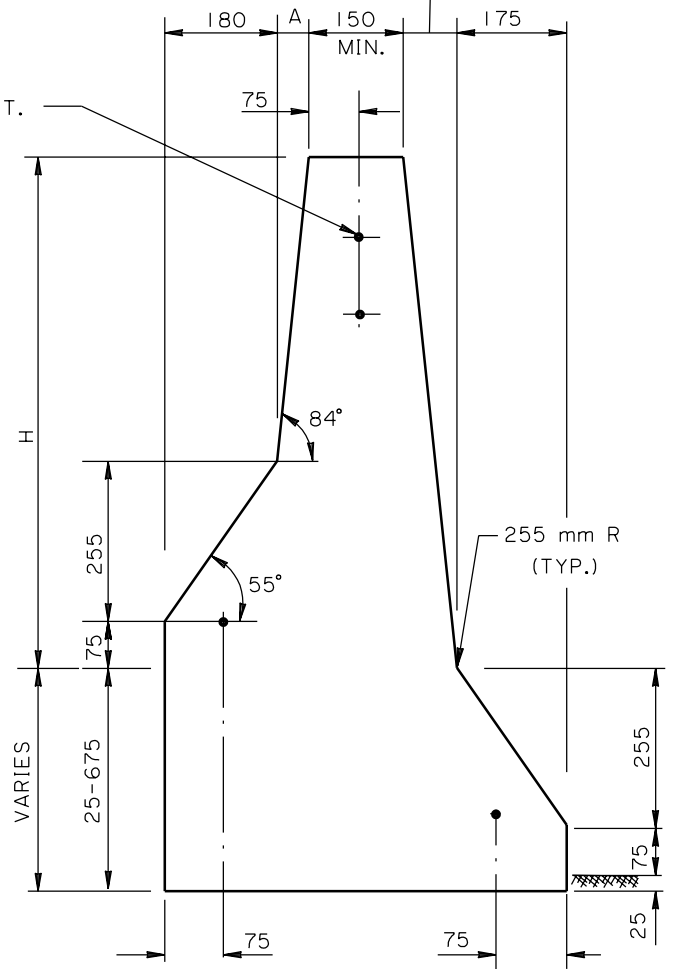
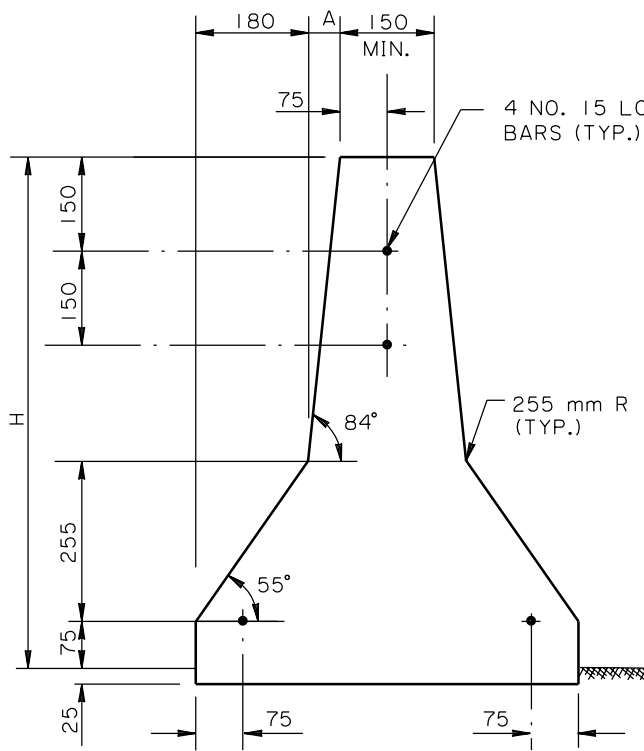
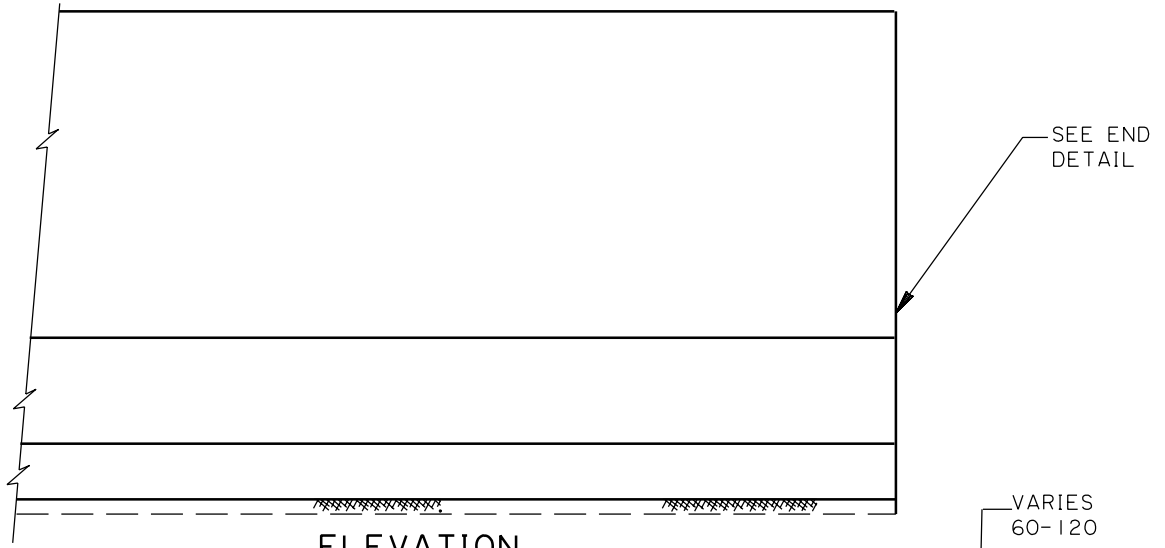
SYSTEM	B
F-SHAPE (PL-2)	910
F-SHAPE (PL-3)	1170

**F-SHAPE MEDIAN BARRIER**



**NOTES:**

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.

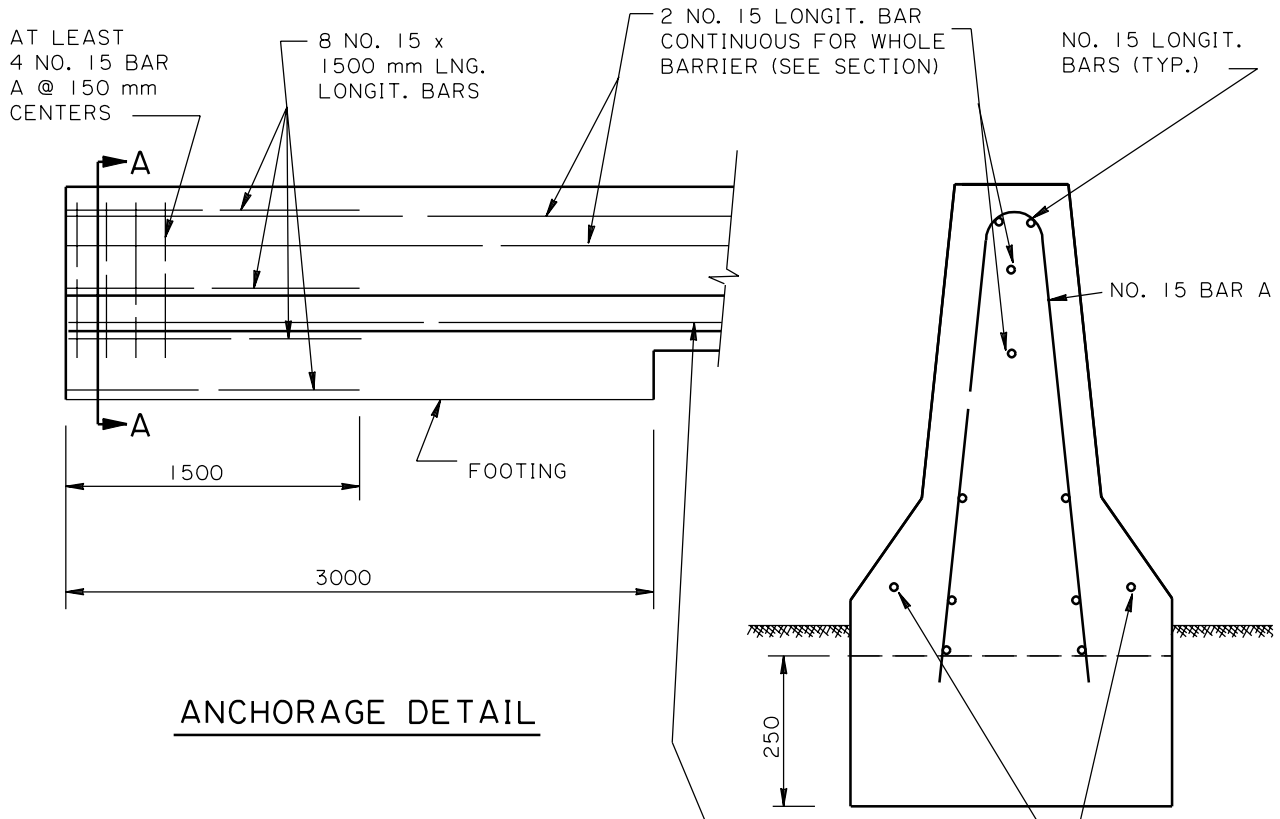


SYSTEM	A	H
N.J. SHAPE (PL-2)	50	810
N.J. SHAPE (PL-3)	80	1070

**SAFETY-SHAPE MEDIAN BARRIER**

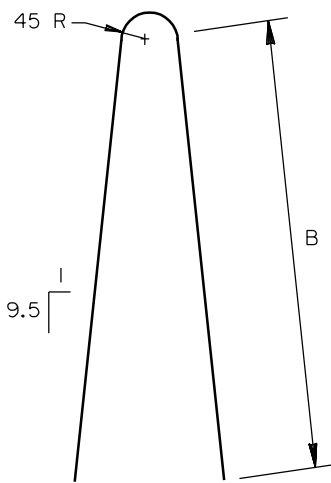
**NOTES:**

1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



**ANCHORAGE DETAIL**

**SECTION A-A**



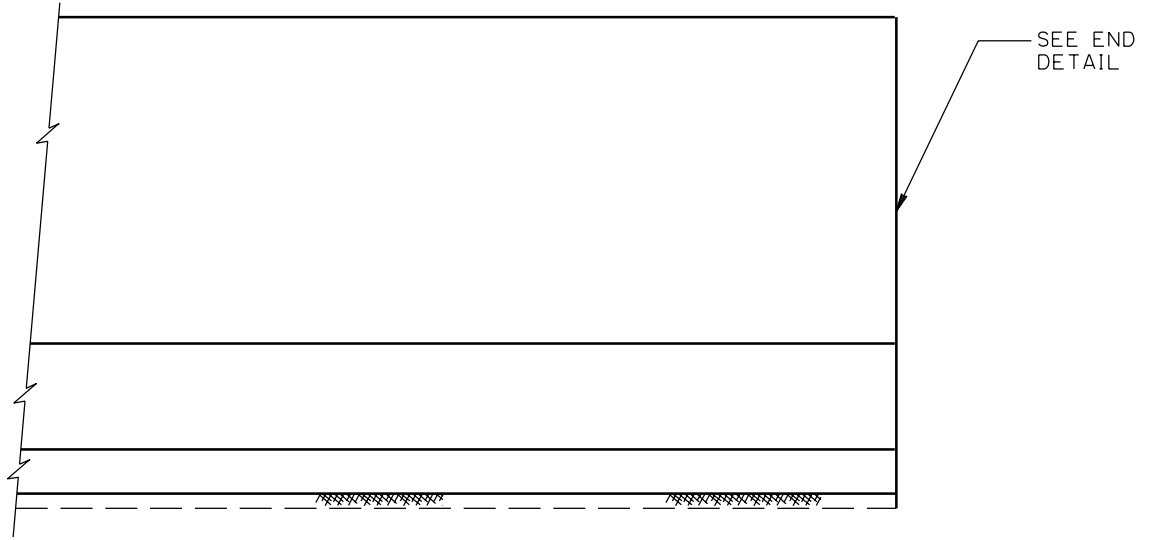
**BAR A (NO. 15)**

SYSTEM	B
N.J. SHAPE (PL-2)	910
N.J. SHAPE (PL-3)	1170

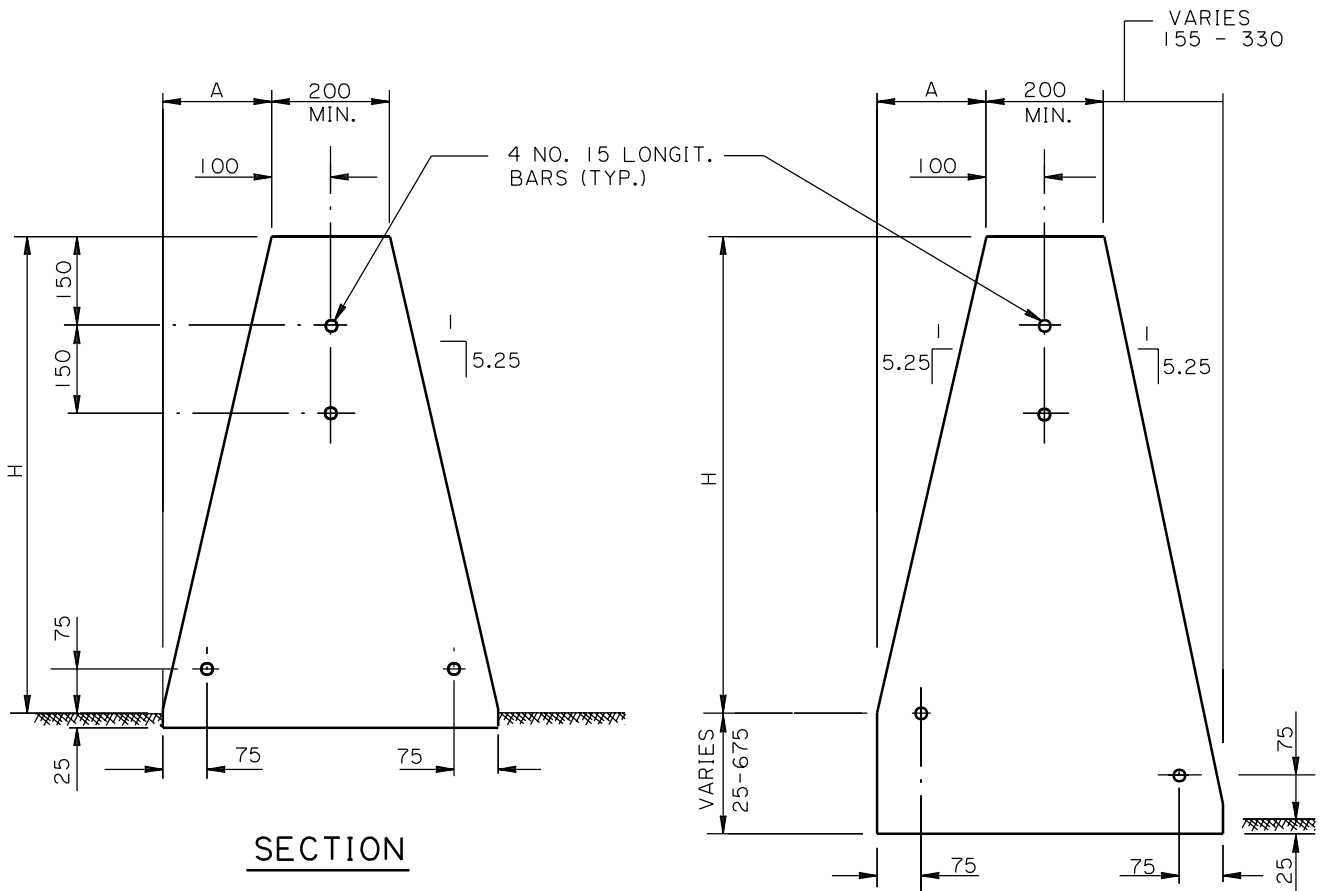
**SAFETY-SHAPE MEDIAN BARRIER**

**NOTES:**

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.



**ELEVATION**



**SECTION**

**SECTION**

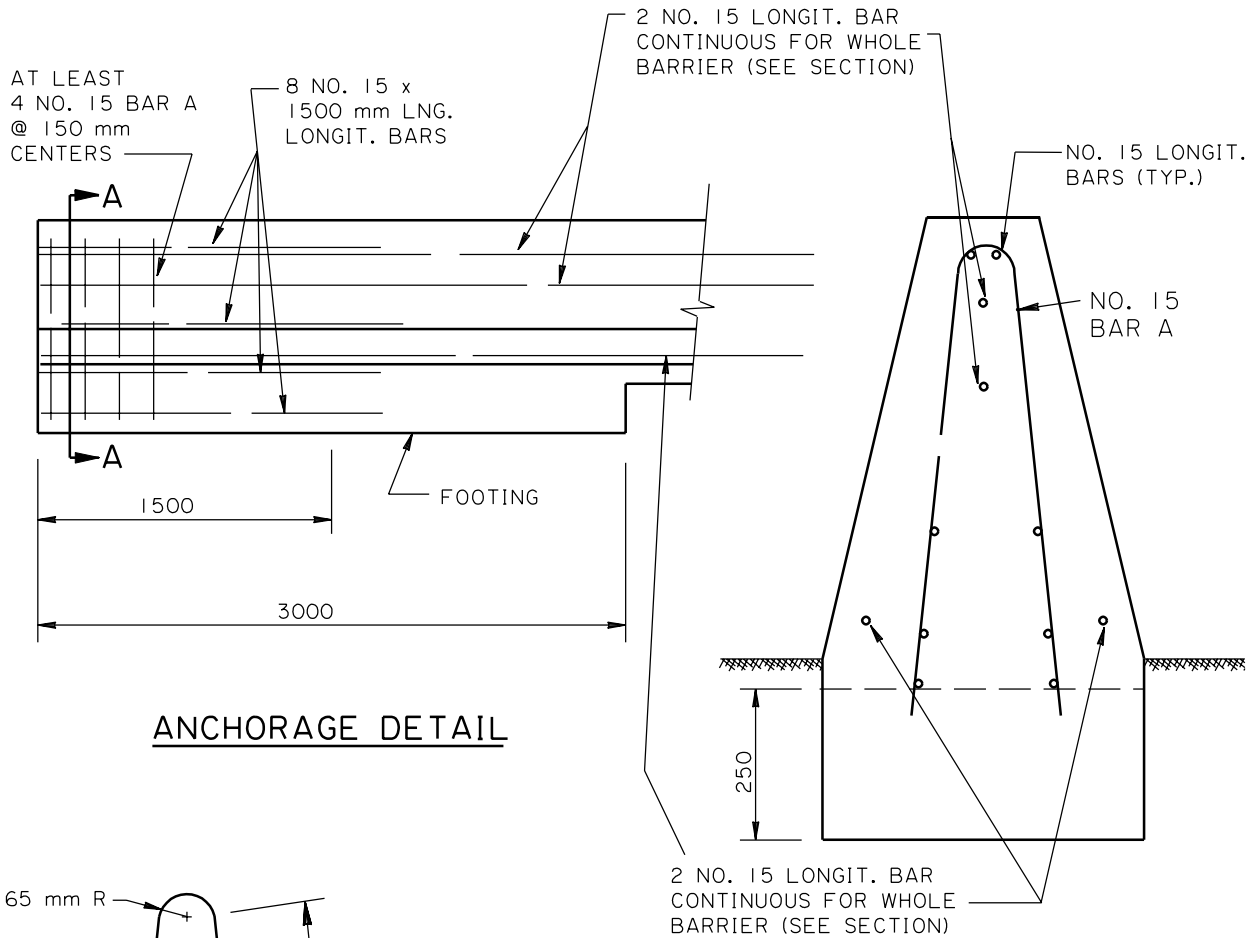
SYSTEM	A	H
SINGLE-FACE (PL-2)	155	810
SINGLE-FACE (PL-3)	205	1070

**SINGLE-FACE MEDIAN BARRIER**

I OF 2

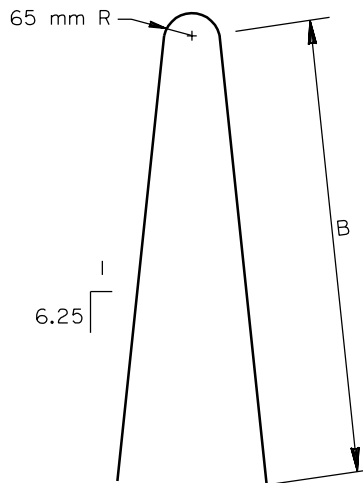
**NOTES:**

1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



**ANCHORAGE DETAIL**

**SECTION A-A**



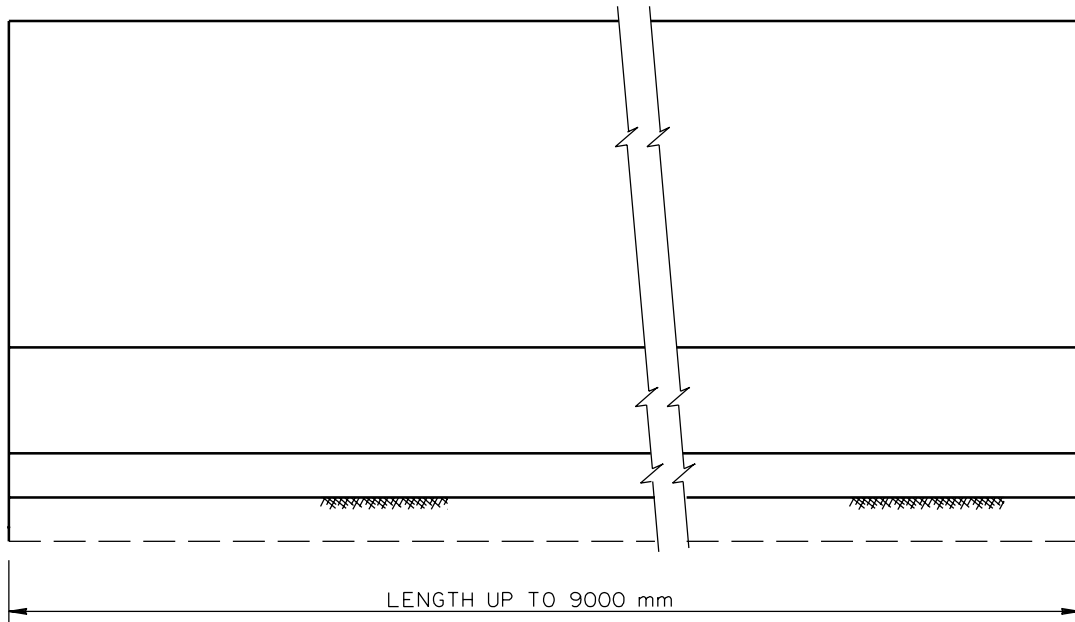
**BAR A (NO. 15)**

SYSTEM	B
SINGLE FACE (PL-2)	910
SINGLE FACE (PL-3)	1170

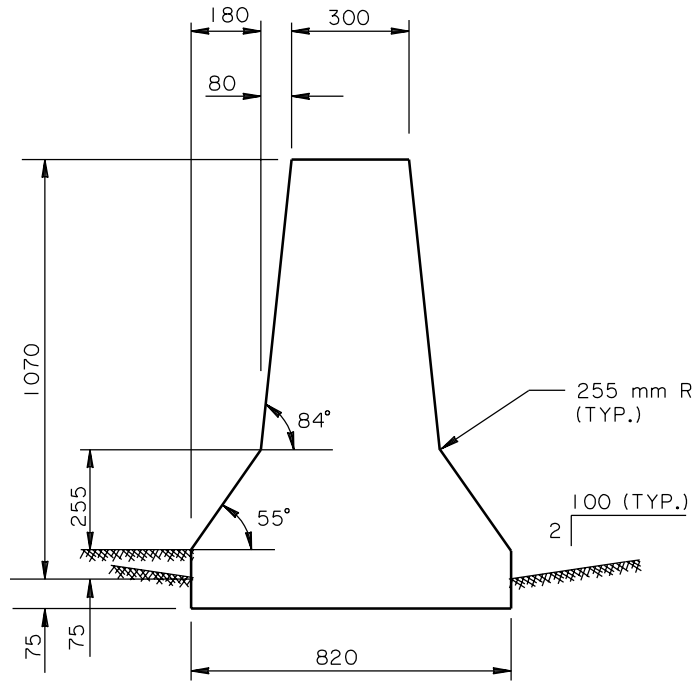
**SINGLE-FACE MEDIAN BARRIER**

**NOTES:**

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THIS BARRIER DOES USE REINFORCEMENT STEEL.
3. BARRIER RESTS DIRECTLY ON COMPACTED GRAVEL. 75 mm THICK PAVEMENT OR COMPACTED GRAVEL LAYER PROVIDES LATERAL SUPPORT TO THIS BARRIER.



**ELEVATION**

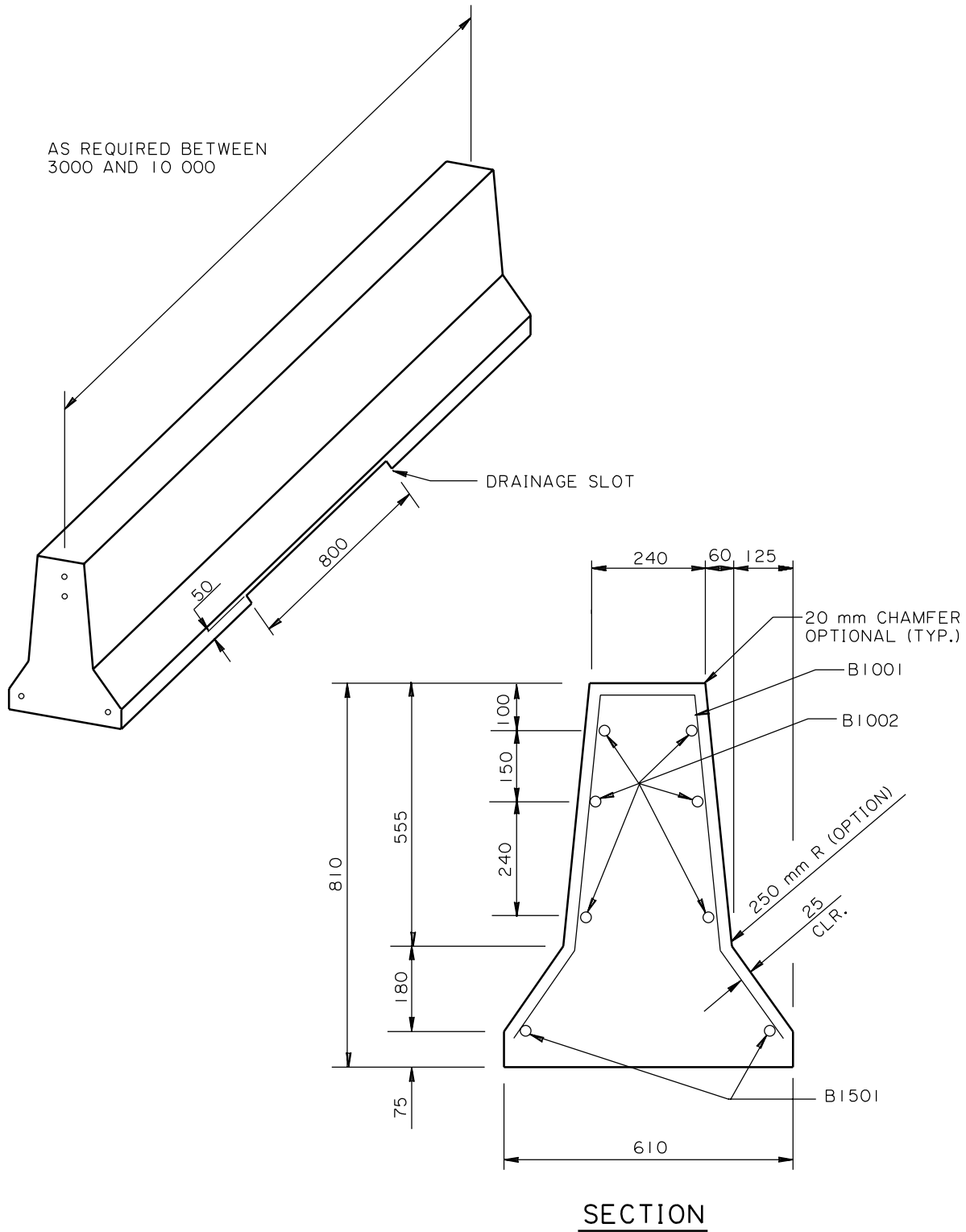


**SECTION**

**TALL-WALL MEDIAN BARRIER**

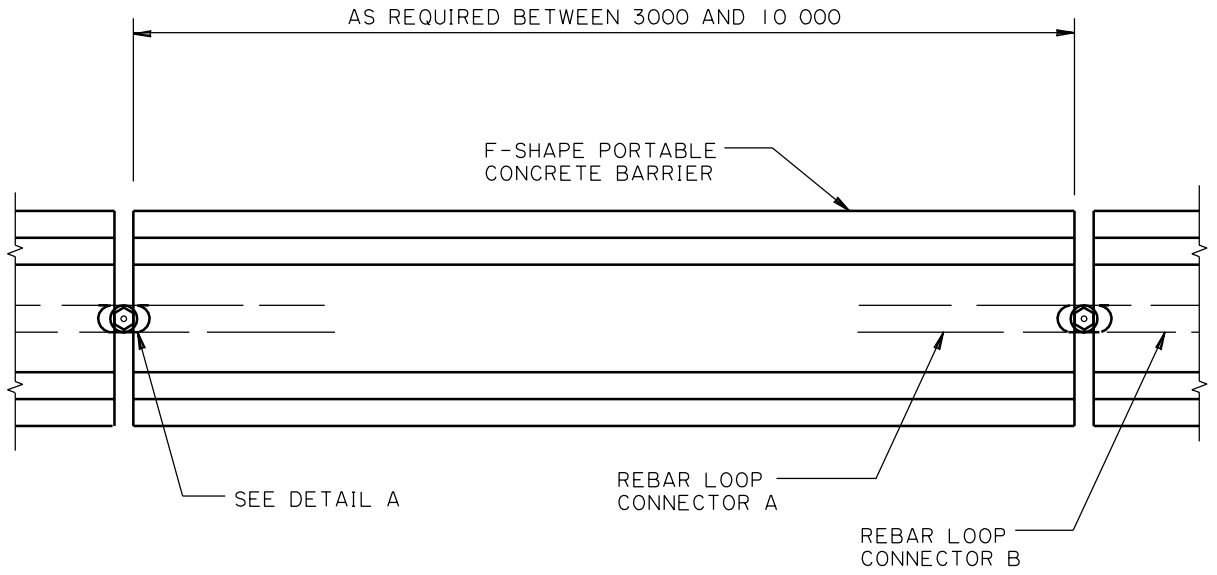
**NOTE:**

1. A CORNER RADIUS OF 25 mm IS PERMISSIBLE ON ALL EDGES UNLESS NOTED OTHERWISE.
2. EMBED A SUITABLE CONNECTOR INTO THE CONCRETE AT EACH END.

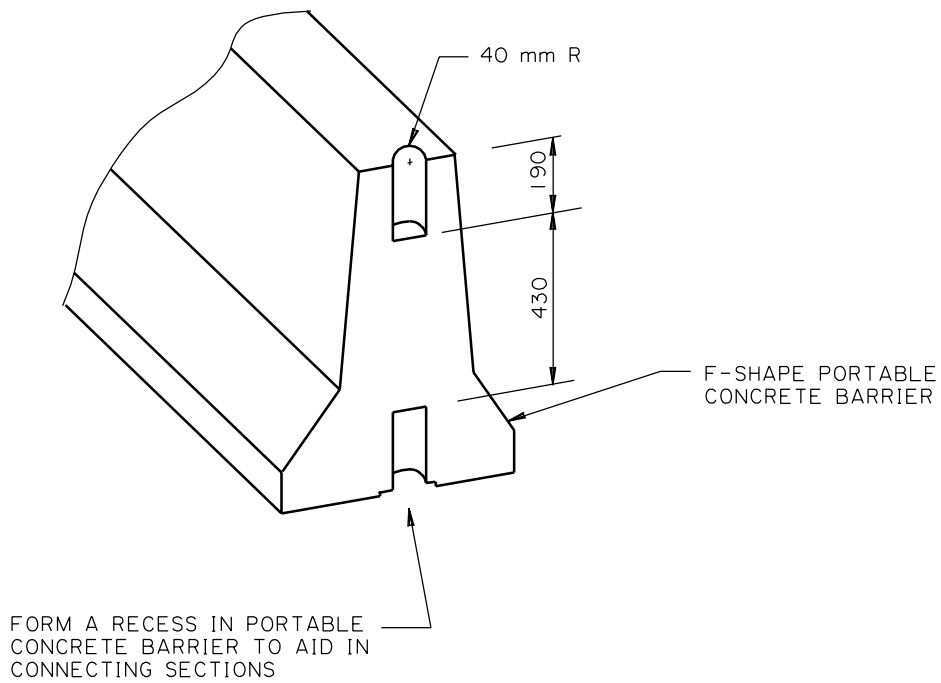


**F-SHAPE PORTABLE CONCRETE BARRIER**

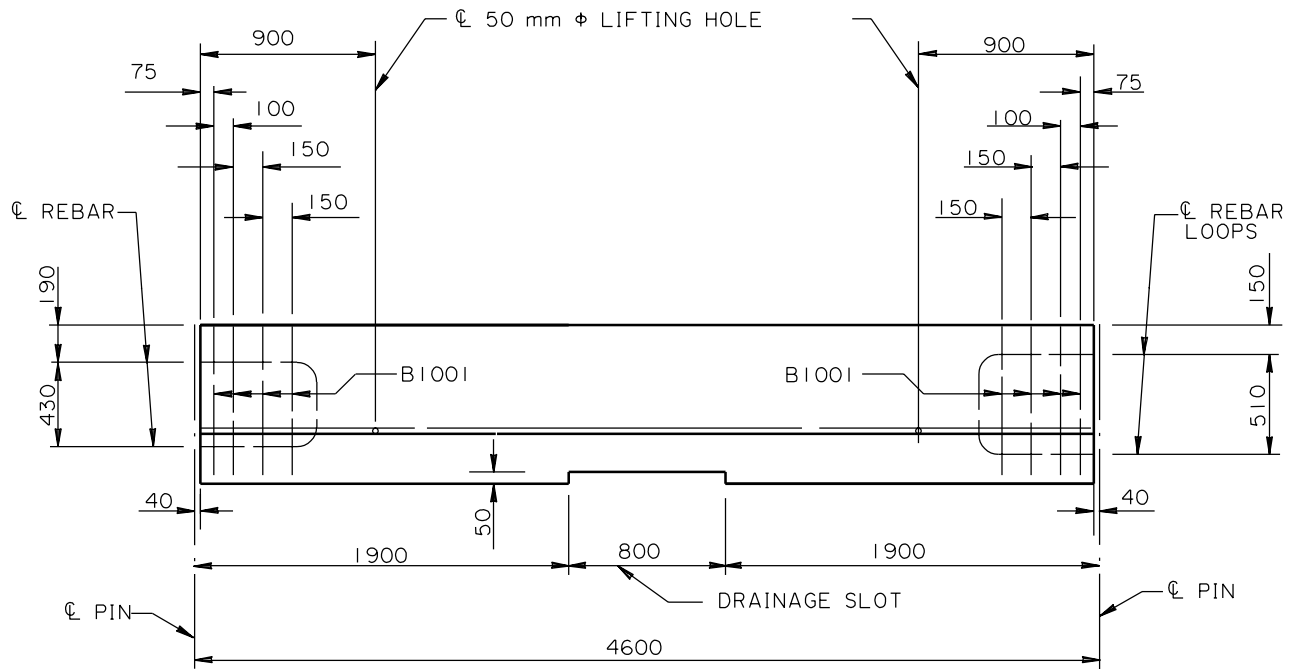
I OF 4



PLAN

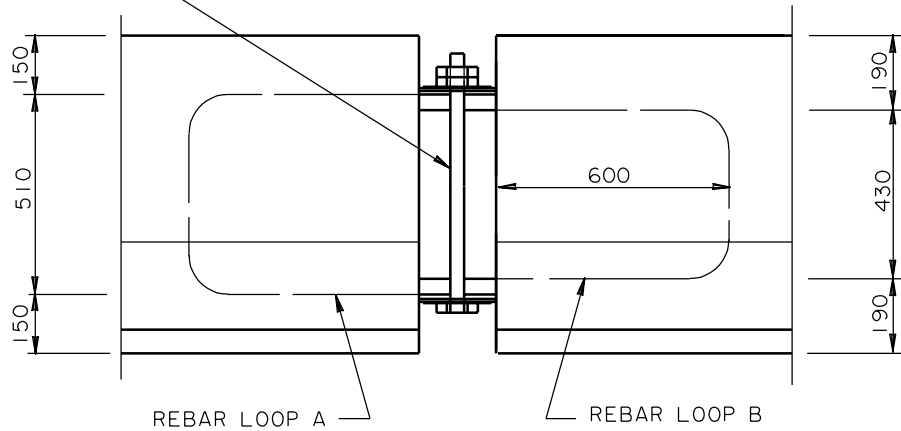


**F-SHAPE PORTABLE CONCRETE BARRIER**

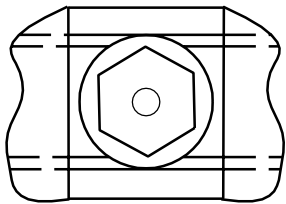


ELEVATION

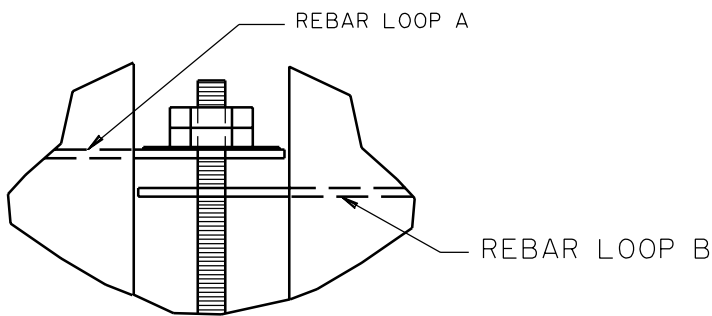
M30 x 650 mm STUD AND NUT  
W/WASHER AND EXTRA NUT AT  
EA. END



ELEVATION



PLAN



ELEVATION

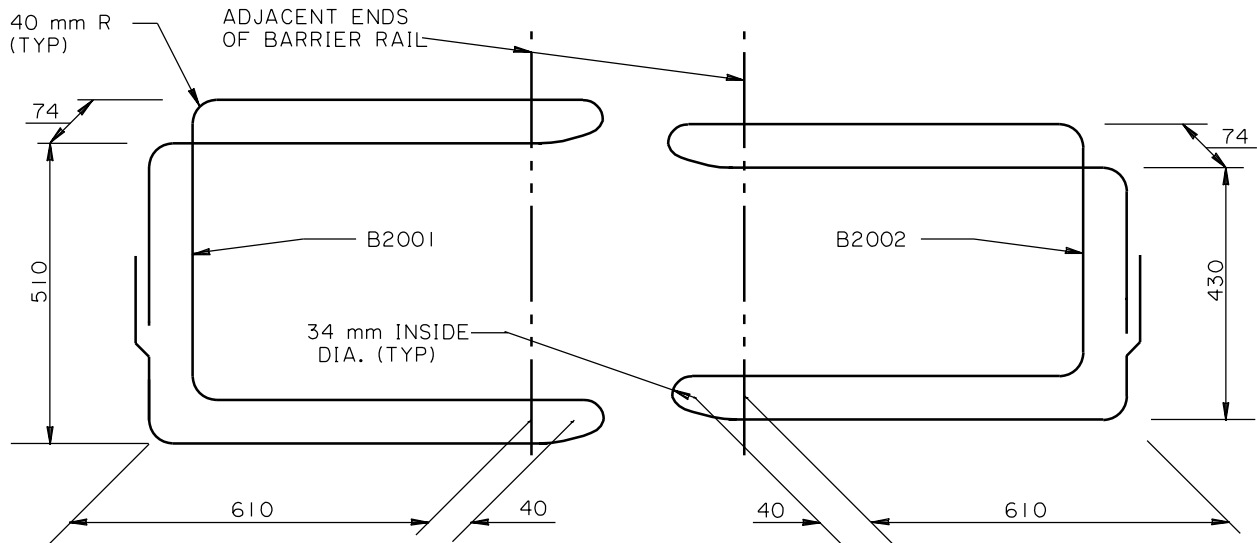
DETAIL A (CONNECTION)

**F-SHAPE PORTABLE CONCRETE  
BARRIER**



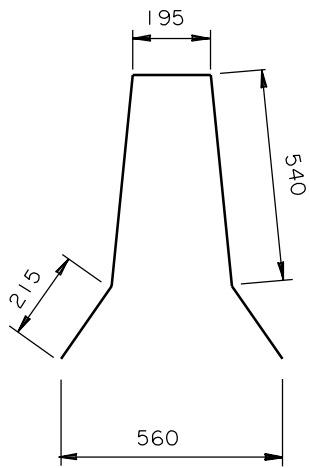
**NOTES:**

1. ALL REBAR DIMENSIONS ARE OUT-TO-OUT UNLESS NOTED OTHERWISE.
2. CONNECTOR MUST BE EMBEDDED INTO PORTABLE CONCRETE BARRIERS.



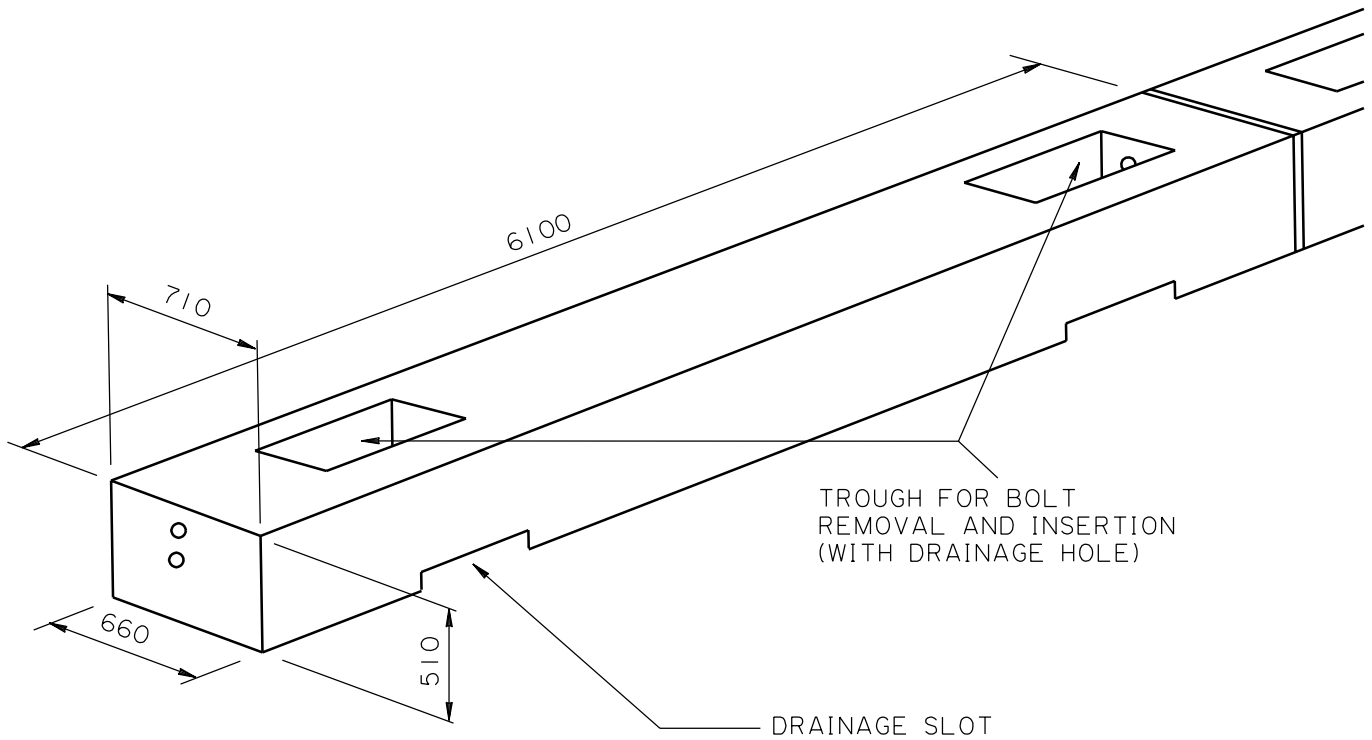
**REBAR LOOP A**  
(ISOMETRIC)

**REBAR LOOP B**  
(ISOMETRIC)

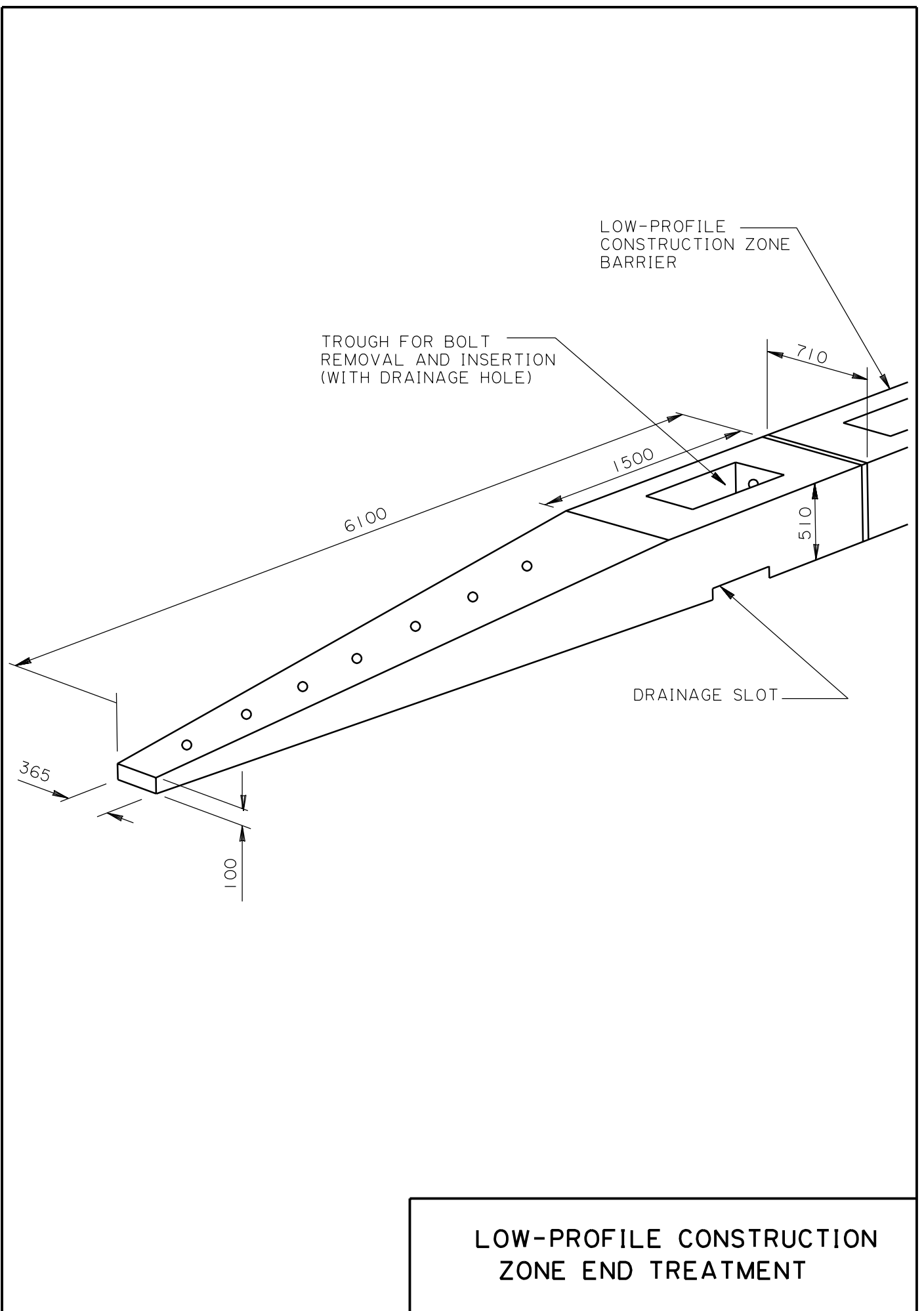


**B1001**

**F-SHAPE PORTABLE CONCRETE BARRIER**



LOW-PROFILE CONSTRUCTION  
ZONE BARRIER



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## MOVABLE BRIDGES

### INTRODUCTION

Movable bridges are sometimes required for navigable waterways, where high level bridges are economically unfeasible, particularly urban areas where high level structures would cause excessive relocations. Particular attention must be given to geometric requirements for marine traffic clearance, and the fitting of the bridges and approaches to the site. The Coast Guard should be involved early in the design process (*See Exhibit "B", Coordination with Other Agencies*)

When the economics of a movable bridge are being considered, long term maintenance costs, as well as initial construction costs should be considered. The current and projected opening frequencies for marine traffic should be carefully weighted against the vehicular traffic volume.

### SCOPE

This is a guide for the structural analysis and details involved in the plan preparation for movable bridges. It is also a guide for the economic comparison of a movable bridge to other alternatives. The AASHTO Specification for Movable Bridges is the base specification governing the analysis design of movable bridges.

#### On Selection Of Alternates

There are three basic bridge configurations to be considered at a navigable waterway crossing:

1. The low level movable bridge
2. The semi-high level movable bridge
3. The high level movable bridge

There are three basic types of movable bridges:

1. The vertical lift
2. The swing span
3. The bascule

Additional types of water crossings are the pontoon bridge and the ferry.

The economic factors in evaluating the alternative for crossing a waterway are extensive, and the data required satisfying a rigorous analysis is not readily available, or at least not easily quantified. However, reasonable estimates of this data often result in economic analyses which so heavily factor a particular alternate that significant errors in assumption will have little effect on the comparison.

High level fixed bridges are to be preferred unless the economics clearly indicate that a movable bridge would be significantly less expensive. Although lengthy approaches are required for high level bridges, they afford the following advantages: unrestricted flow of both marine and highway traffic, operators are not needed, less required maintenance, and lower susceptibility to marine collision. High levels of vehicular and marine traffic make the movable bridge alternate less tolerable.

Low level movable bridges provide for near grade crossing of highway traffic, with minimal bridge approaches. Every attempt should be made to provide sufficient clearance under the bridge to allow passage of 80% or more of all navigation, as well as all-small marine vessels, such as runabouts, without opening the bridge. These structures require complex electrical and mechanical equipment for operation of the span, along with operating personnel. Due to the closeness to the water, the probability of collision damage is greater than for a high level or semi-high level structure. Maintenance frequency and cost are relatively high compared to fixed bridges, as are the operating costs, which include electrical power and manpower.

Semi-high level movable bridges are difficult to justify economically because they incorporate the economic disadvantages of low level movable bridges, and, in part, the economic disadvantages of high level fixed bridges. Because they have long approach structures, the maintenance costs include those required for high level bridges, as well as those required for operating equipment. Semi-high level bridges do provide the advantage of passing most marine traffic without opening, which may justify placing an operator "on call" rather than requiring continuous operating status. However, potential damage to operating equipment and loss of operational integrity are factors which greatly increase repair cost compared to fixed structures with similar collision damage.

The traditional approach to bridge economics of comparing initial cost and choosing the least cost alternate to gain as many improvements as possible with the construction budget is not applicable when comparing fixed and movable structures. The significant long-term cost associated with operating and maintaining movable bridges impact operations and maintenance budgets in a way not associated with fixed structures, not to mention the inconvenience to the traveling public. Though these costs do not affect the current construction budget, they do affect future total budgets shared between maintenance, operations and construction. To account for this, the long-term costs should be incorporated over the life expectancy of the bridge alternates being considered. Economic analyses such as present-worth should be used with a typical life expectancy of 50 years.

Though economics are usually the most significant consideration, a particular site condition or service intent of a bridge may dictate a choice of an alternate other than the apparent most economical one. However, a rational economic analysis will give the Department and the public the needed knowledge of the additional cost required to satisfy any overriding peripheral issues controlling the choice of alternates.

### Analysis

Movable bridges are designed to sustain an intricate set of load conditions in addition to those for fixed bridges. These loads simulate wind, traffic and impact conditions under which the bridge must operate. Provisions for adjustment to balancing and for anticipated malfunctions are considered in the design and planning of a movable bridge, to minimize the probability of in-service structural or mechanical damage. Accordingly, certain structural design practices for movable bridges tend to be more conservative than those allowed in the specifications for fixed bridges. These practices are derived from engineering judgment and experience, and are intended to assure the long term durability and safety of such structures.

1. The moving elements of a movable bridge, including the supporting substructure, should be designed by the working stress methods.
2. A fifth load configuration and an additional group load shall be incorporated into the design of swing span bridges. The load configuration is:
  - a) "Case V: Unbroken Live Load - Bridge closed and considered as a continuous girder, but the live load placed so as not to cause negative reactions." <sup>1</sup>
  - b) An additional group loading combines Case I and Case V. This combination represents a malfunction condition where the wedges fail to drive and the span is operating under live load applied such that the ends bear on the rest piers.
3. The general policy of providing for an additional 600 N/m<sup>2</sup> for future wearing surface will not be incorporated into the design of movable (lift, swing, bascule) span structures. If resurfacing is required, the rehabilitated surface will match the original grade causing no additional weight or adjustments to the counterweight. The plans must indicate in the General Notes sheet that these structures have not been designed for future wearing surface.

### Design Details

1. Construction materials are strategically selected to achieve the most effective advantage in terms of strength, weight, and cost requirements. The deck (steel grid or concrete) of movable spans are chosen for light weight to minimize the

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<sup>1</sup> Movable Bridge, volume 1, O. E. Hovoy, John Wiley and Sons, Inc. 1926, pp. 191-192

counterweights, strength of supporting elements, and the power to operate the span. Where the deck contributes to the counterweighting of the span, such as for short arm of an unequal arm swing span, or the tail side of the trunion on a bascule span, heavier decks such as concrete are chosen.

2. Where machinery must be located under steel grid floors, the steel grid should be partially filled with concrete to provide shelter from the roadway debris and weather.
3. On swing span bridges, the top of the pivot pier cap should be at an elevation that will clear the design high water sufficiently to prevent the machinery from getting wet. The desirable value is usually 0.30 meters above the 50 year high water elevation. Any value less than this must be balanced between the competing constraints.
4. The area around the anchorage beams for the hydraulic arm attachment shall be poured monolithically with the cap.
5. The sag in swing spans caused by differential temperature in the flanges must not be incorporated in the stress, deflection, and camber requirements for the span. However, this sag component will be incorporated into the end lift reactions.
6. The erection and construction sequence for the main girders of the steel plate girder swing spans shall be completely outlined in the details for the swing span. This information is normally shown adjacent to the camber diagrams and should read as follows:

#### Erection Notes

THE CONTRACTOR WILL BE REQUIRED TO SUBMIT DETAILED ERECTION DRAWINGS SHOWING THE SEQUENCE OF ERECTION AND THE FALSEWORK TO BE USED. THIS INFORMATION MUST BE SUBMITTED TO THE BRIDGE DESIGN ENGINEER WITH SUFFICIENT TIME TO ALLOW FOR CHECKING, CORRECTIONS, AND APPROVAL PRIOR TO ERECTION OF THE SPAN.

THE FALSEWORK SHALL BE PILE SUPPORTED AT BOTH ENDS AND AT THE FIELD SPLICED LOCATIONS OF THE MAIN GIRDERS. IT MUST PROVIDE ADEQUATE RIGIDITY AND STRENGTH TO SUPPORT THE ERECTION POSITION AND LOADS REQUIRED. THE ERECTION POSITION OF THE MAIN GIRDERS SHALL BE REGULARLY CHECKED AND MAINTAINED DURING THE ERECTION PROCESS. THE FALSEWORK SHALL BE DESIGNED TO ACHIEVE THE FOLLOWING STAGES:

- A. THE MAIN GIRDERS SHALL BE ERECTED ON FALSEWORK SUPPORTING THEM IN THE POSITION OF THE CAMBER DIAGRAM.
- B. THE CONNECTIONS FOR THE MAIN GIRDERS (FIELD SPLICES), FLOOR BEAMS, STRINGERS, AND LATERAL BRACING SHALL BE COMPLETED.



C. MAIN GIRDERS SHALL BE ALLOWED TO DEFLECT TO A POSITION ABOVE THE FINISH GRADE POSITION, SUCH THAT ITS ORDINATES ARE NO CLOSER THAN 25% OF THE END LIFT DEFLECTION ORDINATES ABOVE THE FINISH GRADE ORDINATES (WEDGES DRIVEN). IF THE MAIN GIRDERS DO NOT DEFLECT ENOUGH TO MAKE CONTACT WITH THE FALSEWORK, WHEN PROPERLY ADJUSTED FOR THIS POSITION, SHIMS SHALL BE ADDED TO PROVIDE FULL SUPPORT IN THE DEFLECTED POSITION.

D. THE COUNTERWEIGHT SHALL BE POURED AND THE GRID DECK PLACED IN POSITION BUT NOT WELDED TO THE STRINGERS.

E. THE MAIN GIRDERS SHALL BE ALLOWED TO DEFLECT TO THE FINISH GRADE ORDINATES WITH THE END LIFTED.

F. THE CONCRETE DECK SHALL BE PLACED AND THE BRIDGE RAILING CONNECTIONS COMPLETED, ASSURING THAT THE ENDS OF THE SPAN WILL NOT DEFLECT BELOW FINISH GRADE. THE GRID DECK SHALL BE WELDED TO THE STRINGERS.

G. UPON COMPLETION OF THE ERECTION OF THE MAIN SPAN (INCLUDING INSTALLATION OF THE BALANCE WHEELS, THE PLACEMENT OF THE ESTIMATED NUMBER OF BALANCE BLOCKS ON THE COUNTERWEIGHTS NECESSARY TO BALANCE THE SPAN, PUMP, AND ROLLERS), THE SUPPORTING FALSE WORK SHALL BE REMOVED.

H. THE FREE SWINGING SPAN SHALL BE PRECISELY BALANCED AND THE ORDINATES MEASURED IN THE MORNING PRIOR TO SUNRISE TO AVOID TEMPERATURE EFFECTS. THE ORDINATES SHALL BE COMPARED TO THE FINISH GRADE ORDINATES, WITH THE ENDS NOT LIFTED. THE ROLLER BASE ELEVATIONS SHALL BE SET TO PRODUCE THE END LIFT DEFLECTION OF THE SPAN AT CONSTANT TEMPERATURE.

I. THE HORIZONTAL BASE LINE SHALL BE ROTATED WHILE THE SPAN IS FREE SWINGING TO PROVIDE FOR EQUAL END LIFTS WITH DESIGN TEMPERATURE DEFLECTION. THE BALANCE WHEELS SHALL BE ADJUSTED TO CLEAR THE TRACK BY NOT MORE THAN 0.8 mm WHILE THE SPAN IS IN THIS POSITION.

J. THE ROLLER BASE RISERS AND RISER WALLS ON THE REST PIERS SHALL BE PLACED AND THE ROLLER BASES INSTALLED. CHECK THE END LIFT SYSTEM TO ENSURE ITS ABILITY TO LIFT TO THE FINAL ORDINATES WITHOUT EXCEEDING THE DESIGN PRESSURE.

K. THE APPROACH SPANS ADJACENT TO THE MAIN SPAN SHALL BE PLACED WITH FINISH GRADE AND END DAMS ADJUSTED AS REQUIRED TO MATCH THE COMPLETED MAIN SPAN WITH ENDS LIFTED.

#### COUNTERWEIGHTS:

THE CONTRACTOR WILL BE REQUIRED TO MAKE THREE (3) TEST BLOCKS IN THE PRESENCE OF THE ENGINEER, AS REQUIRED BY THE STANDARD SPECIFICATIONS. THE ENGINEER WILL BE NOTIFIED OF THE TIME AND PLACE THAT THE TEST BLOCKS ARE TO BE MADE. THE RESULTS OF THE TEST BLOCKS ALONG WITH THE COUNTERWEIGHT CALCULATIONS MUST BE SUBMITTED TO THE BRIDGE DESIGN ENGINEER, WITH SUFFICIENT TIME ALLOWED FOR CHECKING, CORRECTIONS, AND APPROVAL PRIOR TO ERECTION OF THE SPAN."

## Special Requirements

1. The Department has a special way of presenting the mechanical and electrical drawing for movable bridges. This format must be followed on all projects, whether the plans are prepared in-house or by consultant engineers.
2. The operating house should be located with primary consideration for good visibility of the roadway, traffic gates, and the navigation channel. There not being any advantage to visibility, other criteria in order of importance are location of existing utilities and accessibility in open position on long arm (bobtail swing) downstream side. The designer should have the District Maintenance Engineer visit the site of the proposed bridge to recommend the location of the operating house. This is especially important when the alignment crosses a bend of the waterway.
3. The floor elevation of the operating house shall permit the standing operator to have a blind area of waterway 18 m, but no more than 30 m beyond the fascia of the bridge. This will require the floor elevation to be governed by the width of the structure.
4. When detailing the safety railing leading to the operators' house, it should be brought as close to the bridge rail as possible. The safety rail shall be continuous from the bridge to the house, so as to avoid any unsafe openings.
5. The access from the deck to the top of the pivot pier must be provided when the deck is in the open as well as closed positions. Platforms for the landings shall be provided with safety rails long enough to avoid accidents. Additionally, platforms for inspection and working areas of traffic gates, traffic barriers, and end lifts (swing spans) shall have safety rails as described above.
6. Access shall also be provided from the deck to the top of the rest piers. A platform may be required on the backside of the rest pier wall with a passageway through the wall, in order to provide adequate access. The designer should consult with the Bridge Maintenance Section in determining inspection requirements.
7. Traffic gates are located and striped in accordance with "Manual of Uniform Traffic Control Devices for Streets and Highways" (MUTCD) published by the Federal Highway Administration (see section in the manual on "List of Specifications . . . .Bridges"). When not installed on structures, traffic gates are normally located 1.8 m from the edge of roadway or 0.6 m from the outer edge of a sidewalk when present. Traffic gates are normally located 50 m in advance of the movable span or its barrier, if present. Consideration must also be given to the visibility of the gates to the motorists when establishing their actual location.

8. Traffic warning signals are located and painted in accordance with MUTCD. When not installed on structures, they are normally located 1.8 m from the edge of roadways or 0.6 m from the outer edge of the sidewalk when present. Signals are normally located 15 m in advance of the traffic gates, and should not be placed behind the guardrail BCT. Additionally, curbs should not be used in front of the guardrail. Consideration must be given to the visibility of the signals to the motorists in establishing their actual location.
9. Navigation lights for bridges crossing navigable inland waterways controlled by the U.S. Coast Guard must be in conformance with their established rules. Consult the "Aids to Navigation" Manual published by the Coast Guard to locate navigation lights when required. Examples are given therein for different types of bridges, which must be followed. A sketch on letter-size paper, with a location map, elevation and plan view of the proposed bridge with navigation lights located and shown in the proper color, must be sent to the appropriate Coast Guard District for approval. If the bridge is not over a navigable waterway controlled by the Coast Guard, it must be determined if any local rules apply. If not, the navigation lights are installed according to the directions of the District Administrator.
10. Aerial beacons for structures that are controlled by the U.S. Department of Transportation, Federal Aviation Administration. Consult the "Obstruction Marking and Lighting" Manual published by the agency for regulations concerning height and location of proposed construction and need for aerial beacons. If the proposed construction appears to require aerial beacons or other obstruction markings, Federal Aviation Administration Form No. 7460-1 should be prepared along with a location map, elevation and plan views showing lights and/or markings, then sent to the FAA for comment and/or approval.
11. Submarine cables require a permit from the Coast Guard before work can begin. The Department obtains this permit from the Coast Guard before the work is started during the plan preparation phase. The permit request requires a sketch on letter-size paper showing the geographic locations, elevation and plan views of the proposed bridge with the submarine cable shown in red. This permit request is sent to the proper Coast Guard District for approval. It may be combined with the navigation light permit showing all information on the same sketch. A permit sketch is also necessary for adding or removing submarine cables on repair jobs. (consult the manual, "Aids to Navigation" published by the Coast Guard for complete information for permit applications)
12. The motor for the span is specified by the Electrical Engineering Unit with the torque, rpm, and size requirements provided by the Mechanical Engineering Unit. The latter specifies both size and type of smaller motors such as the barrier motor.

13. The operating house shall contain within it the switchboard, control desk, auxiliary electrical panels, lighting, receptacles, heating/cooling unit, office type desk and chair. In some instances it shall also contain one or all of the following: bathroom facilities, sewage treatment facility, central heating and air-conditioning, baseboard heating and emergency generator. Depending upon the equipment to be installed the operating house can be single story or two story with the lower deck either enclosed or open. The designer shall obtain information from the Bridge Maintenance and Electrical Design Units.

DISTRIBUTION OF PR

W/SE

REF

L SEC

(22)

2

(ESTATE)

01/31/2000

## DISTRIBUTION OF PRINTS BY BRIDGE DESIGN SECTION (CON'T.)

PURPOSE (DIRECT LETTER TO:)	NO. OF SETS	FOR	SHEETS NEEDED	REMARKS	
(16)  FINAL UNCHECKED PLANS (IN-HOUSE DESIGN)  ADVANCE CHECK PRINTS (CONSULTANT DESIGN)  (CONTRACTS AND SPECIFICATIONS)	1	CONTRACTS & SPECIFICATIONS	FULL SET & CROSS-SECTIONS	ONLY IF FEDERAL NHS PLANS	
	1	PROJECT ENGINEER			
	1	CONSTRUCTION SECTION (HEADQTRS)			
	1	FHWA			
	1	CONTRACTS MANAGEMENT	TITLE SHEET ONLY	FULL SET	ONLY IF ROAD WORK REQUIRED
	1	DISTRICT UTILITY REPRESENTATIVE			
	1	GEOTECHNICAL ENGINEER			
	1	TRAFFIC SERVICES			
	1	ROAD DESIGN SECTION			
	1	GEOMETRICS SECTION			
	1	MAINTENANCE SECTION (HEADQTRS)			
	1	UTILITY UNIT			
	1	PUBLIC HEARING & ENVIRONMENTAL IMPACT SECTION	ONLY FOR R/R CROSSINGS		
	1	REAL ESTATE			
1	CONSULTANT	IF ROAD AND/OR BRIDGE PLANS PREPARED BY CONSULTANT			
1	DISTRICT CONSTRUCTION ENGINEER				
P. S. & E. (1) (CONTRACTS AND SPECIFICATIONS)	1	CONTRACTS AND SPECIFICATIONS SECTION	FINAL MATTED PLANS SPECIFICATIONS AND ESTIMATE		
(1)  GENERAL FILES	1	GENERAL FILES	FINAL SIGNED MATTED PLANS	COPY OF LETTER TO:  REAL ESTATE, LOCATION & SURVEY, UTILITY, DISTRICT ADMINISTRATOR, DISTRICT CONSTRUCTION ENGINEER, ROAD DESIGN ENGINEER, PARISH OR CITY GOVERNMENT AGENCY. PRINTS ARE FURNISHED ON REQUEST BY GENERAL FILES.	
(32)  PLAN CHANGE  (CONSTRUCTION)	1	PROJECT ENGINEER	TITLE SHEET & REVISED SHEETS	NHS FUNDING ONLY ONLY IF R/W CHANGED IF APPLICABLE IF APPLICABLE	
	18	CONSTRUCTION SECTION			
	1	FHWA			
	10	REAL ESTATE			
	1	UTILITY			
1	DISTRICT UTILITY				

☒ ALL SETS SHALL BE HALF-SIZED, EXCEPT FOR THOSE WHICH ARE SENT TO REAL ESTATE & UTILITY, WHICH WILL BE FULL-SIZED.

## Geotechnical Analysis

### GENERAL:

Normally, the location, number, and depth of soil borings will be recommended by the Geotechnical Design Section. The boring request form on the page 19 shall be used to order borings, and consolidation tests through our Pavement and Geotechnical Design Section. If slope stability analysis is needed this should also be discussed and requested at this time.

For borings done in-house, three (3) sets of plans with the information described in items "1 through 6" listed below should be transmitted to our Pavement and Geotechnical Design Section. Upon receipt of this information, the Pavement and Geotechnical Design Section will order the boring logs & any additional soil information as deemed necessary for the project, including a fill height recommendation.

Some Consultant contracts require the Engineer to furnish the boring logs and test reports. For those contracts, items "1 through 6" listed below are to be submitted to the Department for approval prior to obtaining borings.

There will be some projects in which sufficient existing foundation information is available, thus eliminating the need for additional borings and foundation studies. It will be the responsibility of the Project Coordinator to request this information in writing.

Boring logs shall be included in the plan-in-hand drawings. However, in some cases, when they are not available, plan-in-hand field inspections may be made without boring logs. The boring logs shall be required as a part of the preliminary bridge plans in final form. Correlation of boring logs to actual elevation will be required and will be the responsibility of the Engineer.

The Engineer is to obtain approval from the Department for all foundation (roadway and bridge) design criteria to be used on any project, prior to submittal of preliminary plans. This will include foundation types and lengths (footings, piers, piles, drilled shafts, etc.), pile supported approach slabs, fill heights, retaining wall and sheet pile wall types and consolidation criteria (surcharge, wick drains, etc.)

Foundation studies can change structures from culverts to bridges or vice-versa. Also, the type of substructure and superstructure can be changed by these foundation studies.

Preliminary plans will show controlling fill heights as determined by or approved by the Department.

A foundation report may be required in special cases. The extent of bridge foundation studies, embankment studies, and format for the soil report is to be approved by the Department. This work should be completed and approved prior to submittal of preliminary bridge plans in plan-in-hand form.





Boring Request Form

(one boring request form per site)

**PROJECT INFORMATION**

Construction No. \_\_\_\_\_ Engineering No. \_\_\_\_\_  
 Project Name \_\_\_\_\_  
 FAP No. \_\_\_\_\_ Structure No. \_\_\_\_\_  
 Route No. \_\_\_\_\_ Parish \_\_\_\_\_  
 Letting Date \_\_\_\_\_ Project Alignment  New  Old  
 Prelim. Plans Date \_\_\_\_\_ Project Units  English  Metric

**STRUCTURAL INFORMATION**

- Bridge Length \_\_\_\_\_ Pile Type & Size \_\_\_\_\_ Pile load \_\_\_\_\_  
 Abut. max. Fill Ht. (Beg. Bridge) \_\_\_\_\_ (End Bridge) \_\_\_\_\_ Crown Width \_\_\_\_\_  
 Projected Scour Elevation \_\_\_\_\_  
 Are Old Borings From This Site or Adjacent Sites Available?  Yes  No  
 If Yes, Please Provide Copies and The Project Number.  
 - Any Roadway Embankment?  Yes  No If yes, complete the following information.  
 New Embankment or  Widening Height Range \_\_\_\_\_  
 Beg. Station \_\_\_\_\_ End Station \_\_\_\_\_  
 - Are there any walls?  Yes  No If yes, complete the following information.  
 Type Wall \_\_\_\_\_ Beg. Station \_\_\_\_\_ End Station \_\_\_\_\_  
 Wall Height Range: \_\_\_\_\_  
 Are Cross-Sections Available?  Yes  No If Yes, please provide copies.  
 Comments: \_\_\_\_\_

Structural Info. Completed by \_\_\_\_\_ Date \_\_\_\_\_

**FIELD & LABORATORY REQUEST**

(to be completed by the Pavement and Geotechnical Design Section)

Total No. Borings Requested \_\_\_\_\_

Sampling Frequency Boring No.(s)

Standard \_\_\_\_\_

Continuous \_\_\_\_\_

Boring Depth(s) \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Water Table \_\_\_\_\_

Consolidation Testing \_\_\_\_\_

	<u>Boring No.(s)</u>	<u>Sieve</u>	<u>Hydrometer</u>	<u>Depth</u>
<input type="checkbox"/> Grain Size	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____
	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____
	_____	<input type="checkbox"/>	<input type="checkbox"/>	_____

COMMENTS: \_\_\_\_\_

Field & Lab. Request Completed by \_\_\_\_\_ Date \_\_\_\_\_

- ☞ NOTES: Required Attachments
- ➡ 4 copies of general plan(s) (or field roll) & location map(s)

Rev. 08-12-98

Preliminary Plan Payment Milestones Table

PAYMENT MILESTONE	TASKS	BRIDGE	COMMON	ROAD
30 % Distribution	Completed	<ol style="list-style-type: none"> <li>1. Bridge hydraulic study and scour analysis</li> <li>2. Type, Size &amp; Location of Structure set</li> <li>3. Deep Borings</li> </ol>	<ol style="list-style-type: none"> <li>1. Pre-design criteria established</li> <li>2. Horizontal &amp; vertical alignment set</li> </ol>	<ol style="list-style-type: none"> <li>1. Plan/profile sheets with existing topo</li> <li>2. Preliminary typical sections submitted for review</li> <li>3. Title Sheet</li> <li>4. Typical Section questionnaire distributed</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Superelevation diagram</li> <li>2. Economic study (if appropriate)</li> </ol>		<ol style="list-style-type: none"> <li>1. Preliminary typical sections being reviewed</li> <li>2. Pavement Design</li> <li>3. Soil borings and pH/resistivity data</li> <li>4. Capacity analysis</li> </ol>
60% Distribution	Completed	<ol style="list-style-type: none"> <li>1. Preliminary design of substructure &amp; superstructure</li> <li>2. Foundation analysis</li> <li>3. General Plan</li> <li>4. Typical bridge sections</li> </ol>		<ol style="list-style-type: none"> <li>1. Horizontal/vertical alignment on plan/profile sheets</li> <li>2. Geometric details submitted for review</li> <li>3. Hydraulic design submitted for review</li> <li>4. Cross sections and required right of way</li> <li>5. Final typical section</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Span and bent details</li> <li>2. Foundation layout</li> <li>3. Framing plan</li> </ol>	<ol style="list-style-type: none"> <li>1. Sequence of construction &amp; and construction signing</li> </ol>	<ol style="list-style-type: none"> <li>1. Earthwork computations</li> <li>2. Construction notes &amp; details</li> </ol>
90 % Distribution	Completed	<ol style="list-style-type: none"> <li>1. Bridge quantities and general notes</li> </ol>	<ol style="list-style-type: none"> <li>1. Assemble plans</li> <li>2. Cost estimate</li> </ol>	<ol style="list-style-type: none"> <li>1. Geometric and hydraulic comments incorporated</li> <li>2. Pre-plan in hand review</li> </ol>
	In Progress		<ol style="list-style-type: none"> <li>1. Pre-plan-in-hand review</li> </ol>	
95 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Plan-in-hand prints distributed</li> </ol>	
100 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Plan-in-hand inspection and comments addressed</li> <li>2. Right of way taking lines set and transmitted to Location and Survey</li> <li>3. Permit sketches</li> <li>4. Revise cost estimate</li> </ol>	

## **FINAL PLANS**

### General

1. For consultant projects the engineer shall become familiar with the requirements

3. The General Index to all plans may be placed on the title sheet provided the index is not complex.
4. The index should be complete for ease of plan use.

#### GENERAL NOTES

1. General notes for the design and construction of all structures shall be combined into one sheet. There is usually a need for additional notes to be placed on structural detail drawings. A standard general note sheet is available through the Bridge Design Section, however modifications may be required to suit the particular project.
2. The General Notes should include the following: AASHTO design specifications under which the bridge structures are designed; the construction specifications under which the bridge structures are to be constructed; highway design speed, live load design vehicles, concrete instructions, reinforcing steel, welding structural metalwork, pile instructions, erection and construction procedures, etc.; all design criteria not specifically covered by the AASHTO design specifications, and any instructions considered necessary for the proper construction of the bridge structure.

#### SUMMARY OF BRIDGE QUANTITIES

1. The "Summary of Bridge Quantities" is a master summary for all bridge quantities. It shall include item numbers, item descriptions, units of measure, quantities for each item, sub-total quantities for each bridge and grand total for all bridge structures.
2. The grand total for each item from the "Summary of Bridge Quantities" must be included in the Master Summary of Estimated Quantities for the contract plans.

commercial equipment and apparatus. Furnish complete design of electrical and illumination systems and of all components. Since the Department has its own method of presenting the wiring diagrams, the Engineer should become familiar with the detail practice of the Bridge Design Section prior to beginning any work.

2. The plan shall include complete power and control elementary wiring diagrams with all conductors and equipment and apparatus identified; complete conduit and wire layout; detail drawings and equipment list.
3. When necessary, written special provisions shall be supplied.
4. The Engineer shall be responsible for obtaining written confirmation from the utility company as to their ability to supply proposed load.

#### PERMANENT SIGNING PLANS

1. For projects requiring permanent signing, separate detail sheets showing the signing layout, signing quantities and specific signing details are required. The permanent signing is normally coordinated through our Geometric Design Section.
2. Permanent signing standard details are maintained by the Bridge Design Section. These details include small ground signs (breakaway) and large overhead signs. Structure mounted special support details (bridge, median barrier, retaining wall, etc.) for large overhead signs are not shown on the standard sign details; these must be designed and detailed on an individual basis for each specific sign when required.

#### Bridge Plans In Final Form (A.C.P.'s submittal procedure)

1. The Engineer shall submit "reproducibles" of the "Advance Check Prints" (95% Final Plans) along with any required special provisions and a construction cost estimate for review and comments. Each sheet must be stamped by a Civil Engineer registered by the State of Louisiana.
2. The plans, specifications, and estimates are to be reviewed by the Department of Transportation and Development and others that may be involved such as the Federal Highway Administration, etc. The Department will advise the Engineer of all comments, errors and omissions relative to the plans, specifications, and estimate; which shall be revised and/or corrected by the Engineer. Please be advised that this is only a cursory check and the Engineer is responsible for the accuracy and completeness of the plans.
3. The Engineers are to work closely with the Department in order that the final plans, specifications and estimates may be completed and ready for the proposed contract letting date.

Final Plan Payment Milestones Table

PAYMENT MILESTONE	TASKS	BRIDGE	COMMON	ROAD
30 % Distribution	Completed	<ol style="list-style-type: none"> <li>1. General plan</li> <li>2. Framing plan</li> <li>3. Superstructure design</li> </ol>		<ol style="list-style-type: none"> <li>1. Submit final typical sections for review &amp; approval</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Foundation layout</li> <li>2. Lighting and signing design</li> <li>3. Superstructure details</li> <li>4. Substructure design</li> </ol>		<ol style="list-style-type: none"> <li>1. Review R/W maps</li> <li>2. Finalizing hydraulic design</li> <li>3. Finalizing vertical &amp; horizontal geometry</li> <li>4. Finalizing construction notes</li> </ol>
60% Distribution	Completed	<ol style="list-style-type: none"> <li>1. Superstructure details</li> <li>2. Substructure design</li> <li>3. Foundation layout</li> <li>4. Lighting and signing design</li> </ol>	<ol style="list-style-type: none"> <li>1. Submit for sequence of construction and construction signing review</li> </ol>	<ol style="list-style-type: none"> <li>1. Submit for final drainage</li> </ol>
	In Progress	<ol style="list-style-type: none"> <li>1. Substructure details</li> <li>2. General notes</li> <li>3. Summary of quantities</li> </ol>		<ol style="list-style-type: none"> <li>1. Summary sheets</li> <li>2. Joint Layouts</li> <li>3. Graphical grades</li> </ol>
90 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Pre-ACP submitted for review prior to distribution</li> </ol>	
95 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. Advance Check Print distribution</li> <li>2. Cost estimate</li> </ol>	
	In Progress		<ol style="list-style-type: none"> <li>1. Special Provisions</li> </ol>	
98 % Distribution	Completed		<ol style="list-style-type: none"> <li>1. ACP comments addressed</li> <li>2. Final cost estimate</li> <li>3. Entire set of original plan sheets transmitted to Contracts Unit</li> <li>4. Special provisions</li> </ol>	
100 %	Completed		<ol style="list-style-type: none"> <li>1. Plans, Specifications &amp; Estimate</li> <li>2. Plans &amp; Estimate transmitted to General Files</li> </ol>	

## **TYPICAL ORDER FOR BRIDGE PLAN SHEETS**

Plan sheets shall be organized to facilitate construction. Shown below is an example for a moderate size project.

1. General Notes, Summary of Quantities and Bridge Index
2. General Plan
3. Superelevation Transition Detail
4. Detour Layout
5. Foundation Layout
6. Pile Data Sheet
7. End Bent Details
8. Intermediate Bent Details
9. Bent Elevations and Layout Sheets
10. Column Details
11. Framing Plan
12. Girder Details
13. Span Details<sup>1</sup>
14. Miscellaneous Span and Girder Details
15. Approach Slab Details
16. Joint Details
17. Optional Span Details
18. Standard Pile Details
19. Bridge End Drain Details
20. Core Borings & Test Piles

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<sup>1</sup> Steel Span Details can be grouped together and include; typical sections, pouring sequence, framing plans, camber diagrams, girder details showing all connections, splices and bearing details.

## **PROCEDURES FOR REVISIONS AND PLAN CHANGES**

### **DEFINITIONS**

#### Revisions

Any change made to the plans after they have been signed by the Chief Engineer and prior to the letting is classified as a revision.

#### Plan Change

Any change made to the plans after the project has been let to contract is classified as a plan change.

### **REVISION PROCEDURES**

In the event that a revision is required, a written request for the plans must be submitted to the General Files Section along with an approval of the Contracts Engineer in order to receive the plans from General Files. This request must specify the nature of the intended revision, the anticipated amount of time required, and the name of the person in charge of the revision. A speed letter will suffice for this request.

When a revision is made, a circle with a number inside is used to "bug" the change and to reference it to the revision block. All sheets involved in the revision will have the same numerical bug and date. All sheet numbers are to be recorded on the title sheet revision block including the title sheet numbers.

Once the revision is completed, the cost estimate should be revised as required, and the plans and estimate sent to the Contracts and Specifications Section for review. Once accepted by the Contracts and Specification Section, the person in charge and Chief Engineer shall sign the title sheet and the plans returned to General Files.

### **PLAN CHANGE PROCEDURES**

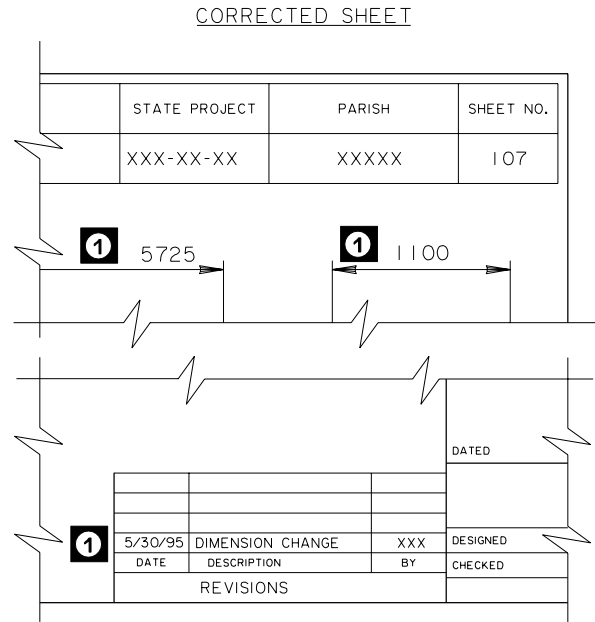
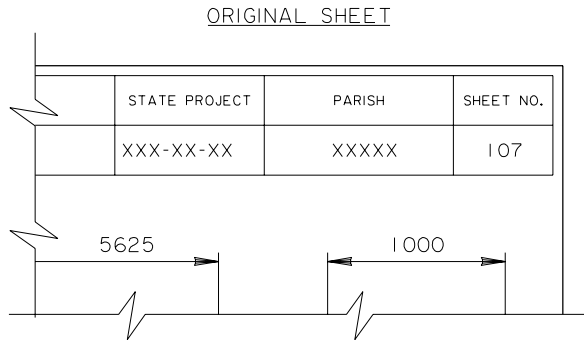
For a plan change, the plans may be verbally requested from the General Files Section. A triangle with a number inside should be used to "bug" the change and reference it to the revision block. Plan changes are not recorded on the title sheet revision block. No erasures are allowed for a plan change. For minor changes, the changes are superimposed on the existing sheet. In the case of major changes, new sheets may be created and added to the plans. If a new sheet is created to replace an existing sheet, the old sheet is stamped "VOID". The replacement sheet will have an "A" added to the sheet number. Once the plan change is finalized, a letter must be sent to the Construction Section transmitting 18 sets of prints of all affected sheets explaining the plan change. A set of prints will be transmitted to the Project Engineer by copy of the letter. If consultants are involved, a separate set of plans should be transmitted to the consultant by copy of the letter sent to the Construction Section. If Real



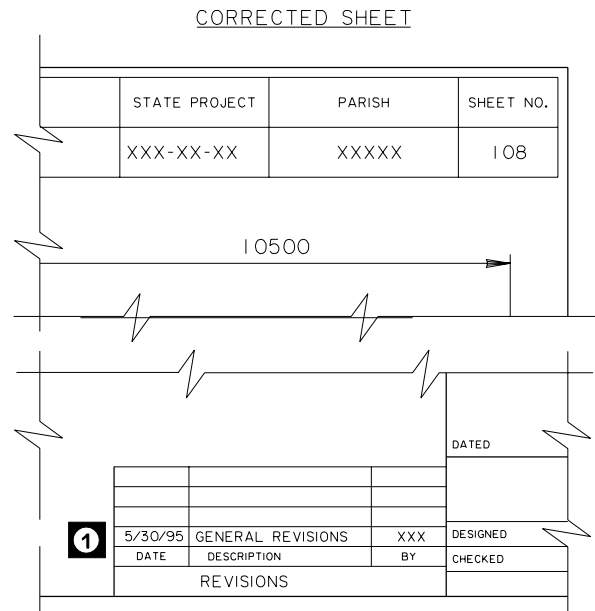
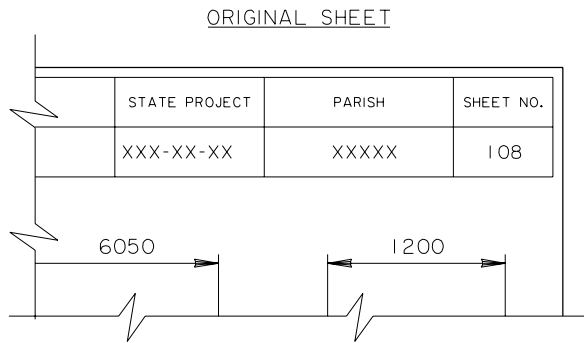
Estate and Utilities are involved, full-sized sets are to be transmitted, 10 sets to Real Estate and 1 set to Utilities, by copy of the letter. (See example)



1. IF MINOR REVISIONS ARE NEEDED, MAKE CHANGES ON THE ORIGINAL SHEET.  
ERASURES ARE ALLOWED. FOR EXAMPLE:



2. IF MAJOR REVISIONS ARE NEEDED, DESTROY THE ORIGINAL SHEET AND MAKE CHANGES ON THE NEW SHEET FOR EXAMPLE:



3. SHOW REVISION NUMBER (1) FOR ALL REVISED SHEET NUMBERS (INCLUDING TITLE SHEET NUMBER) IN THE TITLE SHEET REVISION BLOCK.
4. IF QUANTITIES ARE INVOLVED, REVISE COST ESTIMATE.
5. THE TITLE SHEET REVISION BLOCK MUST BE SIGNED BY THE CHIEF ENGINEER.
6. TRANSMIT A SET OF PRINTS AND A COPY OF ESTIMATE TO CONTRACTS AND SPECIFICATIONS SECTION.
7. RETURN THE REVISED PLANS TO GENERAL FILES.

## REVISION PROCEDURE



TABLE OF "M" VALUES IN METERS

VELOCITY	50 km/hr			70 km/hr			80 km/hr			100 km/hr			120 km/hr		
SSD(m)	57.4	65.5	68.6	94.1	117.5	125.8	112.8	148.8	160.5	157.0	220.8	240.6	202.9	310.1	341.0
GRADE (%)	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0	0.0	-3.0	-6.0
RADIUS(m)															
20.00															
40.00															
60.00															
80.00	5.09														
100.00	4.08	5.31													
120.00	3.41	4.44	4.86												
140.00	2.93	3.81	4.18												
160.00	2.56	3.24	3.66												
180.00															
200.00															
220.00															
240.00															
260.00		2.06	2.26	4.24											
280.00		1.91	2.10	3.94											
300.00			1.96	3.68				5.28							
320.00			1.83	3.45	5.37			4.95							
340.00				3.25	5.06			4.66							
360.00				3.07	4.78			4.40							
380.00				2.91	4.53	5.19		4.17							
400.00				2.76	4.30	4.93		3.96							
420.00				2.63	4.10	4.69		3.78							
440.00				2.51	3.91	4.48		3.60							
460.00				2.40	3.74	4.29		3.45							
480.00				2.30	3.59	4.11		3.31							
500.00				2.21	3.44	3.95		3.17							
520.00				2.12	3.31	3.79		3.05	5.31						
540.00				2.05	3.19	3.65		2.94	5.11						
560.00				1.97	3.07	3.52		2.83	4.93						
580.00				1.90	2.97	3.40		2.74	4.76		5.30				
600.00				1.84	2.87	3.29		2.65	4.60	5.35	5.12				
620.00					2.78	3.18		2.56	4.45	5.18	4.96				
640.00					2.69	3.08		2.48	4.31	5.02	4.80				
660.00					2.61	2.99		2.41	4.18	4.87	4.66				
680.00					2.53	2.90		2.33	4.06	4.72	4.52				
700.00					2.46	2.82		2.27	3.94	4.59	4.39				
720.00					2.39	2.74		2.20	3.84	4.46	4.27				
740.00					2.33	2.67		2.15	3.73	4.34	4.15				
760.00					2.27	2.60		2.09	3.63	4.23	4.04				
780.00					2.21	2.53		2.04	3.54	4.12	3.94				
800.00					2.15	2.47		1.98	3.45	4.02	3.84				
820.00					2.10	2.41		1.94	3.37	3.92	3.75				
840.00					2.05	2.35		1.89	3.29	3.83	3.66				
860.00					2.00	2.30		1.85	3.21	3.74	3.58				
880.00					1.96	2.24		1.80	3.14	3.65	3.49				
900.00					1.91	2.19			3.07	3.57	3.42				
920.00					1.87	2.15			3.00	3.49	3.34				
940.00															
960.00															
980.00						2.02		2.82	3.28	3.14			5.24		
1000.00						1.97		2.76	3.21	3.08			5.13		
1500.00								1.84	2.14	2.05	4.06	4.81	3.42		
2000.00											3.04	3.61	2.57		
2500.00											2.43	2.89	2.06	4.80	
3000.00											2.03	2.41		4.00	

\*TABLE OF M VALUES BASED ON MINIMUM VALUES OF STOPPING SIGHT DISTANCE IN WET CONDITIONS.  
RADIUS=THE RADIUS TO CENTERLINE OF INSIDE LANE

## NORMAL HIGHWAY CLEARANCES

### STRUCTURES

#### Vertical Clearance

Freeways and Arterials	5.05 m ( min.) <sup>2</sup>
Truss Portals	5.35 m (min.) <sup>2</sup>
Pedestrian Bridge	6.00 m ( Desirable ) <sup>2</sup> 5.35 m (min.) <sup>2</sup>
All other roads and streets	4.75 m (min.) <sup>2</sup>

#### Horizontal Clearance

All roadways<sup>3</sup>

### OVERHEAD SIGNS<sup>4</sup>

#### Vertical Clearance

From high point of pavement to bottom of sign face	5.5 m (min.) <sup>2</sup>
From high point of pavement to bottom of lighting or other appurtenances	5.2 m (min.) <sup>2</sup>

#### Horizontal Clearance

From edge of roadway (with flat shoulders) <sup>3</sup>	
From edge of curbed roadways	0.6 m (min) behind the curb

---

<sup>2</sup> Includes 150 mm for future overlays

<sup>3</sup> See G.R.-200(M) Standard Plans to determine clear zones. In general, guardrail or crash protection shall be provided where horizontal clearances are less than the minimum.

<sup>4</sup> For additional information see AASHTO "Roadside Design Guide", the current MUTCD, and the "Louisiana Manual on Uniform Traffic Control Devices".

## Impact

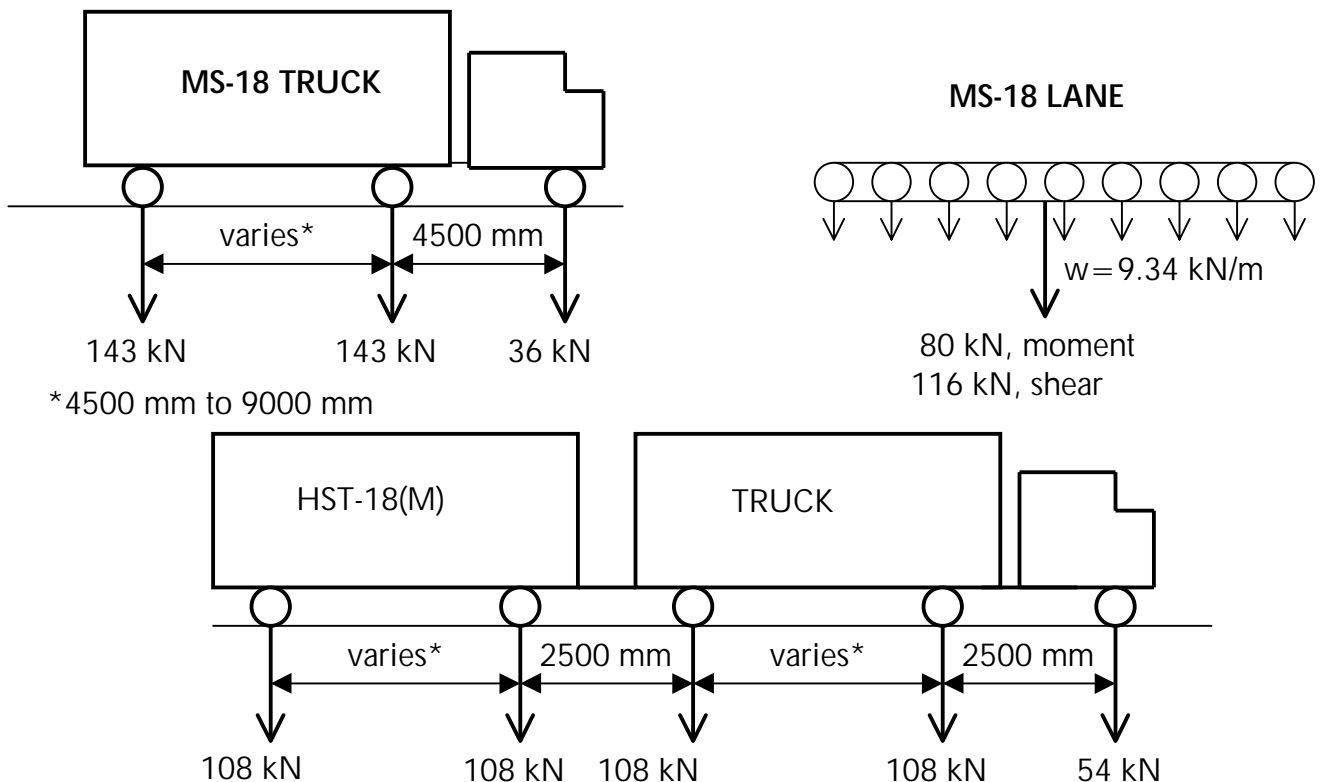
Impact shall be applied as specified in the AASHTO Specifications except as follows: impact shall be applied to caps of pile bents and to all portions of column bents except piles.

## Summary Of Live Loads

TRUCK TYPE	WHERE USED	SPECIAL CONSIDERATIONS
<b>MS-18</b>	All bridges	Truck or lane <sup>6</sup> , whichever governs
<b>HST-18(M)</b>	All bridges except on local (farm to market) roads	Not used for serviceability requirements, fatigue or camber calculations
<b>MILITARY</b>	Interstate bridges only	Generally governs only for spans < 9.15 m

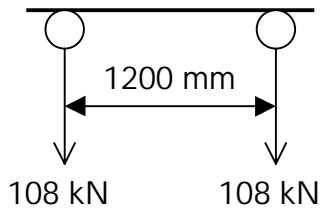
### Longitudinal View of Loading

Axle Load shown, wheel load = ½ axle load

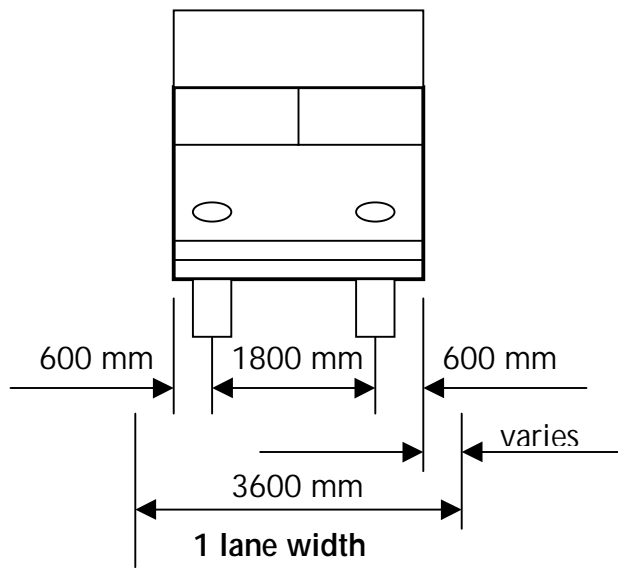


<sup>6</sup> Additional concentrated load requirements for continuous spans, see AASHTO Specifications

### Military Loading



### Transverse View of Loading



### Sound Wall Load:

Bridges which require installation of Sound Walls shall be designed to accommodate the appropriate dead, live and wind loads for the required wall height. Dead loads of the wall shall be minimum of 45 kg/m for wall heights up to 3 meters and 90 kg/m for walls greater than 3 meters.



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## Deck Design Details

1. Deck thickness shall vary from a minimum of **180 mm** to a maximum of **220 mm** in **20 mm** increments. Optional deck panels will not be allowed as an alternate for **180 mm** decks. Any deck thickness other than 200 and 220 mm, shall be considered a special case, and will have to be approved by the Bridge Design Engineer.
2. A suggested pouring sequence for continuous spans is to be provided for spans over **25 m** in length, giving the minimum rate of pour in cubic meters per hour. The necessary information should be added to the "Miscellaneous Span and Girder Details" sheet 1 of 3. The pouring sequence is based on a 4 hour set time and attempts to minimize cracks in the top of the deck. Try to break the deck into segments at contraflexure points and pour positive moment areas first unless a continuous pour across the support is possible. See Louisiana Standard Specifications article 805.03(d) and limit rate to 45 m<sup>3</sup> per hour.
3. Reinforcing steel shall have **50 mm** cover at the top of the slab, and **25 mm** cover at the bottom of the slab.
4. Main reinforcing bars shall be **#15, or #20** and be placed as near perpendicular to the girders as possible.
5. Longitudinal reinforcing bars shall be **#10**, unless a larger size is needed for continuity over the bents. The top plane of longitudinal steel shall have a maximum spacing of **300 mm** center to center.
6. All bars greater than **#10** will have a detailed maximum length of 18.0 m unless spliced. **#10** bars shall be limited to 12.2 m in length for handling purposes.
7. Main reinforcing steel shall have a minimum spacing of **120 mm** and not greater than the gross deck thickness plus 5 mm.
8. Interpolation of reinforcing steel in deck design table will be allowed only between two sets of identical bar size.
9. 150 mm diameter drains should not be used directly above lower travel lanes, R.R. tracks or abutment slopes, even if revetment is present.
10. Optional deck panels are restricted from use in areas with severely skewed joints (see optional deck panel sheets for geometric limits). On bridges in curves or variable width roadways, the contractor may be allowed to use panels if he provides an independent check of his design and review of all shop drawings at no additional cost.

11. When the use of stay-in-place concrete panels will be allowed, the standard detail sheets will be incorporated into the plans and the general note sheet shall include the item "Optional Deck Details: Precast-prestressed concrete panels conforming to the optional deck detail sheets may be used at the contractor's option."
12. Stay-in-place steel forms will be allowed as an option to the contractor for deep widely spaced plate girders or box girders. The steel panels shall be galvanized in accordance to ASTM A 653M, Z 900 (450 g/m<sup>2</sup> coverage or 64 μm thick each face) and not increase the dead load from the deck concrete.
13. In order to combat the corrosive effects of salting on primary routes in Districts 04 and 05, as listed below, epoxy coated reinforcing steel shall be required as follows:
  - a) All superstructure reinforcing steel, top and bottom mattes.
  - b) All reinforcing steel used in bridge barrier rails and bridge sidewalks.

In addition, the engineer should contact District 04 or 05 to verify if deicing is practiced on a particular structure in an unlisted control section. Galvanized reinforcing steel may be substituted wherever epoxy coated reinforcing steel is required.

Control Sections in Districts 04 and 05 requiring epoxy coated concrete reinforcing steel:

1-01 to 1-09	37-01 to 37-04	83-01 to 83-06
2-01 to 2-06	38-03 & 38-04 & 38-30	85-07
10-02 to 10-03	43-01 to 43-06	86-01 & 86-02
10-05, 10-06 & 10-33	44-01 to 44-03	87-02
11-01 to 11-04	45-01 & 45-03 & 45-30	98-02
15-08 & 15-31	48-01	124-03
16-01 to 16-05	49-01	156-01 to 156-03
20-06 to 20-09	51-04 to 51-08	420-01
21-01 to 21-05 & 21-30	53-06 to 53-09	427-01
23-06 & 23-09 to 23-11	67-07 to 67-09	451-01 to 451-08
25-05 to 25-08	69-02 to 69-04	451-30 & 451-31
26-08 to 26-10	70-01 to 70-07	455-07 & 455-08
27-01 to 27-06	72-01 to 72-02	809-08

The term control section refers to a section of highway and is designated by the first two digit groupings of a construction project number, for example:

Project No. 156-02-0053 -----Control Section 156-02

14. Tension development length modification factors for epoxy reinforcing steel must be used. See AASHTO 8.25.2.3

## Analysis

1. In the design analysis the initial camber (deflection at release due to prestress and self-weight) can be assumed to be the final camber (deflection after all dead loads and applied prestress). For construction purposes the initial camber and expected dead load deflection are calculated and given.
2. To relieve the stress at the ends of the girders, prestress girders will be designed utilizing either the debond or draped strand design. The preferred debond design must follow AASHTO LRFD limits on total percent debonded and percent debonded per row. If the debond design results in a more costly design (four or more additional strands per girder, additional girder line, etc.), then a draped pattern should be utilized.
3. The sidewalk and traffic railing dead and live load shall be assumed to be carried by the exterior girder. If in the judgement of the designer, the sidewalk and the parapet places an excessive load on the exterior girder, he may distribute a percentage of the load to the adjacent interior girder(s) as directed by the Bridge Design Engineer. Exterior girders shall not have less capacity than interior girders and will almost always be designed to carry the full weight of the barrier rail.
4. For design purposes, the haunch shall be taken as 15 mm less than the actual haunch dimension used at the centerline bearing to account for loss of structural depth due to camber.
5. It is desirable that the temporary tension stress in the top fiber near the ends of prestressed girders be reduced as much as possible by debonding (see #2 above and LRFD 5.11.4.2). If the tensile stress still exceeds the allowable after maximum debond, bonded non-prestressed reinforcing steel shall be supplied in an amount to resist the total tension force developed in the uncracked girder section at a working stress of  $0.4 F_y$ . (See example, page 4-21 PCI Handbook, 4th edition).
6. A future wearing surface of  $600 \text{ N/m}^2$  in dead load shall be added to the clear roadway width. However, no section loss or gain is assumed due to the wearing surface in the composite section.
7. Raised medians shall have required construction joints between the raised portion and the regular roadway slab. Girders affected by raised medians shall be designed

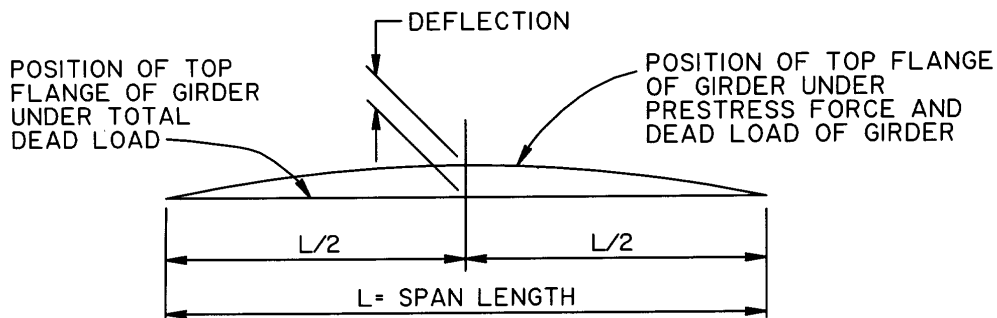
9. The actual camber ( $\Delta$ ) due to prestressing forces plus girder dead load may vary by  $\pm 10 \text{ mm}$  from the predicted value, but the actual minimum camber should not be less than the predicted deflection due to composite and non-composite superimposed dead load (excluding future wearing surface). If the final deflection is negative, (i.e. sagging) then adding more strands or reducing the dead load to reduce the undesirable deflection will be required.

Let  $c$  = camber due to prestress force and girder weight  
 $\Delta$  = deflection due to diaphragms, deck, haunch, and barrier rail

Then at release:  $C_{\max} = c + 10 \text{ mm}$   
 $C_{\min} \geq (c - 10 \text{ mm}) \geq \Delta$

	EXT. GIRDER		INT. GIRDER	
DEAD LOAD REACTION	○		○	
DEFLECTION				
ALLOWABLE CAMBER	MIN	MAX	MIN	MAX

○ INCLUDES  $600 \text{ N/m}^2$  FUTURE WEARING SURFACE.



DEFLECTION OF PRESTRESSED GIRDER UNDER DEAD LOAD OF CAST- IN- PLACE CONCRETE

The strands shall generally be debonded in a sequence beginning in the row nearest the bottom flange and progressing upward as required to satisfy design conditions.

### Analysis

1. Determine the number of strands required at the midspan of the girder based on conventional procedures for service load and load factor analysis. Stresses and moments shall be determined at increments of 1/10 of the design span length or less.
2. Determine the number and location of the strands required to be debonded to avoid overstress at the ends of the girder at detensioning (initial conditions). The allowable tension shall be  $0.249(f'_{ci})\%$  and the allowable compression shall be  $0.6f'_{ci}$ . For calculation purposes, the strands are assumed to introduce prestress force to the girder as follows:
  - a) Transfer length for service load (initial and final conditions): Linearly from no contribution at the debond point to full effect over a distance of fifty times the strand diameter<sup>4</sup>.
  - b) Development length for ultimate strength: Linearly from no contribution at the debond point to full effect over a distance of two times the development length specified in the AASHTO Specifications subsection 9.28.1.
3. Establish the number and sequence of each set of strands to be debonded at intermediate points along the girder based on stresses at detensioning. Preferably, a 2 m distance between debond lengths will be utilized. Limit debond to 25% of total, 40% of any row (LRFD 5.11.4.2).
4. Exterior strands in each horizontal row should be fully bonded.
5. Locate the point that the strand pattern required at midspan will produce the maximum allowable stress in the girder at detensioning. Debond the first set of strands from this point to the end of the girder.
6. Locate the point that the remaining strand pattern will produce the maximum allowable stress in the girder at detensioning. Debond the second set of strands from this point to the end of the girder. Repeat this step for the third and additional sets of strands to be debonded at intermediate points along the girder.
7. Check stresses at final conditions at the centerline of the girder, at debond points and along the transfer lengths.
- 8.

length from the ends of the girder. Then, check the capacity at all critical points, debond points and midspan, to insure that the ultimate moment capacity is greater than the factored moment. The ultimate moment capacity shall be the sum of the capacities of all fully developed strands plus the capacity of partially developed strands. At two development lengths from debond points, strands are fully developed. At points less than two development lengths from the debond point, the partial capacity of debonded strands shall be calculated based on a linear proportion from zero at the debond point to full capacity at two development lengths.

9. In the event that the number of strands required for the factored moment at a critical point cannot be bonded for two development lengths, determine the service load stress in the bottom fibers for Group I loads. If no tension stress occurs along the beam, one development length can be used in lieu of two development lengths.

### Design Details

1. The use of debonding material and the number of debonding termination points should be minimized.



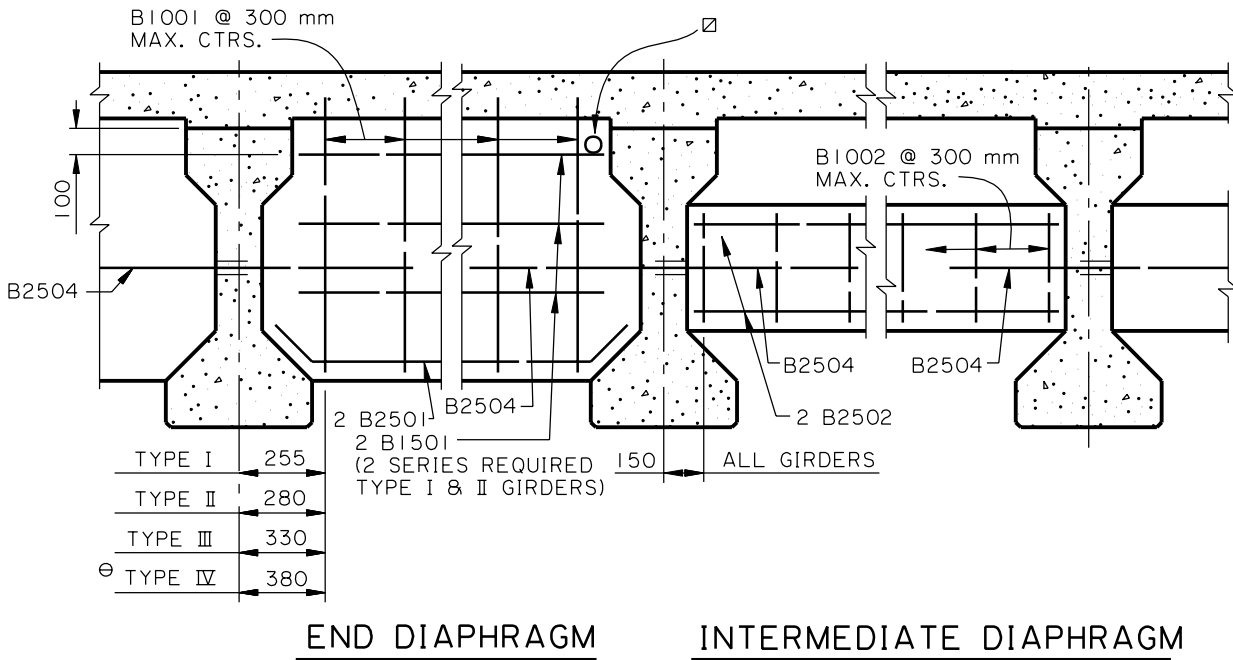
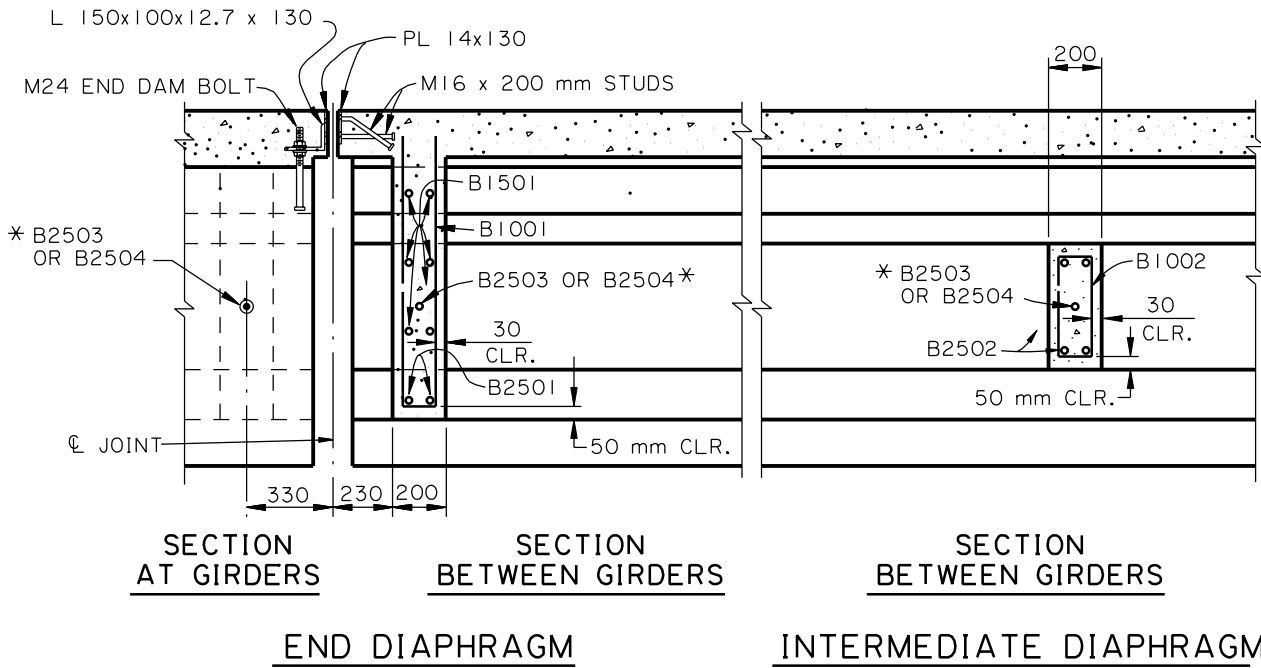
Strand Properties Table

ASTM DESIGNATION A 416 UNCOATED 7-WIRE STRANDS FOR PRESTRESSED GIRDERS								
Strand Size (Dia)	Strand Grade (MPa)	Breaking Strength (kN)	Nominal Area (mm <sup>2</sup> )	Weight (kg/1000 m)	Initial Load (kN) <sup>⊙</sup>	Load @ 1% Extension (kN)	Initial Tension (70% Breaking Strength) (kN)	Initial Tension (75% Breaking Strength) (kN)
9.5 mm	1860 L.R.	102.3	54.84	432	8.9	92.1	-----	76.7
	1725	120.1	69.68	548	12.0	102.3	84.1	-----
11.1 mm	1860 S.R.	137.9	74.19	582	13.8	117.2	96.5	-----
	1860 L.R.	137.9	74.19	582	13.8	124.1	-----	103.4
12.7 mm	1725	160.1	92.90	730	16.0	136.2	112.1	-----
	1860 S.R.	183.7	98.71	775	18.4	156.1	128.6	-----
	1860 L.R.	183.7	98.71	775	18.4	165.3	-----	137.8

S.R. DENOTES STRESS-RELIEVED.  
L.R. DENOTES LOW-RELAXATION.

⊙ INITIAL TENSION PRIOR TO RELEASE OF STRANDS.

\*B2503 (EXTERIOR GIRDER ONLY)  
ONE END THREADED 75 mm



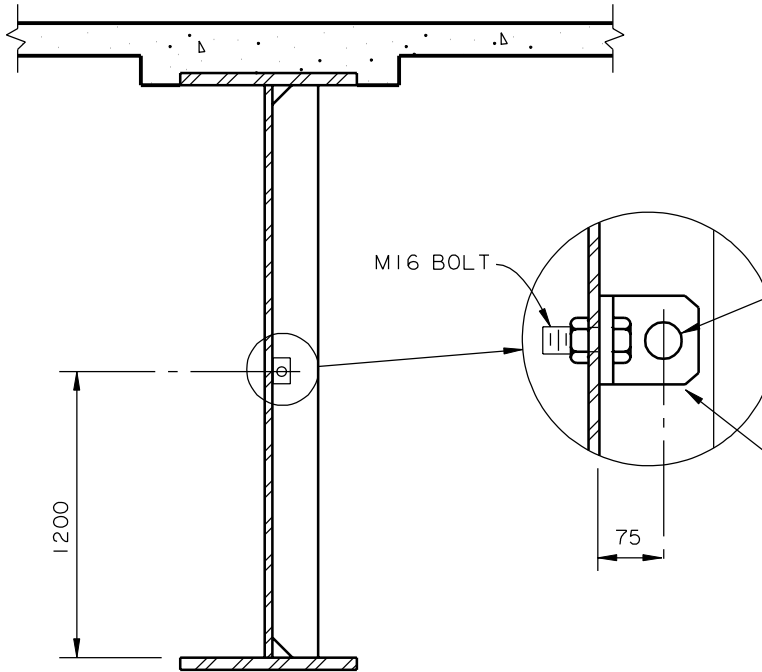
**NOTES:**

SPANS >15 m REQUIRE ONE INTERMEDIATE DIAPHRAGM.  
SPANS >30 m REQUIRE TWO INTERMEDIATE DIAPHRAGMS.

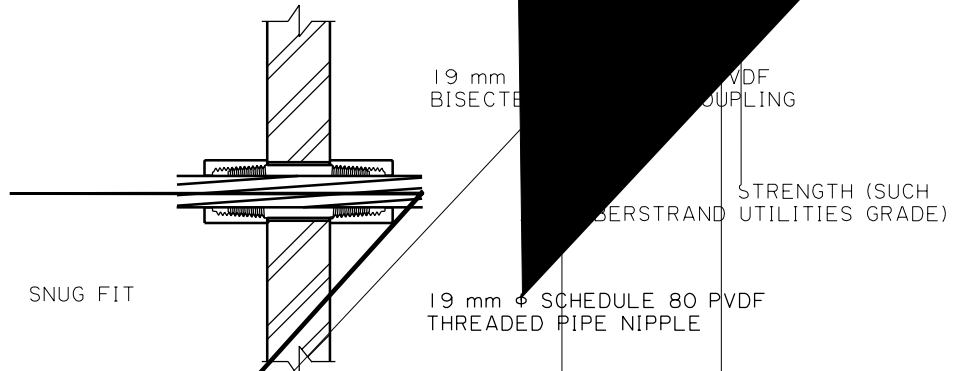
⊠ 75 mm  $\phi$  VENT HOLE IN EACH END DIAPHRAGM WHERE INUNDATION BY FLOOD IS POSSIBLE.

TYPE I-IV (END & INTERMEDIATE DIAPHRAGMS)

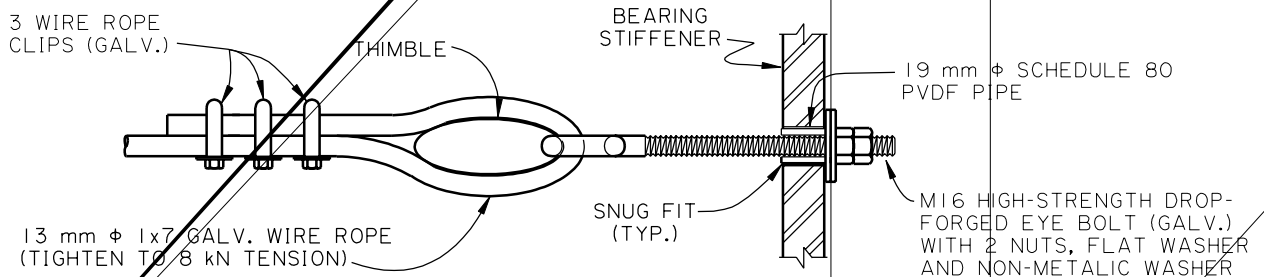
**DIAPHRAGM DETAILS**



**TYPICAL GIRDER SECTION**  
(SHOWING WIRE ROPE LOCATION)



**DETAIL OF SAFETY CABLE BUSHING**  
(SHOWING WIRE ROPE PASSING THROUGH STIFFENER)

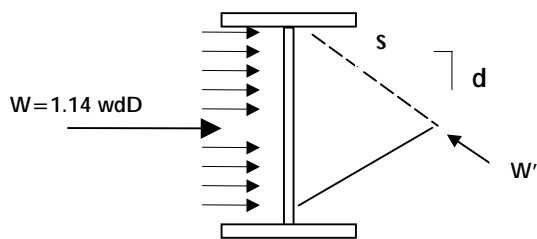


**DETAIL OF SAFETY CABLE TERMINATION**  
(OPPOSITE END MAY UTILIZE PIN ANCHOR SOCKET)

**INSPECTION HANDRAIL**

## Cross Frames Diaphragms

1. Cross frames have a high price per kilogram but are given less attention by the designer than primary members.
2. Cross frame spacing is based on stability requirements during erection, lateral torsional buckling of compression flange and 1996 AASHTO LFD 10.20.1. However, 1996 AASHTO LRFD 6.7.4 allows the engineer to determine the need for permanent cross frame based on engineering analysis rather than arbitrary specified requirements. It may be economical to increase dimensions of the flange and reduce the number of cross frames to be fabricated to achieve a cost-effective design. The Bridge Design Engineer must approve the spacing greater than 7.6 m.
3. Unless required due to horizontal curve, treat elements of a cross frame as secondary members (AASHTO 10.20.1) to reduce undesirable load paths and design according to articles 10.7.1, 10.19.1.2 and 10.20 . Once the deck is placed, cross frames provide little resistance to wind loads but still may be required in negative moment regions.



$W$  = wind load (Newtons) on cross frame

$w = 2400 \text{ N/m}^2$

$d$  = beam depth (meters)

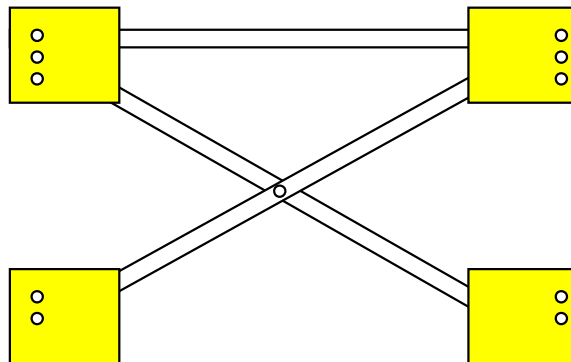
$D$  = cross frame spacing

$s$  = girder spacing (meters)

$W'$  = axial load in cross frame member in Newtons

$$= \frac{1.14 \times w \times (d) \times D \times (s^2 + d^2)^{1/2}}{2s}$$

4. Reduce the cost by not mixing connections within a cross frame. Construction requires welded joints to be welded all around unless otherwise noted, then painted. In a bolted joint, faying surfaces receive two coats of paint before assembly. If a bolted joint is used in the middle, with welded ends, construction requires all surfaces to be painted before welding, then painted again. Avoid this mix.



## **DRIVEN PILES**

### **INTRODUCTION**

The most commonly used driven pile types are precast-prestressed concrete, cast-in-place concrete, steel "H", steel pipe and timber. This section is a guide to methods of pile foundation design and details.

It is conceded that the problem of foundation analysis is a highly complex one and that sometimes experience and intuition will be the better part of analysis. In this light, if any analysis and soil boring interpretation is followed blindly, serious errors in estimating foundation capacities can result.

The bridge designer normally proposes the type and length of pile foundation during preliminary plans. The Geotechnical and Construction sections should be consulted both during preliminary and final design to review and make comments on the proposed pile lengths, pile type and field-testing.

### **PILE DESIGN**

Soil borings are required on all bridge projects for which piling is involved. In cases where an existing bridge will be widened or replaced on an existing alignment, the engineer should evaluate the following information first from the existing bridge records.

- a) Existing bridge borings.
- b) Existing test pile reports.
- c) Existing pile driving records.

On projects for which all or some of the above information is available and contains sufficient information for the design of the foundation, there will be no need to order new borings.

Should the existing information not be sufficient or is not available, new borings must be ordered. New borings must be ordered through our Geotechnical Section. Information on how to order new borings and a boring request form can be found in chapter 1 or you may contact the Geotechnical Section. Any existing deep boring data should be attached to the boring request. The date when the complete geotechnical data (borings, consolidation and settlement analysis) are needed, should be included in the request. In the absence of this information, priority will be established by the preliminary plan date.

Piles shall be designed using service loads excluding live load impact. The maximum pile loads (design load) should always be shown on the construction drawings, normally with bent details or on the pile data sheet. Piles can be designed as friction piles, bearing piles, or a combination of both. The weight of the pile is normally neglected except in special cases involving large diameter piles and when cofferdams and tremie seals are used. The pile lengths for both on-system and off-system bridges are determined using the appropriate safety factors which are selected based on field-testing, type and amount of soils data and geotechnical analysis, type of project, static and dynamic load test and method of modeling pile installation. See Field Testing for more information on safety factors.

In order to set the plan pile lengths, a static analysis to determine ultimate pile capacity is normally performed on each boring for friction and bearing capacity. Due to the variety of soil conditions, this manual will not attempt to describe the analysis procedures. The engineer should confer with the Geotechnical Section when performing a static analysis. The design engineer will normally use the total soil shear strengths determined from either unconfined compression tests or standard penetration tests to determine the pile friction and end bearing for various piles and loads. If economically feasible, the engineer should attempt to tip end bearing piles in very dense sands ( $n > 50$  blows). The end bearing piles should penetrate a minimum of 1.5 m into the 50 blows count material.

The plan pile lengths are established when the design event ultimate pile capacity divided by the required factor of safety is equal to or greater than the design load.

Pile sizes should be proportioned so that the following criteria are met.

- a) As a general rule, the maximum slenderness ratio of  $L/d \leq 20$  should be maintained.

$L$  = pile unsupported length (mm). The unsupported length is measured down below the channel bottom or ground line accounting for estimated scour, if appropriate (1.5 m minimum), plus a distance to the assumed point of pile fixity. In general, pile fixity can be assumed at 1.5 m below scour line or ground line. See figure on page 25.

$d$  = the least dimension or diameter of the pile section (mm).

The maximum unsupported pile lengths based on a  $L/d = 20$  are as follows:

Pile Size(mm)	<sup>1</sup> Max. unsupported length (mm)
350	7000
400	8000
450	9000
600	12000
750	15000

- b) If  $l/d > 12$ , batter exterior piles.
- c) All pile friction above the estimated scour line should be ignored. A minimum of 1.5 m of scour shall be assumed.
- d) Piles should be proportioned so that the maximum pile design load is less than the allowable axial compressive loads and the allowable lateral loads. The allowable axial compressive pile loads are shown on page number 6 (6).

When favorable soil conditions exist, the design pile load should approach the upper limit of the allowable load range. In cases where the soil strength is questionable, lower design loads should be used.

- e) The design of laterally loaded piles is usually governed by the lateral movement criteria. Proprietary computer programs are available for lateral pile geotechnical analysis. In addition the pile must be able to resist the additional lateral loads structurally. In the absence of lateral pile test information or a more detailed lateral analysis as described above, the following allowable lateral loads may be used.

Pile Type	Allowable Lateral Pile Load (kN)
Timber	13.0 kN
Concrete	18.0 kN
Steel	22.0 kN

- f) Pile splices for concrete piles may be required when pile order lengths are expected to exceed the maximum casting length shown on the Standard Detail CS-216. The plans will have an S-item for pile splices (per each) with the anticipated number that may be required. The item will be bugged noting that this item may be deleted if final order lengths are less than maximum casting lengths shown in the plans.

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<sup>1</sup> Maximum unsupported lengths may be exceeded in special situations with the BDE's approval. However,  $l/d > 25$  will require investigations for elastic stability as columns.

Table, Allowable Axial Pile Load

PILE TYPE	PILE SIZE	ALLOWABLE AXIAL COMPRESSIVE LOAD	STANDARD DETAIL NAME
<sup>1</sup> Precast Prestressed Concrete Piles (square)	1155-1730 kNCS-216(Muar)TJ		
Steel Pipe Piles	350 400	490 kN 755 kN	Concrete Pile Alternates
Cast-in-place Concrete			
Cast-in-place Concrete : Tapered: Raymond Helcor or Corwell Monotube	350, 400 350, 400 350, 400	490 kN, 755 kN 490 kN, 755 kN 490 kN, 755 kN	Concrete Pile Alternates
Timber	Butt Dia. (500-300) Tip Dia. (225-125)	265 kN 355 kN (Special Cases)	N/A
<sup>3</sup> Steel "H" (common sizes)	HP250×62 HP250×85 HP360×108 HP360×132 HP360×152 HP360×174	495 – 650 670 – 885 855 – 1130 1050 – 1385 1200 – 1590 1375 – 1820 –	N/A
Steel Pipe (other sizes available, check w/suppliers)	PP460× 9.5 PP610× 12.7 PP760× 15.9	830 – 1100 1475 – 1952 2310 – 3050	N/A

<sup>1</sup> The allowable loads are based on the formulae set up by the joint AASHTO and PCI for piles with  $f'c = 35\text{MPa}$  PSI. (F.S. =  $4 \frac{L}{D} = 25$  and 10 respectively); The loads are further reduced to account for soil capacity (Additional F.S. = 1.6 to 2.2). For situations where  $\frac{L}{D}$  is approaching zero, i.e., footing piles, and very favorable soil conditions exist, the designer may consider loads 1.5 times higher than those shown.

<sup>2</sup> Refer to standard detail CS-216(M) for maximum pile casting lengths.

<sup>3</sup> The lower and upper values represent allowables of the pile area  $0.25F_y$  and  $0.33 F_y$  respectively. Loads above the lower value may be used only with approval of the BDE and must incorporate static and/or dynamic load tests to confirm satisfactory results.



The following typical splices are approved to be used on precast concrete and steel piles.

Pile Type	Pile Size (mm)	Pile Splice Type
Precast Concrete	350, 750	Cement dowel
Precast Concrete,	350,400,450	Dyna-a-splice (proprietary)
Precast Concrete,	600	ABB (proprietary)
Steel	All sizes	Full penetration butt weld

Standard details are available for the precast concrete pile splices, except for ABB splices.

- g) For piles with a diameter less than 0.6 m, an 8 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.
- h) For pile diameters equal to or greater than 0.6 m, a 9 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.

Battering piles is an expensive process and should be specified only when necessary. The exterior pile in bents should be battered when the unsupported pile length is excessive. Battering footing piles provides the necessary lateral support that is sometimes required to resist excessive lateral loads transferred from the column to the footing. This is particularly true for short column bents due to cap shrinkage. Maximum batter is usually 1 on 4 for footing piles and 1 on 8 on pile bents.

The allowable strength of precast concrete piles is seldom, if ever, exceeded by the design loads. Pile handling and transportation govern the design, thus establishing the maximum casting length and pick up point locations.

Cast-in-place concrete piles are used primarily in south Louisiana and are designed either as friction piles or combination friction and bearing piles. When cast-in-place piles are included as an alternate for precast piles, the pile lengths should be set based on the cast in-place pile, and only precast piles will be allowed in the end bents.

When hard driving is anticipated, particularly where jetting is not desirable, such as footing piles, the designer should consider non-displacement piles such as open-ended pipe or H piles. The designer should discuss this with the Geotechnical section.

The pile group capacity will be considered in foundation analysis if the center to center spacing is less than three pile diameters. Under normal situations, this is not allowed.

The consolidation settlement shall be computed for all pile groups. The pile group settlement shall be the same as shown for drilled shafts on page 19.

All timber piles for permanent structures shall be treated timber according to the Standard Construction Specification. Coastal treatment should be considered for use at locations south of I-10/I-12 line. Where coastal treatment is used, it should be clearly specified in the plans. Temporary structures such as detour bridges shall use treated timber piles.

## PILE DETAILS

1. The following pile standard details are available and shall be included in the plans when applicable.

Standard Detail	Description
CS - 216(M)	Precast-Prestressed Piles
Concrete Pile Alternates	Cast-in-place Concrete Piles
Pile Splice Details	Cement Dowel, Dyna-a-Splice

2. Steel pipe piles shall generally be driven with open ends only.
3. Pile lengths should normally be shown on the general bridge plan. Pile tips, cutoff elevations, pile lengths and design loads should be shown on a pile data table. In addition, a column for end of driving pile capacity should be provided.
4. For moderate to complex projects involving skews, horizontal curves, interchanges, etc., or where interaction with existing foundations is present, the plans should include a foundation layout. The layout must show bents and/or footing pile locations and referenced to the centerline or P.G.L. Existing structures or substructures that may conflict with the pile driving must be clearly shown. Boring locations as well as test piles, CPT probings, PDA monitor piles and indicator piles must also be shown.

- a) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE DEPARTMENT IN ACCORDANCE WITH SECTION 804.04 (I) OF THE SPECIFICATIONS.
- b) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE CONTRACTOR.

When the CPT probings are performed by the contractor, (note b), the maximum CPT penetration elevation should be specified in the plans as follows:

- a) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR ALL CPT PROBINGS SHALL BE \_\_\_ (*elevation in meters*).
- b) THE MAXIMUM CPT PROBING PENETRATION ELEVATION SHALL BE \_\_\_ (*elevation in meters*). FOR CPT PROBINGS TAKEN AT BENTS (##) THROUGH (##).
- c) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR TEST PILE (##) SHALL BE \_\_\_ (*elevation in meters*).

#### Pile Driving Analyzer, (PDA)

PDA may be used to monitor the pile driving installation of Test Piles, Indicator Piles, and Monitor Piles with the Pile Driving Analyzer (PDA). A note similar to the following note should be placed in the **General Notes of the bridge plans**. It should be modified as needed.

PDA MONITORING: PILE DRIVING ANALYZER (PDA) MONITORING WILL BE REQUIRED AT EACH TEST PILE, INDICATOR PILE, AND MONITOR PILE OR AS DIRECTED BY THE ENGINEER.

#### Indicator Piles

Indicator Piles may be used to determine the final pile order lengths. In this case, an Indicator Pile is driven in advance of the production piles. The difference between Indicator Piles and a standard test pile is that loading Indicator Piles is not anticipated. Indicator piles should be cast long enough to be redriven, if necessary, to the plan tip elevation of the piles at the nearest bent or as determined necessary by the CPT probing. Indicator Piles are usually piles tipped on marginal end bearing soils. The Indicator Pile is used to access pile driveability problems such as hard driving which may require jetting or predrilling and to assess the bearing capacity of marginal bearing soil. The Indicator Pile driving installation is monitored with the PDA to evaluate the pile driving equipment performance and to monitor the pile driving stresses. Pile bearing capacity and driving criteria will be developed from data obtained from the PDA monitoring. The location of

these piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The indicator pile is paid for as a modified test pile (i.e. Item 804.07(A) Precast Concrete Test Pile (Indicator Pile)). Pay items for each type of indicator pile used should be shown in the plans.

Redriving of indicator piles is paid for under Item 804(14), Redriving Test Piles. If it is determined from the driving records and PDA monitoring that the indicator pile should be load tested, each load test shall be paid for under Item 804(12)(A).

The following note should be placed in the **General Notes of the bridge plans**.

INDICATOR PILE: INDICATOR PILES WILL BE REQUIRED AT THE LOCATIONS SHOWN ON THE GENERAL PLANS OR FOUNDATION LAYOUT.

### Monitor Piles

A Monitor Pile may be used to monitor the pile driving installation with the PDA. This is usually accomplished by monitoring the first permanent pile of its type and size to be driven at each bridge structure or at a specified bent location. The location of these Monitor Piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The PDA is used to evaluate the pile driving equipment and to monitor the pile driving stresses. Pile driving criteria will be developed from this information. The Monitor Pile is paid for as a permanent pile. The dynamic monitoring is paid for with the PDA Monitoring item. One of the following notes should be placed in the **General Notes of the bridge plans** depending on where the indicator pile(s) is located.

- a) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT EACH BRIDGE SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- b) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENT NO. (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- c) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENTS (##) THROUGH (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).

## Permanent Piles

Permanent Piles are those piles that are furnished by the contractor in accordance with an approved order list for use in production driving of foundation piles for the final substructure. If the driving resistance of a permanent pile should not correlate with the test pile or be less than that of the test pile, the engineer may require a static load test among other courses of action.

The following plan note should be placed in the **General Notes of the bridge plans**.

PILES: ALL PILE REQUIREMENTS INCLUDING SIZE, TYPE AND MAXIMUM DESIGN LOAD AND TEST PILE REQUIREMENTS AS TO LOCATION AND TEST LOADING SHALL BE AS DESCRIBED ON THE PLANS OR IN THE SPECIFICATIONS. SEE STANDARD DETAIL CS 216(M). THE MINIMUM PILE TIP ELEVATIONS WILL BE PLAN PILE TIP ELEVATIONS UNLESS NOTED ON THE PLANS OR OTHERWISE AS DIRECTED BY THE ENGINEER.

In addition, one of the following pile length notes shall be included as needed in the PILES: note in the plans.

- a) PILE LENGTHS SHOWN IN THE PLANS ARE ORDER LENGTH PILES.
- b) PILE ORDER LENGTHS WILL BE PROVIDED AFTER COMPLETION OF THE CPT PROBINGS AND/OR TEST PILE LOAD TESTING AND/OR INDICATOR PILE INSTALLATION AND EVALUATION AS REQUIRED BY THE PLANS.

## Jetting

When appropriate, jetting may be used to facilitate pile installation. This practice shall be predominately used when hard driving is anticipated during pile installation of end bearing piles. Jetting should not be allowed for friction piles, piles in footing, header banks or where stability of embankment or other improvements may be endangered. When jetting is allowed or required, the following note shall be added to the Special Provisions

JETTING: JETTING MAY BE REQUIRED IN ACCORDANCE WITH SECTION 804.05(I) AT (list of the locations).

The note above amends the Standard Specifications sub section 804.05(I), Water Jets.

For more specific information on this subject as well as appropriate plans and specifications requirements including pay items, refer to the latest DOTD's Standard Specifications.

## Types of Field Load Testing

1. **Static Load Test:** This work consists of applying static loads at predetermined intervals to Test Piles and in some cases to Indicator Piles or Permanent Piles. The static loads are applied in increments of 10 to 15 percent of the design load and held for an interval of 5 minutes. The loads are increased until pile failure occurs or three times the design load is reached. The ultimate pile capacity is determined through the analysis of the load settlement curve then a safety factor of 2.0 is applied to determine adequacy of pile tip elevation. Test piles will be loaded unless otherwise directed by the engineer. Test piles shall remain undisturbed for at least 14 calendar days after driving, unless otherwise directed by the engineer, to required penetration before beginning loading operations.
2. **Dynamic Load Test:** This work consists of assisting the Department in obtaining dynamic measurements with the Department's Pile Driving Analyzer (PDA) of test piles, indicator piles, and permanent piles during initial pile driving and during pile restrikes. The cost of equipment mobilization or any delays due to dynamic monitoring shall be at no direct pay. To allow space for attachment of instrumentation when dynamic monitoring is specified on test piles, indicator piles, and monitor pile, the piles shall be long enough to allow access to the top 2.5 pile diameters or side dimension of the pile at the end-of-driving penetration. The dynamic monitoring shall be performed for the purpose of obtaining the ultimate pile capacity, pile driving stresses, pile integrity, and pile driving system efficiency.

## Types Of Pile Capacities

1. **Static Load Test Capacity:** This is the computed ultimate pile resistance that we are anticipating during the static load testing of a test pile, indicator pile, or permanent pile. The soil resistance will depend on the as-driven conditions such as overburden of the scour zone, scour zone soil resistance if it has not been cased or excavated, etc. The reaction system shall be sized to resist three times this estimated Static Load Test Capacity shown in the plans or as directed by the engineer.
2. **Ultimate Pile Capacity:** This is the ultimate pile capacity that has been determined from either a static or dynamic test of a test pile, indicator pile, or permanent pile.
3. **Design Load:** Is the maximum computed working load that the pile foundation is anticipated to support during the life to the structure.
4. **Design Event Ultimate Pile Capacity:** This is the computed static ultimate pile resistance that should be available after neglecting the scour zone and accounting



## STANDARD PLANS AND STANDARD DETAILS

### Introduction

This section is intended to provide a list of available standard plans and standard details in order to prevent duplication of work. As these standard plans and standard details are continually being revised, it is the responsibility of the consultant or the in-house engineer to check with the project coordinator that the appropriate standard plans and standard details are included in the plans. Consultant manhours should not be included for details already covered on standard plans or standard details. All standard plans are listed on the title sheet along with its call number and latest revision date. Drawings for standard plans and standard details maintained by the Bridge Design Section are included in Appendix "A". All other standard plans (roadway, hydraulic, traffic control) may be obtained through the Department's General Files Section or the appropriate Department section.

### Definitions

**Standard plan:** An independent design detail (or series of details) that is routinely incorporated into the construction plans without modification and has been designated by the Chief Engineer as a standard plan. Official Department standard plans are signed by the Chief Engineer and described by a call number on the drawing ( i.e., GR-200 (M)).

**Standard detail:** Details maintained by the Bridge Design Section and are not signed by the Chief Engineer. These details are not official Department standards, and may require supplemental information for specific projects. These details are normally used on bridge related projects only.

### Policy for Adoption, Revision and Distribution of Standard Plans

The Contracts and Specifications Engineer Administrator will be responsible for the administering of all Standard plans. Proposed additions, deletions, and revisions must be submitted to his office in order to obtain the approval of the Chief Engineer. See E.D.S.M. I.1.1.2 for further information.

### Use of Standard Plans and Standard Details by entities other than DOTD

1. The Department will furnish a blue-line print of a Standard Plan or Detail stamped "**For Informational Purposes Only**".
2. The Department will furnish a reproducible copy of a Standard Plan or Detail if the requesting entity submits a formal, hold-harmless resolution, signed by someone with authority to accept responsibility. The letter for this request shall specify the project name and location for which the plans will be applied.



3. The reproducible will be furnished to the consultant working for the requesting entity on a project specific basis.

#### Standard Plans Maintained by the Bridge Design Section

##### Guardrail:

1. GR-200 (M), Guardrail For Bridge Ends, T-intersections
2. GR-201 (M), Guardrail For Median & Roadside Obstacles
3. GR-202 (M), Guardrail For Box Culvert
4. GR-203 (A) (M) and GR-203( B) (M), Guardrail For Off-System Bridges

##### Miscellaneous:

1. SWBS-100 (M), Steel Wire Bar Supports
2. RW-01 (M), Retaining Wall

#### Standard Details maintained by the Bridge Design Section

##### Concrete Slab Spans (Superstructure, Substructure and Approach Slabs)

1. 6 m and 20 ft. Cast-In-Place Slab Spans (On-System Bridges)
2. 6 m and 19 ft. Precast Slab Spans (Off-System Bridges)

### Span and Girder Details:

1. Miscellaneous Span and Girder Details, Prestressed Girders
2. Optional Span Details Concrete, (precast panels)
3. Optional Span Details Steel, (precast panels)
4. Strip Seal Joint
5. GF-1, Open Steel Grid Floor
6. GF-2, Open Steel Grid Floor (Heavy Duty)
7. Bridge End Drain Details

### Revetment:

1. CR-1 (M), Cast-In-Place Revetment
2. FR-01 (M), Flexible Revetment and Rip-Rap

### Piling:

1. CS-216 (M), Precast-Prestressed Piling
2. Prestressed Cylinder Pile
3. Alternate Pile Splice, Dyna-A-Splice
4. Pile Splice, Cement Dowel
5. Concrete Pile Alternates

### Approach Slab Drainage:

1. ASD-SS, Underdrains for Approach Slabs (Slab Spans)
2. ASD-SA, Underdrains for Approach Slabs (Girder Spans)

### Barrier Railing:

1. BR-01 (M), Barrier Railing (Girder Spans)
2. BR-02 (M), Barrier Railing (Slab Spans)
3. BR-03 (M), Barrier Railing (Low Speed Urban Transition)
4. BR-04A (M), Barrier Railing (Precast Slab Spans, Bolted Barrier)
5. BR-04B (M), Barrier Railing (Precast Slab Spans, Cast w/Panel)
6. BR-05 (M), Barrier Railing Transition

### Guardrail:

1. MELT, Guardrail End Treatment
2. New Jersey Bridge Rail Retrofit
3. Anchor Block Retrofit
4. Approach Guardrail & Bridge Rail Rehabilitation (Misc. Details)

### Detours:

1. Bridge Detour (Precast Concrete Panel)
2. Bridge Detour Substructure (Acrow Panel)
3. Temporary Precast Barrier

### Signing:

1. Permanent Signing (Overhead & Ground Mounted Signs)

### Lighting:

1. High Mast Tower Details

### Miscellaneous:

1. YP-01(M), year plates

Typically used Standard Plans maintained by other sections

1. SD-50,100,150,200 - 50 ft. to 200 ft. Spur Dike Details, (Hydraulics Section)
2. RS-31, Hazard Markers, (Road Design Section)
3. HS-01, Construction Signs and Barricades, (Traffic and Planning Section)
4. PM-01 (M), Raised Traffic Markers and Pavement Markings, (Traffic and Planning Section)

Other standard plans not listed may be obtained through the DOTD General Files Section. These include: roadway, hydraulic and traffic standard plans.

## LOUISIANA PRACTICE

### Barriers

Details of several crash- tested roadway barriers have been shown in this chapter. Among these barriers, the double-face thrie beam and the sloped-face concrete barriers are considered by FHWA as "Innovative Barrier". When required by FHWA, these barriers may be used in lieu of the more conventional type.

Barriers shown here are in two basic categories. First, the permanent barriers second the temporary barriers. Temporary barriers are commonly used in construction zone. When temporary barriers are utilized on bridge structures a positive connection to the bridge deck shall be provided, unless it is determined that a considerable lateral deflection of the barrier system can be tolerated. The blunt ends of temporary barriers shall be made crashworthy by means of either an end treatment device or by flaring away from traffic and carrying beyond the clear zone distance.

### Guardrail

Virtually all information pertaining to guardrail is contained in the Standard Plan G.R-200(M). This Standard provides information to the designers for the purpose of determining the "Length of Need" and to the contractors, for the purpose of constructing the guardrail.

In addition to G.R-200(M), Standard Plan G.R-201(M) and G.R-202(M) are provided to aid the designers with specific applications of guardrails. By using these particular standards the designers may show the dimensions which are unique to a specific condition on a simple

Sketch in the contract plans and make reference to a detail on the standard plan to provide the more generic information. Standard plans G.R-201(M) and G.R-202(M) shall always be used in conjunction with Standard Plan G.R-200(M).

Although guardrail standard plans adequately provide the necessary information to construct the guardrail system, it is very important that plans provide all information necessary for the specific site condition. For example, plans shall always show the total length, the length of each pay item, the location, the flare rate, the type of end treatment and any special notes or details.

When bridge construction is considered as "Spot Replacement", often there is little or no road construction, and in such cases minimum guard rail length shall be provided to make the bridge rail blunt ends crashworthy. In these situations, it is not necessary to design "length of need" to provide protection for the full "clear zone" distance behind the bridge rail. An exception to this is when the existing road in the vicinity of the structure provides the design "clear zone" distance, in which case the guardrail for the bridge ends shall provide protection consistent with that "clear zone" distance. The decision whether the minimum length or the standard length is to be utilized shall be made at the Plan-In-Hand

meeting after the road condition is examined. The final decision shall be included in the Plan-In-Hand report. When minimum guardrail lengths are utilized in "spot replacement" conditions, there will be no need for acquiring a design exception.

In all conditions, where the criteria within the standard plans can not be concurred, a design exception from the Chief Engineer shall be obtained and shall be stated in the plans. Statements of such design exceptions will provide easy reference to these exceptions when the department is challenged in litigation. End treatment of bridge railing located outside of the clear zone is recommended unless it is determined not feasible. End treatment of combination traffic and pedestrian railing when curbs and sidewalks are present is not recommended. The standard guardrail end treatment is "Modified Eccentric Loader Terminal" (MELT). This type of end treatment has a parabolic flare and is most suitable for when the line guardrail is flared away from the traffic. When the line guardrail has little or no flare, "MELT" can be used, however, under tight space condition, the placement of a parabolic end treatment may be difficult as well as undesirable. In such cases, a straight end treatment such as ET-2000 or equal may be utilized. When using this type of end treatment the line guardrail may be flared at a rate not to exceed 1:50.

For guardrails on existing roads and bridges see EDSM NO. 11.3.1.3. This EDSM outlines the procedures for guardrail design on existing conditions.

Bridge railing on all detour bridges shall be protected with a crashworthy end treatment. Flexible bridge railing can be adequately protected with a minimum guardrail length of 11 430 mm. However, when rigid barriers such as concrete safety shapes are used an additional 7620 mm transition guardrail section shall be included.

#### Guardrails for Off-System Projects

The guardrail standard plans applicable to off-system bridge projects are as follows:

GR-203A (M)

GR-203B (M)

BR-05 (M)

All standard plans for off-system projects shall be used in conjunction with Standard Plan GR-200 (M).

GR-203A (M) makes provisions for bridge end treatment on all classifications of off-system projects.

GR-203B (M) provides a shorter guardrail length than GR-203A (M), for when site conditions do not allow the installation of the standard length guardrail contained in GR-203A (M).

## MOVABLE BRIDGES

### INTRODUCTION

Movable bridges are sometimes required for navigable waterways, where high level bridges are economically unfeasible, particularly urban areas where high level structures would cause excessive relocations. Particular attention must be given to geometric requirements for marine traffic clearance, and the fitting of the bridges and approaches to the site. The Coast Guard should be involved early in the design process (*See Exhibit "B", Coordination with Other Agencies*)

When the economics of a movable bridge are being considered, long term maintenance costs, as well as initial construction costs should be considered. The current and projected opening frequencies for marine traffic should be carefully weighted against the vehicular traffic volume.

### SCOPE

This is a guide for the structural analysis and details involved in the plan preparation for movable bridges. It is also a guide for the economic comparison of a movable bridge to other alternatives. The AASHTO Specification for Movable Bridges is the base specification governing the analysis design of movable bridges.

#### On Selection Of Alternates

There are three basic bridge configurations to be considered at a navigable waterway crossing:

1. The low level movable bridge
2. The semi-high level movable bridge
3. The high level movable bridge

There are three basic types of movable bridges:

1. The vertical lift
2. The swing span
3. The bascule

Additional types of water crossings are the pontoon bridge and the ferry.

The economic factors in evaluating the alternative for crossing a waterway are extensive, and the data required satisfying a rigorous analysis is not readily available, or at least not easily quantified. However, reasonable estimates of this data often result in economic analyses which so heavily factor a particular alternate that significant errors in assumption will have little effect on the comparison.

High level fixed bridges are to be preferred unless the economics clearly indicate that a movable bridge would be significantly less expensive. Although lengthy approaches are required for high level bridges, they afford the following advantages: unrestricted flow of both marine and highway traffic, operators are not needed, less required maintenance, and lower susceptibility to marine collision. High levels of vehicular and marine traffic make the movable bridge alternate less tolerable.

Low level movable bridges provide for near grade crossing of highway traffic, with minimal bridge approaches. Every attempt should be made to provide sufficient clearance under the bridge to allow passage of 80% or more of all navigation, as well as all-small marine vessels, such as runabouts, without opening the bridge. These structures require complex electrical and mechanical equipment for operation of the span, along with operating personnel. Due to the closeness to the water, the probability of collision damage is greater than for a high level or semi-high level structure. Maintenance frequency and cost are relatively high compared to fixed bridges, as are the operating costs, which include electrical power and manpower.

Semi-high level movable bridges are difficult to justify economically because they incorporate the economic disadvantages of low level movable bridges, and, in part, the economic disadvantages of high level fixed bridges. Because they have long approach structures, the maintenance costs include those required for high level bridges, as well as those required for operating equipment. Semi-high level bridges do provide the advantage of passing most marine traffic without opening, which may justify placing an operator "on call" rather than requiring continuous operating status. However, potential damage to operating equipment and loss of operational integrity are factors which greatly increase repair cost compared to fixed structures with similar collision damage.

The traditional approach to bridge economics of comparing initial cost and choosing the least cost alternate to gain as many improvements as possible with the construction budget is not applicable when comparing fixed and movable structures. The significant long-term cost associated with operating and maintaining movable bridges impact operations and maintenance budgets in a way not associated with fixed structures, not to mention the inconvenience to the traveling public. Though these costs do not affect the current construction budget, they do affect future total budgets shared between maintenance, operations and construction. To account for this, the long-term costs should be incorporated over the life expectancy of the bridge alternates being considered. Economic analyses such as present-worth should be used with a typical life expectancy of 50 years.



Though economics are usually the most significant consideration, a particular site condition or service intent of a bridge may dictate a choice of an alternate other than the apparent most economical one. However, a rational economic analysis will give the Department and the public the needed knowledge of the additional cost required to satisfy any overriding peripheral issues controlling the choice of alternates.

### Analysis

Movable bridges are designed to sustain an intricate set of load conditions in addition to those for fixed bridges. These loads simulate wind, traffic and impact conditions under which the bridge must operate. Provisions for adjustment to balancing and for anticipated malfunctions are considered in the design and planning of a movable bridge, to minimize the probability of in-service structural or mechanical damage. Accordingly, certain structural design practices for movable bridges tend to be more conservative than those allowed in the specifications for fixed bridges. These practices are derived from engineering judgment and experience, and are intended to assure the long term durability and safety of such structures.

1. The moving elements of a movable bridge, including the supporting substructure, should be designed by the working stress methods.
2. A fifth load configuration and an additional group load shall be incorporated into the design of swing span bridges. The load configuration is:
  - a) "Case V: Unbroken Live Load - Bridge closed and considered as a continuous girder, but the live load placed so as not to cause negative reactions." <sup>1</sup>
  - b) An additional group loading combines Case I and Case V. This combination represents a malfunction condition where the wedges fail to drive and the span is operating under live load applied such that the ends bear on the rest piers.
3. The general policy of providing for an additional 600 N/m<sup>2</sup> for future wearing surface will not be incorporated into the design of movable (lift, swing, bascule) span structures. If resurfacing is required, the rehabilitated surface will match the original grade causing no additional weight or adjustments to the counterweight. The plans must indicate in the General Notes sheet that these structures have not been designed for future wearing surface.

### Design Details

1. Construction materials are strategically selected to achieve the most effective advantage in terms of strength, weight, and cost requirements. The deck (steel grid or concrete) of movable spans are chosen for light weight to minimize the

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<sup>1</sup> Movable Bridge, volume 1, O. E. Hovoy, John Wiley and Sons, Inc. 1926, pp. 191-192

counterweights, strength of supporting elements, and the power to operate the span.

C. MAIN GIRDERS SHALL BE ALLOWED TO DEFLECT TO A POSITION ABOVE THE FINISH GRADE POSITION, SUCH THAT ITS ORDINATES ARE NO CLOSER THAN 25% OF THE END LIFT DEFLECTION ORDINATES ABOVE THE FINISH GRADE ORDINATES (WEDGES DRIVEN). IF THE MAIN GIRDERS DO NOT DEFLECT ENOUGH TO MAKE CONTACT WITH THE FALSEWORK, WHEN PROPERLY ADJUSTED FOR THIS POSITION, SHIMS SHALL BE ADDED TO PROVIDE FULL SUPPORT IN THE DEFLECTED POSITION.

D. THE COUNTERWEIGHT SHALL BE POURED AND THE GRID DECK PLACED IN POSITION BUT NOT WELDED TO THE STRINGERS.

E. THE MAIN GIRDERS SHALL BE ALLOWED TO DEFLECT TO THE FINISH GRADE ORDINATES WITH THE END LIFTED.

F. THE CONCRETE DECK SHALL BE PLACED AND THE BRIDGE RAILING CONNECTIONS COMPLETED, ASSURING THAT THE ENDS OF THE SPAN WILL NOT DEFLECT BELOW FINISH GRADE. THE GRID DECK SHALL BE WELDED TO THE STRINGERS.

G. UPON COMPLETION OF THE ERECTION OF THE MAIN SPAN (INCLUDING INSTALLATION OF THE BALANCE WHEELS, THE PLACEMENT OF THE ESTIMATED NUMBER OF BALANCE BLOCKS ON THE COUNTERWEIGHTS NECESSARY TO BALANCE THE SPAN, PUMP, AND ROLLERS), THE SUPPORTING FALSE WORK SHALL BE REMOVED.

H. THE FREE SWINGING SPAN SHALL BE PRECISELY BALANCED AND THE ORDINATES MEASURED IN THE MORNING PRIOR TO SUNRISE TO AVOID TEMPERATURE EFFECTS. THE ORDINATES SHALL BE COMPARED TO THE FINISH GRADE ORDINATES, WITH THE ENDS NOT LIFTED. THE ROLLER BASE ELEVATIONS SHALL BE SET TO PRODUCE THE END LIFT DEFLECTION OF THE SPAN AT CONSTANT TEMPERATURE.

I. THE HORIZONTAL BASE LINE SHALL BE ROTATED WHILE THE SPAN IS FREE SWINGING TO PROVIDE FOR EQUAL END LIFTS WITH DESIGN TEMPERATURE DEFLECTION. THE BALANCE WHEELS SHALL BE ADJUSTED TO CLEAR THE TRACK BY NOT MORE THAN 0.8 mm WHILE THE SPAN IS IN THIS POSITION.

J. THE ROLLER BASE RISERS AND RISER WALLS ON THE REST PIERS SHALL BE PLACED AND THE ROLLER BASES INSTALLED. CHECK THE END LIFT SYSTEM TO ENSURE ITS ABILITY TO LIFT TO THE FINAL ORDINATES WITHOUT EXCEEDING THE DESIGN PRESSURE.

K. THE APPROACH SPANS ADJACENT TO THE MAIN SPAN SHALL BE PLACED WITH FINISH GRADE AND END DAMS ADJUSTED AS REQUIRED TO MATCH THE COMPLETED MAIN SPAN WITH ENDS LIFTED.

#### COUNTERWEIGHTS:

THE CONTRACTOR WILL BE REQUIRED TO MAKE THREE (3) TEST BLOCKS IN THE PRESENCE OF THE ENGINEER, AS REQUIRED BY THE STANDARD SPECIFICATIONS. THE ENGINEER WILL BE NOTIFIED OF THE TIME AND PLACE THAT THE TEST BLOCKS ARE TO BE MADE. THE RESULTS OF THE TEST BLOCKS ALONG WITH THE COUNTERWEIGHT CALCULATIONS MUST BE SUBMITTED TO THE BRIDGE DESIGN ENGINEER, WITH SUFFICIENT TIME ALLOWED FOR CHECKING, CORRECTIONS, AND APPROVAL PRIOR TO ERECTION OF THE SPAN."

## Special Requirements

1. The Department has a special way of presenting the mechanical and electrical drawing for movable bridges. This format must be followed on all projects, whether the plans are prepared in-house or by consultant engineers.
2. The operating house should be located with primary consideration for good visibility of the roadway, traffic gates, and the navigation channel. There not being any advantage to visibility, other criteria in order of importance are location of existing utilities and accessibility in open position on long arm (bobtail swing) downstream side. The designer should have the District Maintenance Engineer visit the site of the proposed bridge to recommend the location of the operating house. This is especially important when the alignment crosses a bend of the waterway.
3. The floor elevation of the operating house shall permit the standing operator to have a blind area of waterway 18 m, but no more than 30 m beyond the fascia of the bridge. This will require the floor elevation to be governed by the width of the structure.
4. When detailing the safety railing leading to the operators' house, it should be brought as close to the bridge rail as possible. The safety rail shall be continuous from the bridge to the house, so as to avoid any unsafe openings.
5. The access from the deck to the top of the pivot pier must be provided when the deck is in the open as well as closed positions. Platforms for the landings shall be provided with safety rails long enough to avoid accidents. Additionally, platforms for inspection and working areas of traffic gates, traffic barriers, and end lifts (swing spans) shall have safety rails as described above.
6. Access shall also be provided from the deck to the top of the rest piers. A platform may be required on the backside of the rest pier wall with a passageway through the wall, in order to provide adequate access. The designer should consult with the Bridge Maintenance Section in determining inspection requirements.
7. Traffic gates are located and striped in accordance with "Manual of Uniform Traffic Control Devices for Streets and Highways" (MUTCD) published by the Federal Highway Administration (see section in the manual on "List of Specifications . . . .Bridges"). When not installed on structures, traffic gates are normally located 1.8 m from the edge of roadway or 0.6 m from the outer edge of a sidewalk when present. Traffic gates are normally located 50 m in advance of the movable span or its barrier, if present. Consideration must also be given to the visibility of the gates to the motorists when establishing their actual location.

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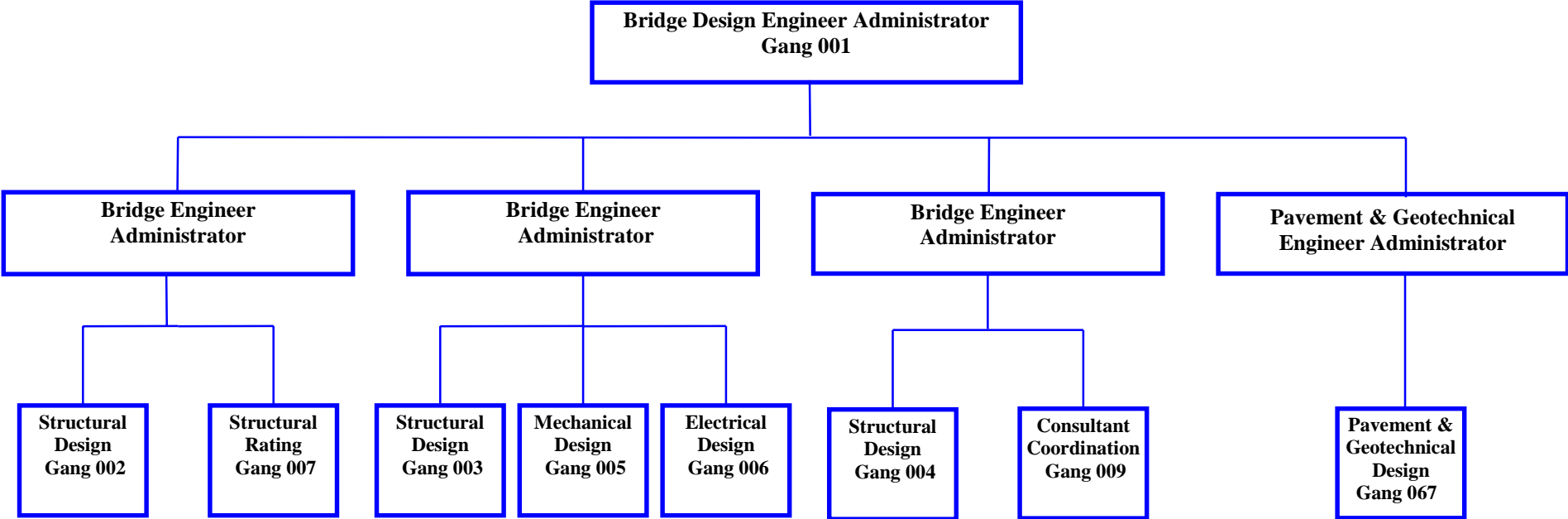
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# BRIDGE DESIGN ORGANIZATION CHART



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## Geotechnical Analysis

### GENERAL:

Normally, the location, number, and depth of soil borings will be recommended by the Geotechnical Design Section. The boring request form on the page 19 shall be used to order boring and consolidation tests through our Pavement and Geotechnical Design Section. If slope stability analysis is needed this should also be discussed and requested at this time.

For borings done in-house, three (3) sets of plans with the information described in items "1 through 6" listed below should be transmitted to our Pavement and Geotechnical Design Section. Upon receipt of this information, the Pavement and Geotechnical Design Section will order the boring logs & any additional soil information as deemed necessary for the project, including a fill height recommendation.

Some Consultant contracts require the Engineer to furnish the boring logs and test reports. For those contracts, items "1 through 6" listed below are to be submitted to the Department for approval prior to obtaining borings.

There will be some projects in which sufficient existing foundation information is available, thus eliminating the need for additional borings and foundation studies. It will be the responsibility of the Project Coordinator to request this information in writing.

Boring logs shall be included in the plan-in-hand drawings. However, in some cases, when they are not available, plan-in-hand field inspections may be made without boring logs. The boring logs shall be required as a part of the preliminary bridge plans in final form. Correlation of boring logs to actual elevation will be required and will be the responsibility of the Engineer.

The Engineer is to obtain approval from the Department for all foundation (roadway and bridge) design criteria to be used on any project, prior to submittal of preliminary plans. This will include foundation types and lengths (footings, piers, piles, drilled shafts, etc.), pile supported approach slabs, fill heights, retaining wall and sheet pile wall types and consolidation criteria (surcharge, wick drains, etc.)

Foundation studies can change structures from culverts to bridges or vice-versa. Also, the type of substructure and superstructure can be changed by these foundation studies.

Preliminary plans will show controlling fill heights as determined by or approved by the Department.

A foundation report may be required in special cases. The extent of bridge foundation studies, embankment studies, and format for the soil report is to be approved by the Department. This work should be completed and approved prior to submittal of preliminary bridge plans in plan-in-hand form.

The following listed information shall be furnished when requesting borings to be done through the DOTD Pavement & Geotechnical Design Section or if borings are to be obtained through consultant contract procedures:

1. Title sheet or vicinity map to locate projects.
2. Typical section of proposed embankment showing crown width and proposed side slopes.
3. Plan and profile of surveyed alignments and preliminary structure layout in plan and profile. (Submit plan sheets in a 11" X 17" format).
4. Plans to show approximate boring locations and recommended depths.
5. Type of structure being considered.
6. Fill heights and/or depth of cuts at bridge ends.

**BORING REQUEST FORM**  
 \*(one boring request form per site)\*

**PROJECT INFORMATION**

Construction No.: \_\_\_\_\_ Engineering No.: \_\_\_\_\_ Parish: \_\_\_\_\_  
 Project Name: \_\_\_\_\_  
 Route No: \_\_\_\_\_ Structure No.: \_\_\_\_\_ FAP No.: \_\_\_\_\_  
 Letting Date: \_\_\_\_\_ Project Alignment:  Original  New  
 Prelim. Plan Date: \_\_\_\_\_ Project Units:  English  Metric

**STRUCTURAL INFORMATION**

Bridge Length: \_\_\_\_\_ Pile Size and Type: \_\_\_\_\_ Pile Load: \_\_\_\_\_  
 Abutment Fill Height (Begin Bridge): \_\_\_\_\_ (End Bridge): \_\_\_\_\_ Bridge Width: \_\_\_\_\_  
 Projected Scour Elevation: \_\_\_\_\_  
 Are Old Borings Available From This Site?  YES  NO If YES, Please Include With Your Submittal  
 Will There Be Roadway Embankment?  YES  NO If YES, Complete the Following Information  
 New Embankment or  Widening Embankment Stations(Begin ): \_\_\_\_\_ (End): \_\_\_\_\_  
 Height at Beginning Station: \_\_\_\_\_ End Station: \_\_\_\_\_  
 Will There Be Embankment Walls?  YES  NO If YES, Complete the Following Information  
 MSE Wall or  Sheet Pile Wall Stations(Begin ): \_\_\_\_\_ (End): \_\_\_\_\_  
 Height at Beginning Station: \_\_\_\_\_ End Station \_\_\_\_\_  
 Are Cross-Sections Available?  YES  NO If YES, PLEASE PROVIDE COPIES  
 Special Comments? \_\_\_\_\_  
 Structural Information Completed By: \_\_\_\_\_ Date: \_\_\_\_\_

**FIELD & LABORATORY REQUEST**

(to be completed by the Pavement and Geotechnical Design Group)

Total Number of Borings Requested: \_\_\_\_\_  
 Sampling Frequency:  
 Standard \_\_\_\_\_  
 Continuous \_\_\_\_\_  
 Boring Depths:  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 Water Table: \_\_\_\_\_  
 Consolidation Testing: \_\_\_\_\_  
 Grain Size:

Boring Nos.	Sieve	Hydrometer	Depth
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	
	<input type="checkbox"/>	<input type="checkbox"/>	

Comments: \_\_\_\_\_  
 Field & Lab. Request Completed By: \_\_\_\_\_ Date: \_\_\_\_\_

⇒ **Required Attachments:** 4 COPIES OF GENERAL PLAN(S) & LOCATION MAPS (Rev. 02/22/01)



battered piles, bent numbers, station of centerline of each bent along profile grade line.

- d) Foundation plans are usually not required for trestle bent type construction. However, complex bridgework may require foundation plans for these type foundations.
- e) Foundation plans are usually required for pier type construction and should include information described in items "a - c" above.
- f) Details and information required to construct the bridge foundations shall be placed in tables for all projects. However, the information furnished in the tables should be properly correlated to the foundation drawings. Also, the tables should be located close to the foundation drawings.
- g) Actual maximum pile or shaft loads shall be shown in the plans for each pier or bent. Maximum soil pressure (dead load, live load) should be shown in the plans for other foundation types such as spread footings and retaining walls.

SPECIAL DETAILS, (spans, girders, bents, piers, footings, approach slabs, joints, bearings, retaining walls, etc.)

1. The design drawings shall include full details showing type of construction details of all structural members, connections, and splices and summary of quantities for each structural item.
2. All the structural drawings shall be to scale.
3. Tables may be utilized for similar structural items and details - provided the information in the tables and the detail drawings are properly correlated.
4. A deformed reinforcing steel summary of quantities is to be provided in the plans (including bar bending details) for each part of the bridge structure (spans, including precast concrete girders<sup>5</sup>, bents, piers, footings, columns, etc.). Dimensions relating to reinforcing steel fabrication are out-to-out of bar. Dimensions relating to reinforcing steel spacing are center-to-center of bar.
5. Listed below is some general information, which should be included in the plans when applicable.
  - a) Camber diagrams for proper fabrication of bridge members and construction of superstructure. Camber diagrams to include separate ordinates for beam dead load and any dead load to be placed upon the member (such as bridge barrier,

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<sup>5</sup> The reinforcing estimated quantities provided for such structure parts as precast-prestressed concrete members paid for per linear meter are for information purposes only. In such case as this, estimated quantities should be provided for a example (or nominal) members of each type.

curb, handrail, wearing surface) after the deck concrete is poured. Final camber ordinates must include correction for vertical curves.

- b) End and intermediate superstructure diaphragms to be located relative to centerline of joint.
- c) Bearing assemblies are to be fully detailed and the finished bearing elevation of each bearing are to be shown (in tables or special details).
- d) Beam dead load reactions for all bridge structures.
- e) Live load and dead load moments and shears for all steel spans. For curved steel spans show LL + DL moments and shears at 20th points.

## STANDARD BRIDGE PLANS AND DETAILS

The Bridge Design Section maintains standard plans and details for various structural bridge members, permanent signing and guardrail. These standard bridge plans and details may be obtained upon written request to the Bridge Design Engineer for incorporation into any DOTD project. These standard plans and details should be included in the final plans when they can be used. For more information, refer to chapter 8.

## MOVABLE BRIDGES

The final plans for mechanical drawings shall show complete layouts of the mechanical systems. All parts to be completely detailed and all commercial equipment shall be completely specified. A complete "bill of materials" shall be included in the mechanical plans. Since the Department has its own method of presenting mechanical drawings, the Engineer should become familiar with the detail practice of the Bridge Design Section prior to beginning any work. Details for the mechanical system should be similar to details usually presented in mechanical shop drawings.

## ELECTRICAL PLANS

1. The final plans shall include complete electrical plans, including conduit and equipment layout; control schematics; and complete details of all fabricated, assembled, or otherwise made-up parts; and complete specifications of all commercial equipment and apparatus. Furnish complete design of electrical and illumination systems and of all components. Since the Department has its own method of presenting the wiring diagrams, the Engineer should become familiar with the detail practice of the Bridge Design Section prior to beginning any work.

2. The plan shall include complete power and control elementary wiring diagrams with all conductors and equipment and apparatus identified; complete conduit and wire layout; detail drawings and equipment list.
3. When necessary, written special provisions shall be supplied.
4. The Engineer shall be responsible for obtaining written confirmation from the utility company as to their ability to supply proposed load.

#### PERMANENT SIGNING PLANS

1. For projects requiring permanent signing, separate detail sheets showing the signing layout, signing quantities and specific signing details are required. The permanent signing is normally coordinated through our Geometric Design Section.
2. Permanent signing standard details are maintained by the Bridge Design Section. These details include small ground signs (breakaway) and large overhead signs. Structure mounted special support details (bridge, median barrier, retaining wall, etc.) for large overhead signs are not shown on the standard sign details; these must be designed and detailed on an individual basis for each specific sign when required.

#### Bridge Plans In Final Form (A.C.P's submittal procedure)

1. The Engineer shall submit "reproducibles" of the "Advance Check Prints" (95% Final Plans) along with any required special provisions and a construction cost estimate for review and comments. Each sheet must be stamped by a Civil Engineer registered by the State of Louisiana.
2. The plans, specifications, and estimates are to be reviewed by the Department of Transportation and Development and others that may be involved such as the Federal Highway Administration, etc. The Department will advise the Engineer of all comments, errors and omissions relative to the plans, specifications, and estimate; which shall be revised and/or corrected by the Engineer. Please be advised that this is only a cursory check and the Engineer is responsible for the accuracy and completeness of the plans.
3. The Engineers are to work closely with the Department in order that the final plans, specifications and estimates may be completed and ready for the proposed contract letting date.

### Construction Specifications

- a) Latest approved Louisiana DOTD Standard Specifications for Roads and Bridges.
- b) Special provisions and supplemental specifications.

### Welding Specifications

Welding of structural steel, steel pipe and tubular members, reinforcing steel and aluminum alloys shall conform to Section 815 of the latest edition of the DOTD Standard Specifications for Roads and Bridges.

### Loading

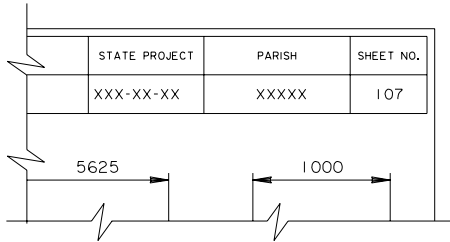
- a) Dead Load - Calculated weight of structure plus  $600 \text{ N/m}^2$  future wearing surface. Dry weight of earth  $20 \text{ kN/m}^3$ ; equivalent fluid pressure  $9.8 \text{ kN/m}^3$ .
- b) Live Load - Design Live Load shall be AASHTO designation MS-18 Truck or Lane Load or HST-18(M) Truck Load, whichever governs except that HST-18(M) shall generally not be used for local roads and streets except where heavy truck traffic exists. Alternate Military Load shall be applied on the Interstate System. Only MS-18 Truck or Lane Loading shall be used for fatigue design when applicable. For two design traffic lanes, the load lanes may be adjacent to and touching one another, causing the wheel loads to be 1.2 meters apart.
- c) Wind Loads - Wind forces are to be applied in accordance with the AASHTO Specifications.
- d) Seismic Loading must be investigated in accordance with the AASHTO Specifications (Guide Specifications for Seismic Design of Highway Bridges).
- e) Other loads such as temperature and stream forces shall be in accordance with the latest AASHTO specifications.

### Materials and Required Strengths

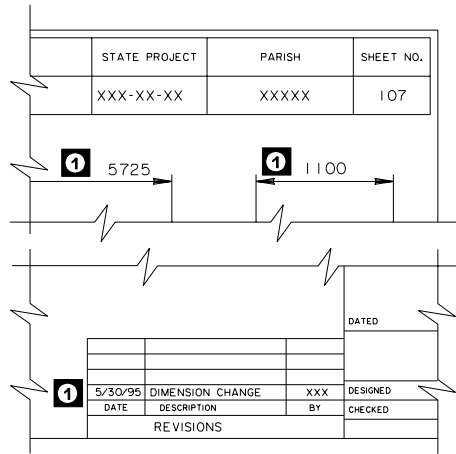
- a) Reinforcing Steel - Reinforcing steel bars shall be Grade 420.

1. IF MINOR REVISIONS ARE NEEDED, MAKE CHANGES ON THE ORIGINAL SHEET.  
ERASURES ARE ALLOWED. FOR EXAMPLE:

ORIGINAL SHEET

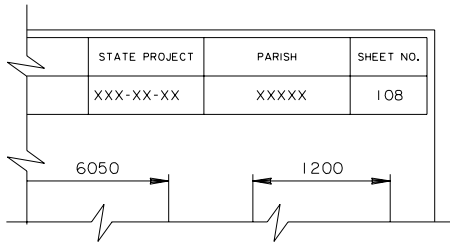


CORRECTED SHEET

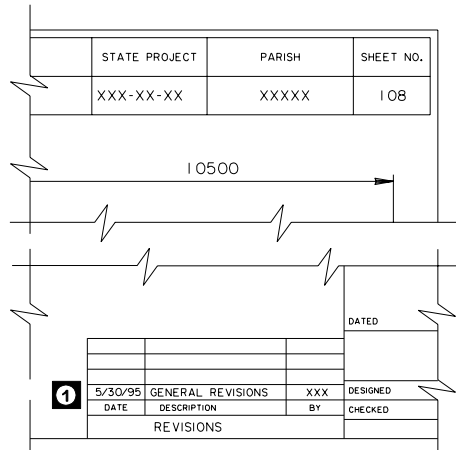


2. IF MAJOR REVISIONS ARE NEEDED, DESTROY THE ORIGINAL SHEET AND MAKE CHANGES ON THE NEW SHEET FOR EXAMPLE:

ORIGINAL SHEET



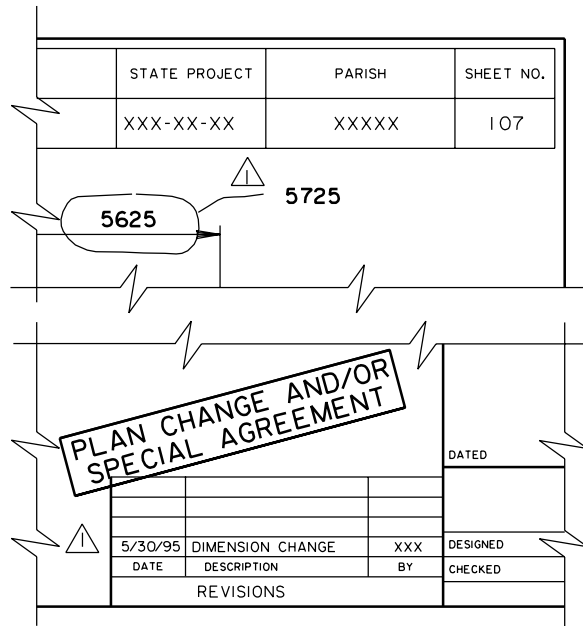
CORRECTED SHEET



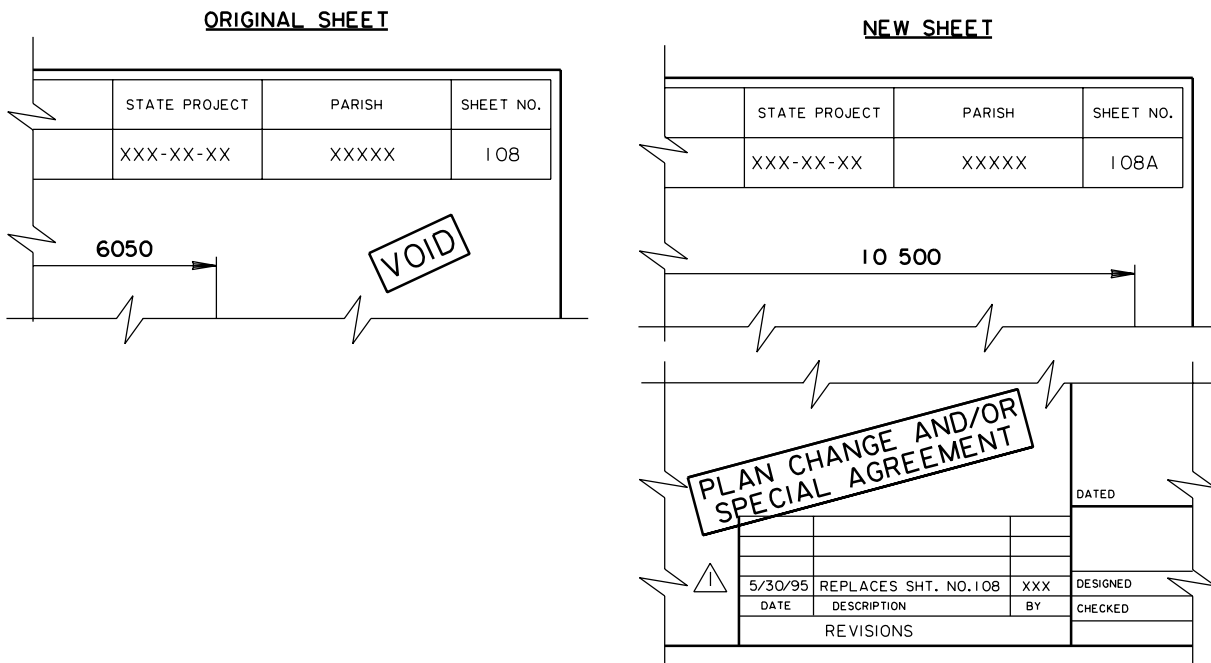
3. SHOW REVISION NUMBER (①) FOR ALL REVISED SHEET NUMBERS (INCLUDING TITLE SHEET NUMBER) IN THE TITLE SHEET REVISION BLOCK.
4. IF QUANTITIES ARE INVOLVED, REVISE COST ESTIMATE.
5. THE TITLE SHEET REVISION BLOCK MUST BE SIGNED BY THE CHIEF ENGINEER.
6. TRANSMIT A SET OF PRINTS AND A COPY OF ESTIMATE TO CONTRACTS AND SPECIFICATIONS SECTION.
7. RETURN THE REVISED PLANS TO GENERAL FILES.

## REVISION PROCEDURE

1. IF A MINOR PLAN CHANGE IS REQUIRED, MAKE THE CORRECTIONS ON THE ORIGINAL SHEET. (NO ERASURES!) NOTE THE CORRECTIONS WITH A "BUG" (Δ) AND SHOW IT IN THE REVISION BLOCK. FOR EXAMPLE:



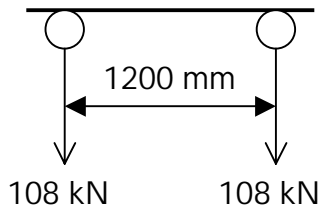
2. IF MAJOR PLAN CHANGE, MAKE CORRECTIONS ON NEW SHEET, ADD "A" TO SHEET NUMBER, AND STAMP "VOID" ON ORIGINAL SHEET. FOR EXAMPLE:



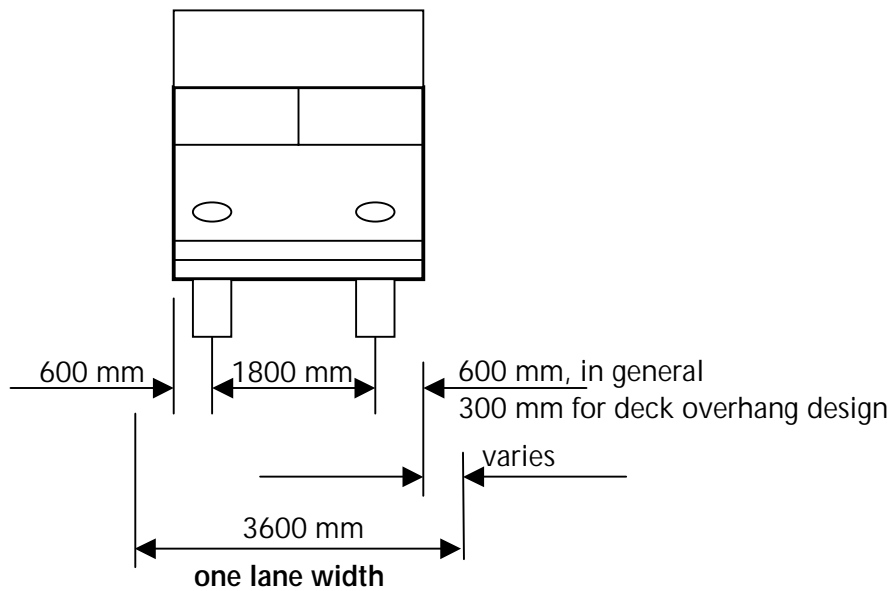
3. DON'T SHOW ANYTHING ON THE TITLE SHEET.
4. IF THE CHANGES ARE SIGNIFICANT, SHOW QUANTITY CHANGES ON BRIDGE SUMMARY SHEET.
5. TRANSMIT 18 HALF-SIZED SETS OF PRINTS OF AFFECTED SHEETS, WITH A MEMORANDUM TO THE CHIEF CONSTRUCTION ENGINEER. TRANSMIT ONE SET OF HALF-SIZED PRINTS TO THE PROJECT ENGINEER, BY COPY OF THE MEMORANDUM. IF CONSULTANTS ARE INVOLVED, SEND THEM A HALF-SIZED SET BY COPY OF THE MEMORANDUM. IF REAL ESTATE AND UTILITIES ARE INVOLVED, FULL-SIZED SETS ARE TO BE TRANSMITTED, 10 TO REAL ESTATE AND 1 TO UTILITIES, BY COPY OF MEMORANDUM.
6. RETURN PLANS TO GENERAL FILES.

## PLAN CHANGE PROCEDURES

## Military Loading



## Transverse View of Loading



## Sound Wall Load:

Bridges which require installation of Sound Walls shall be designed to accommodate the appropriate dead, live and wind loads for the required wall height. Dead loads of the wall shall be minimum of 45 kg/m for wall heights up to 3 meters and 90 kg/m for walls greater than 3 meters.

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## Examples

Given:  $V = 100 \text{ km/h}$

$$R = 600 \text{ m}$$

$$nc = 0.025$$

$$e_{\max} = 10\%$$

$$e = .078$$

$$MRS = 1 / 222$$

(standard cross-slope)

(DOTD rural standard)

(from AASHTO Table III-10)

(from AASHTO Table III-13)

### Rotate about centerline

A) two 3.6 m lanes

no shoulders

$$L = 3.6 \text{ m}$$

(distance from rotation line to edge of rotated surface)

$$LF = 1.0$$

(function of L and page 180, AASHTO)

run = rise / slope

$$AB = [\text{lane} * nc / MRS] * LF = 3.6(0.025) 222 (1.0) = \mathbf{0.09(222)} \cong 20 \text{ m (runout)}$$

$$BD = [\text{lane} * e / MRS] * LF = 3.6(0.078) 222 (1.0) = \mathbf{0.28(222)} \cong \underline{62 \text{ m}} \text{ (matches Table III-10)}$$

AD = superelevation transition length

$$\mathbf{82 \text{ m}}$$

$$g = \text{rise} / \text{run} = (nc + e) * L / AD = (.025 + .078)3.6 / 82 = \mathbf{0.004522 \text{ m/m}}$$

Remainder of the superelevation diagram geometry can be determined from the **control values**.

B) four 3.6 m lanes

no shoulders

$$L = 3.6 * 2 = 7.2 \text{ m}$$

(distance from rotation line to edge of rotated surface)

$$LF = 1.5$$

(function of L and page 180, AASHTO)

$$AB = 3.6 (0.025) 222 (1.5) \cong 30 \text{ m}$$

$$BD = 3.6 (0.078) 222 (1.5) \cong \underline{94 \text{ m}} \text{ (matches Table III-10)}$$

$$AD = \frac{\quad}{124 \text{ m}}$$

$$g = (0.025 + 0.078)7.2 / 124 = 0.005981 \text{ m/m}$$

Minimum Runoff Lengths may be controlled by the two second rule rather than the Maximum Rate of Slope (MRS) when radii larger than minimum values are used for a given design velocity.

B') same as B, except R=1200 m

$$e = 4.3$$

(from Table III-10)

$$\begin{aligned} BD &= [\text{lane} \cdot e / \text{MRS}] * LF = 3.6(.043)222(1.5) = 51.6\text{m} \\ &> \text{distance traveled in 2 seconds} \\ &= \text{time} \cdot \text{velocity} * LF \\ &= 2 \text{ seconds (100 kph)} 1.5 [1000\text{meters/kilometer}][1 \text{ hour}/3600 \text{ seconds}] \\ &= 55.6 \text{ meters} * 1.5 &= 84 \text{ m} \quad \{\text{controls}\} \quad (\text{matches Table III-10}) \\ AB &= BD \cdot n_c / e = 84 * .025 / .043 &= \underline{48 \text{ m}} \\ & &132 \text{ m} \\ g &= (.025 + .043) 7.2 / 132 = 0.003709 \text{ m/m} \end{aligned}$$

C) two 3.6 m lanes

two 3.0 m shoulders

$$L = 3.6 + 3.0 = 6.6 \text{ m}$$

$$LF = 1.4$$

$$\begin{aligned} AB &= 3.6 (0.025) 222 (1.4) &\cong 28 \text{ m} \\ BD &= 3.6 (0.078) 222 (1.4) &\cong \underline{88 \text{ m}} \\ AD &= &116 \text{ m} \\ g &= (0.025 + 0.078) 6.6 / 116 = 0.005860 \text{ m/m} \end{aligned}$$

### Rotate about low gutter

[Page 187 of *A Policy on Geometric Design of Highways and Streets*, 1994 AASHTO, indicates that when rotation is about roadway edge, runoff lengths are similar to those for a centerline rotation with the same roadway width. This is consistent with page 177 where the MRG between profiles of edges of two-lane traveled ways is allowed to double. One way to account for this is by using a lane factor (LF) based on an adjusted length ( $L' = \frac{1}{2} L$ ) when calculating the required runoff length.]

D) two 3.6 m lanes

no shoulders

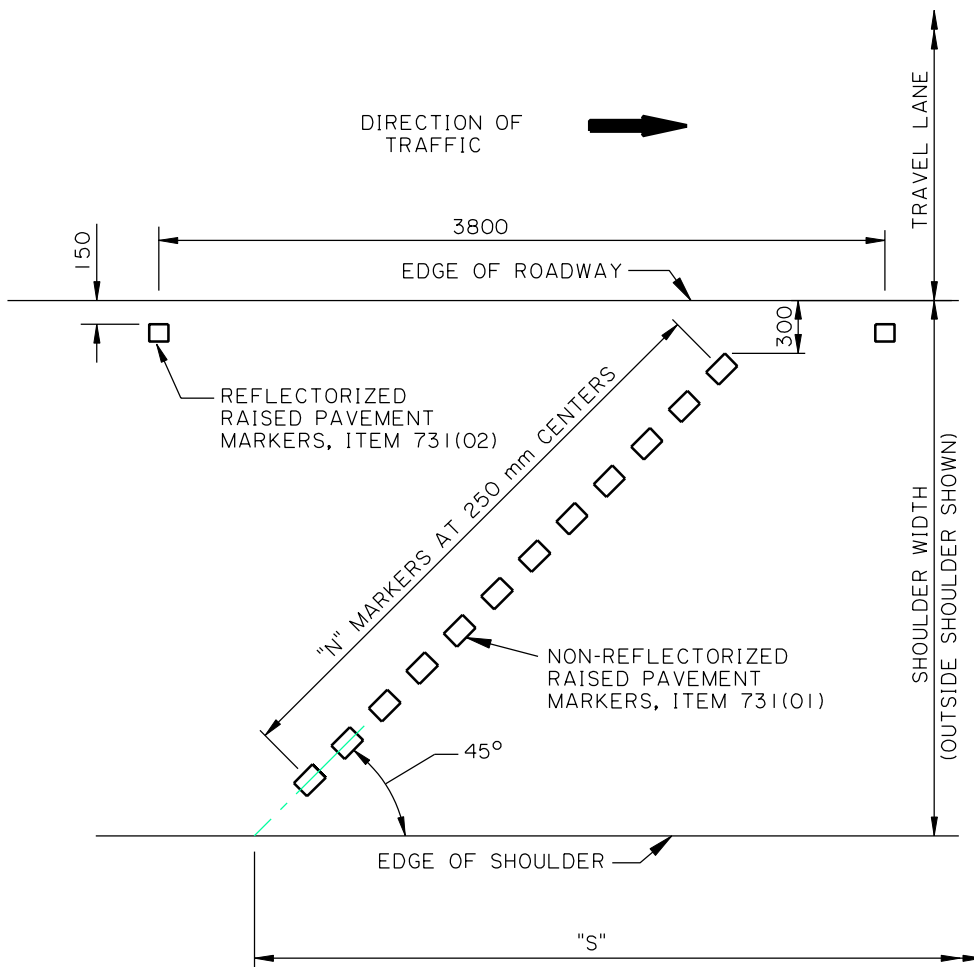
$$\begin{aligned} L &= \text{lanes} + \text{shoulders} = 2 * 3.6 = 7.2 \text{ m} \quad (\text{dist. from rotation line to edge of rotated surface}) \\ L' &= \frac{1}{2} * L = \frac{1}{2} * 7.2 = 3.6 \text{ m} \quad (\text{corrected width for determining LF for low gutter rotation}) \\ LF &= 1.0 &(\text{function of } L' \text{ and page 180, AASHTO}) \\ BC &= [\text{lane} * n_c / \text{MRS}] * LF = 3.6 (0.025) 222 (1.0) = \mathbf{0.09(222)} \cong 20 \text{ m} \\ CD &= [\text{lane} * (e - n_c) / \text{MRS}] * LF = 3.6 (0.078 - 0.025) 222 (1.0) \cong \underline{42 \text{ m}} \\ BD &= [\text{lane} * e / \text{MRS}] * LF = 3.6 (0.078) 222 (1.0) = &\mathbf{62 \text{ m}} \quad (\text{matches Table III-10}) \\ g &= [(\text{runout width}) * n_c + L(e - n_c)] / BD \\ &= [(3.6 * 0.025) + 7.2 * (0.078 - 0.025)] / 62 = (.09 + .3816) / 62 = \mathbf{.4716} / 62 = \mathbf{.007606 \text{ m/m}} \end{aligned}$$

## BRIDGE DECK DRAINAGE

1. On concrete slab span and precast-prestressed concrete girder span bridges, 150 mm diameter deck drains are typically provided along low gutter lines on 3000 mm centers. Spans directly over railroads, roadways, or embankments do not have these drains. On steel bridges, the need for drains is investigated, and when required, drains, which extend their outlet to below the low steel, are used. Design of drains such as scuppers may be found in the Bridge Deck Drainage References, November 1989, DOTD Hydraulics Section and the *Hydraulic Engineering Circular No. 21*, May 1993, Publication No. FHWA-SA-92-010.
2. Structures with significant vertical curves or which incorporate higher embankments ( $\geq 3000$  mm above natural ground elevation) and have large deck drainage areas ( $\geq 250$  m<sup>2</sup>) are susceptible to embankment erosion and should incorporate bridge end drains where needed.

## BRIDGE DECK TRAFFIC MARKERS

1. The summary of estimated bridge quantities should include raised pavement marker items for all structures with lengths of 60 m or more.
2. The designer must check with the Road Design Section to ensure that all striping and lane separating reflectorized markers on the structure are accounted for under the roadway pay items.



\* THE DIAGONAL MARKINGS ARE INTENDED FOR TWO-LANE BRIDGES AS WELL AS DIVIDED MULTI-LANE FACILITIES. SEE STANDARD PLAN PM-01-M FOR MORE DETAILS.

SHOULDER WIDTH (METERS)	NUMBER OF MARKERS PER DIAGONAL (N)
3.6	18
3.0	15
2.4	11
1.8	7
1.2	3
< 1.2	NOT REQUIRED

BRIDGE LENGTH (METERS)	REQUIRED SPACING (S) (METERS)
> 150	30
60-150	15
< 60	NOT REQUIRED

THE LAYOUT SHOWN ABOVE CANNOT BE USED WHERE THE BRIDGE WIDTH IS LESS THAN THE APPROACH WIDTH. SEE PM-01-M FOR DETAILS.

**TYPICAL TRAFFIC MARKER  
PLACEMENT ALONG BRIDGE SHOULDER**

## Deck Design Details

1. Deck thickness shall vary from a minimum of **180 mm** to a maximum of **220 mm** in **20 mm** increments. Optional deck panels will not be allowed as an alternate for **180 mm** decks. Any deck thickness other than 200 and 220 mm, shall be considered a special case, and will have to be approved by the Bridge Design Engineer. Exception, lift spans generally have 165 mm deck.
2. A suggested pouring sequence for continuous spans is to be provided for spans over **25 m** in length, giving the minimum rate of pour in cubic meters per hour. The necessary information should be added to the "Miscellaneous Span and Girder Details" sheet 1 of 3. The pouring sequence is based on a 4 hour set time and attempts to minimize cracks in the top of the deck. Try to break the deck into segments at contraflexure points and pour positive moment areas first unless a continuous pour across the support is possible. See Louisiana Standard Specifications article 805.03(d) and limit rate to 45 m<sup>3</sup> per hour.
3. Reinforcing steel shall have **50 mm** cover at the top of the slab, and **25 mm** cover at the bottom of the slab.
4. Main reinforcing bars shall be **#15, or #20** and be placed as near perpendicular to the girders as possible.
5. Longitudinal reinforcing bars shall be **#10**, unless a larger size is needed for continuity over the bents. The top plane of longitudinal steel shall have a maximum spacing of **300 mm** center to center.
6. All bars greater than **#10** will have a detailed maximum length of 18.0 m unless spliced. **#10** bars shall be limited to 12.2 m in length for handling purposes.
7. Main reinforcing steel shall have a minimum spacing of **120 mm** and not greater than the gross deck thickness plus 5 mm.
8. Interpolation of reinforcing steel in deck design table will be allowed only between two sets of identical bar size.
9. 150 mm diameter drains should not be used directly above lower travel lanes, R.R. tracks or abutment slopes, even if revetment is present.
10. Optional deck panels are restricted from use in areas with severely skewed joints (see optional deck panel sheets for geometric limits). On bridges in curves or variable width roadways, the contractor may be allowed to use panels if he provides an independent check of his design and review of all shop drawings at no additional cost.

9. The maximum spacing of tie reinforcement shall meet AASHTO 9.20.4.5 as given in the table below.

AASHTO TYPE PPCG	MAXIMUM TIE SPACING(mm)	
	#10	#15
II	600	600
III	550	600
IV	450	600
BT	210	425

$$S \leq A \times F_y \div 0.345 \times b_v$$

10. For prestressed girder projects in which the contractor elects to fabricate all the girders at the same time but girder placement will extend more than 4 months after casting (such as for phased construction or very large projects), the contractor will be required to account for camber growth. Camber for each girder shall be measured prior to erection and project engineer acceptable adjustments (such as lowering riser elevations) shall be made such that the top girder flange does not enter the bottom of the deck (maintain a positive haunch).
11. Girder Stability must be checked for transport and erection when  $L / W > 35$ ; where L is the girder length and W is the girder flange width (see PCI Bridge Design Manual 8.10).

#### Applicable Standard Drawings

1. Miscellaneous Span and Girder Details (4 sheets).



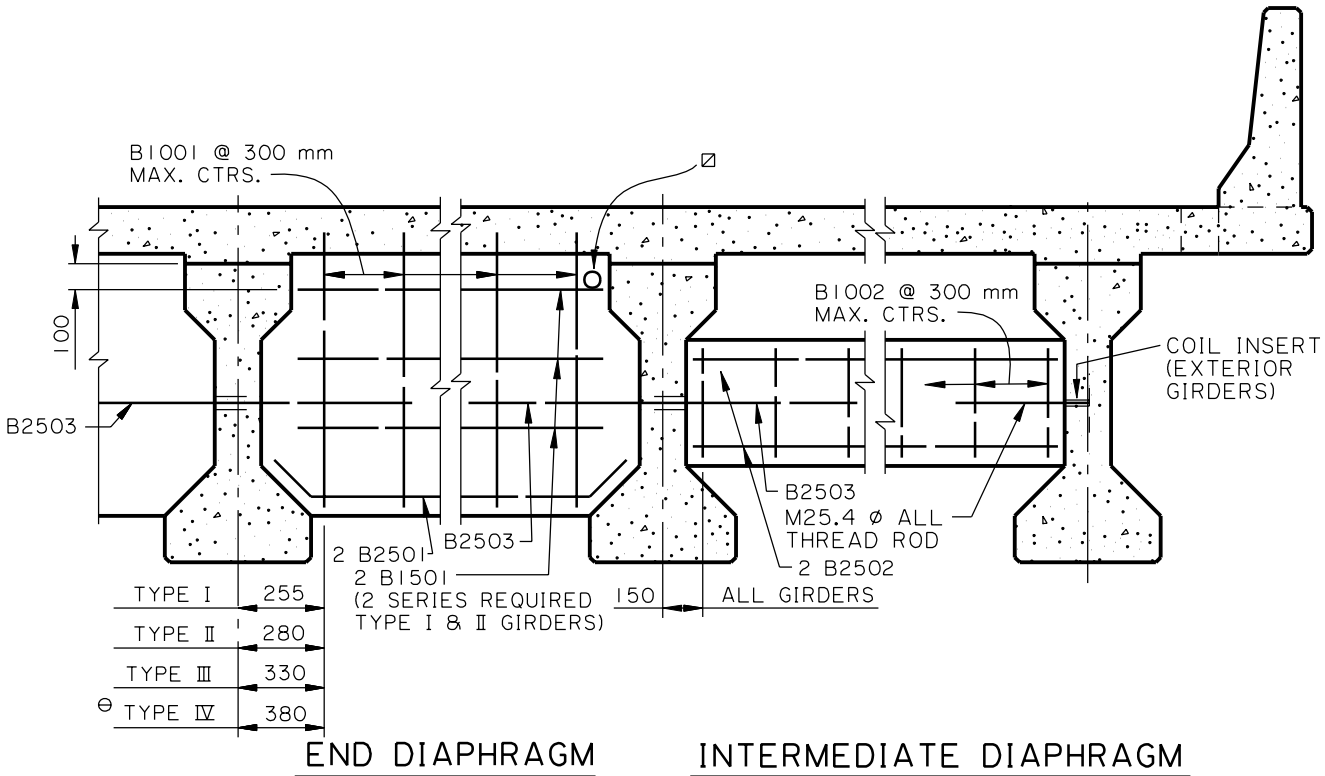
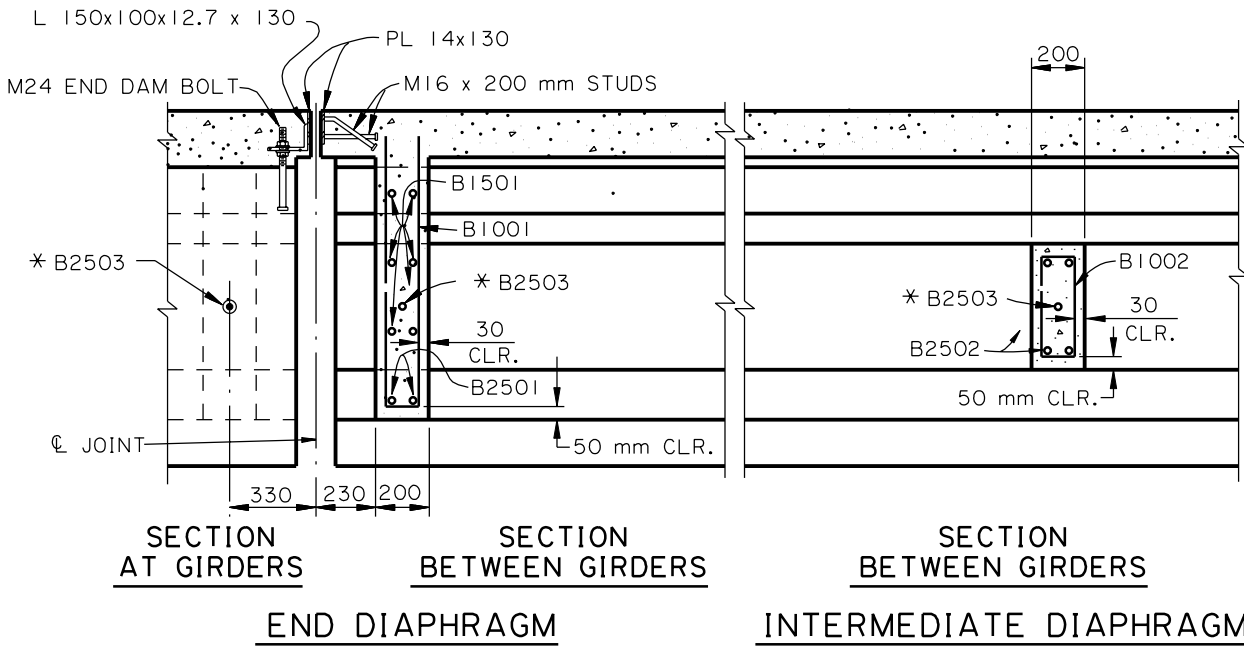
## Strand Properties Table

ASTM DESIGNATION A 416 UNCOATED 7-WIRE STRANDS FOR PRESTRESSED GIRDERS								
Strand Size (Dia)	Strand Grade (MPa)	Breaking Strength (kN)	Nominal Area (mm <sup>2</sup> )	Weight (kg/ 1000 m)	Initial Load (kN) ⊙	Load @ 1% Extension (kN)	Initial Tension (70% Breaking Strength) (kN)	Initial Tension (75% Breaking Strength) (kN)
9.5 mm	1725	89.0	51.61	405	8.9	75.6	62.3	-----
	1860 S.R.	102.3	54.84	432	8.9	87.0	71.6	-----
	1860 L.R.	102.3	54.84	432	8.9	92.1	-----	76.7
11.1 mm	1725	120.1	69.68	548	12.0	102.3	84.1	-----
	1860 S.R.	137.9	74.19	582	13.8	117.2	96.5	-----
	1860 L.R.	137.9	74.19	582	13.8	124.1	-----	103.4
12.7 mm	1725	160.1	92.90	730	16.0	136.2	112.1	-----
	1860 S.R.	183.7	98.71	775	18.4	156.1	128.6	-----
	1860 L.R.	183.7	98.71	775	18.4	165.3	-----	137.8
15.24 mm	1725	240.2	139.35	1094	24	216.2	168.1	-----
	1860 S.R.	260.7	140.00	1102	26.1	221.5	182.5	-----
	1860 L.R.	260.7	140.00	1102	26.1	234.6	-----	195.5

S.R. DENOTES STRESS-RELIEVED.  
L.R. DENOTES LOW-RELAXATION.

⊙ INITIAL TENSION PRIOR TO RELEASE OF STRANDS.

\* EXTERIOR GIRDERS ONLY USE  
M25.4  $\phi$  x 965 mm ALL THREAD ROD



**NOTES:**

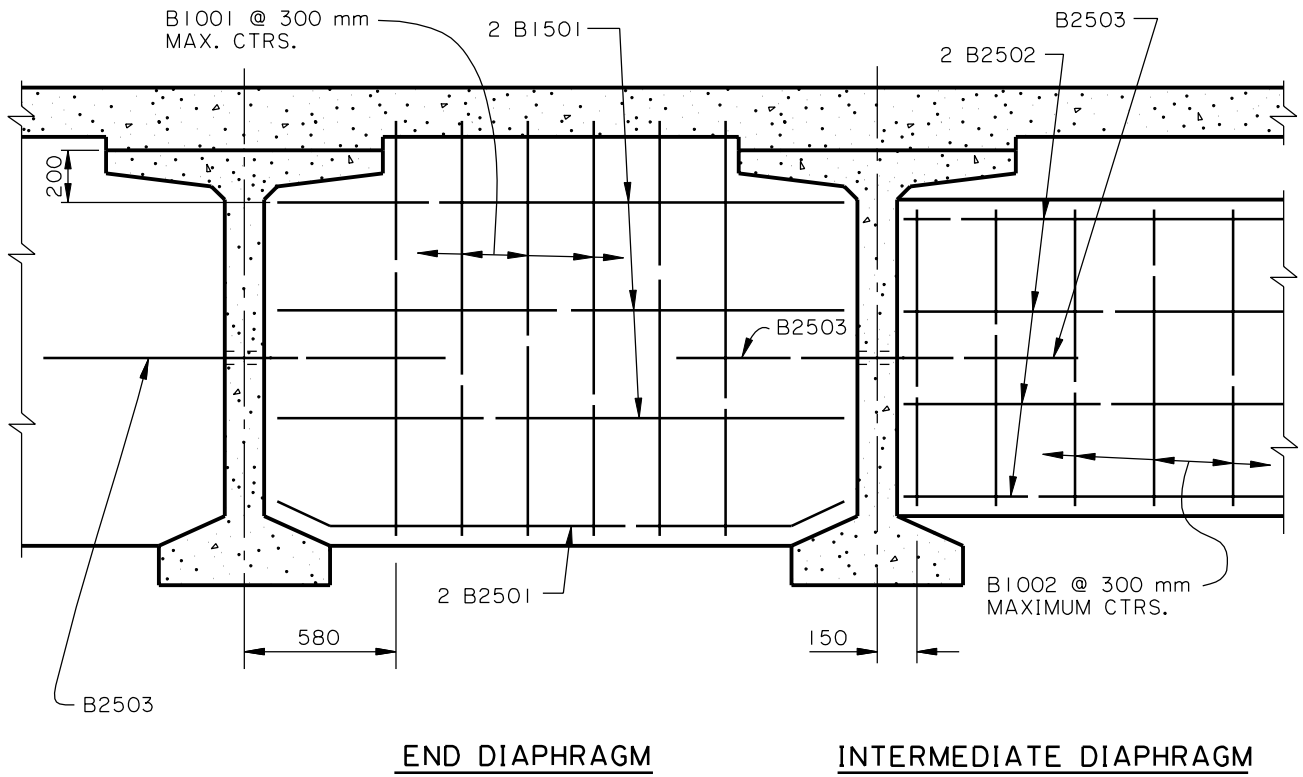
SPANS > 15 m REQUIRE ONE INTERMEDIATE DIAPHRAGM.  
SPANS > 30 m REQUIRE TWO INTERMEDIATE DIAPHRAGMS.

⊠ 75 mm  $\phi$  VENT HOLE IN EACH END DIAPHRAGM WHERE INUNDATION BY FLOOD IS POSSIBLE.

⊕ INCLUDES TYPE IV-MODIFIED

TYPE I-IV (END & INTERMEDIATE DIAPHRAGMS)

DIAPHRAGM DETAILS



TYPICAL DIAPHRAGM DETAILS

(TYPE BT)

**NOTE:**

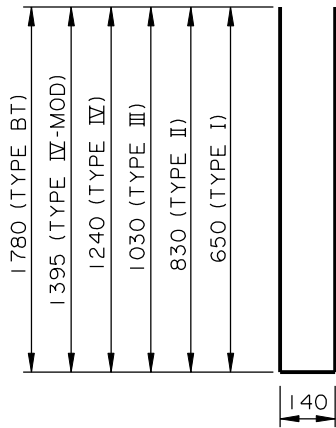
DETAILS NOT SHOWN ARE SIMILAR TO  
DETAILS SHOWN ON SHEET 1 OF 8.

TYPE BT (END & INTERMEDIATE DIAPHRAGMS)

**DIAPHRAGM DETAILS**

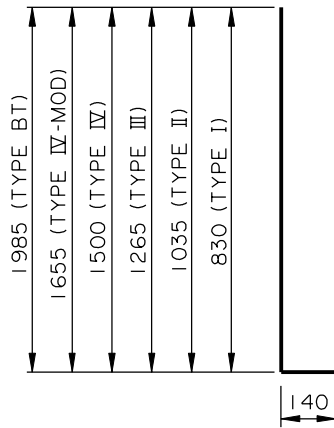
## TOTAL LENGTH OF BARS

BAR	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE IV-MOD.	TYPE BT
B1001	1440	1800	2200	2620	2930	3700
B1002	N/A	1060	1260	1460	1460	3050
B1003	1800	2210	2670	3140	3450	4110
B1501	"Z"	"Z"	"Z"	"Z"	"Z"	"Y"
B2501	"X"+220	"X"+280	"X"+380	"X"+500	"X"+500	"X"+440
B2502	"Y"	"Y"	"Y"	"Y"	"Y"	"Y"
B2503	1980	1980	1980	1980	1980	1980



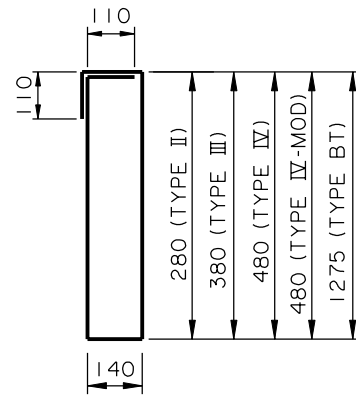
**B1001**

(45 mm  $\phi$  PIN)



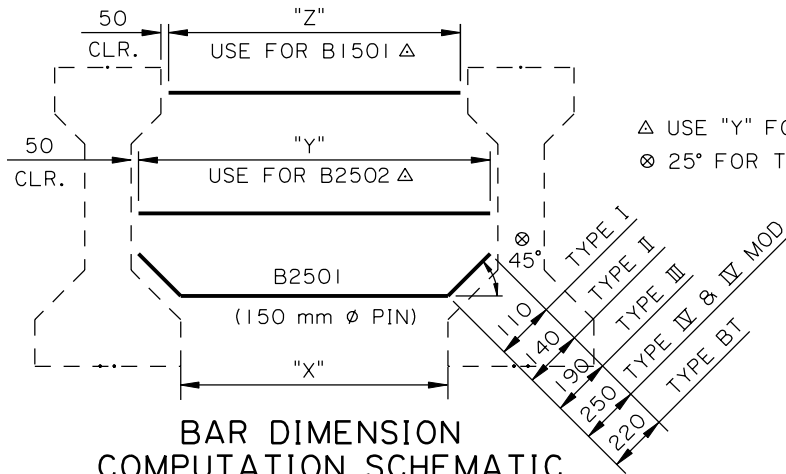
**B1003**

(45 mm  $\phi$  PIN)



**B1002**

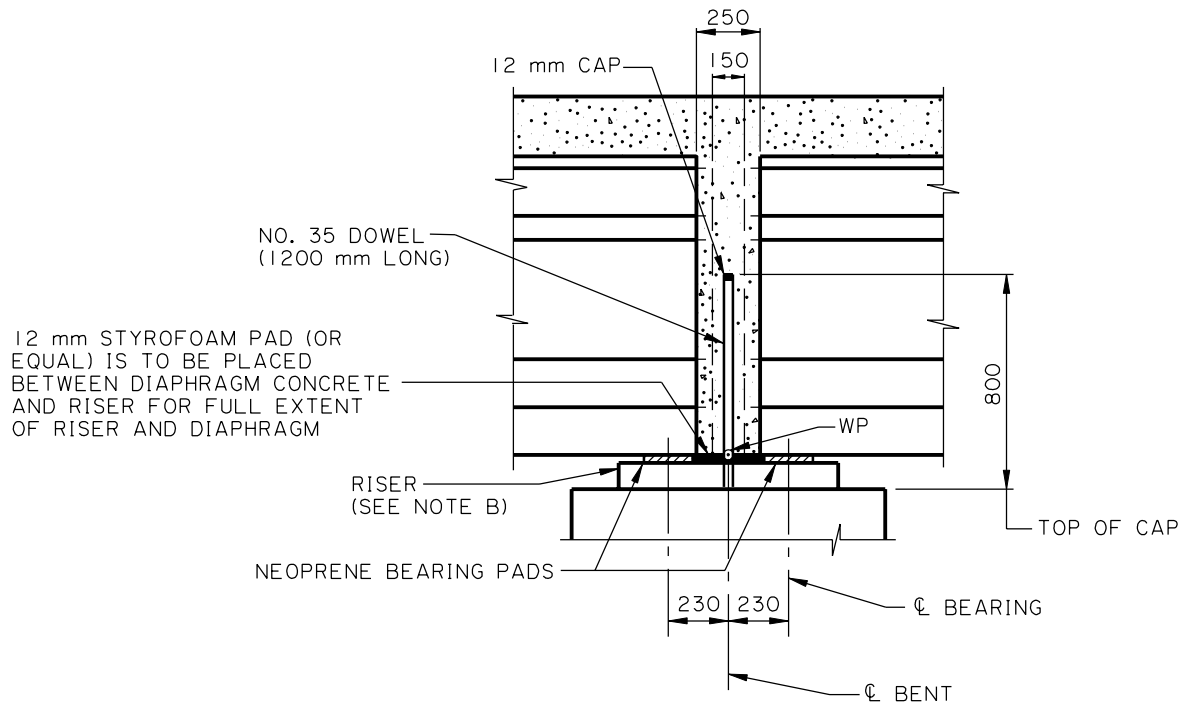
(45 mm  $\phi$  PIN)



**BAR DIMENSION  
COMPUTATION SCHEMATIC  
(B1501, B2501, B2502)**

TYPE I-IV AND BT (REINFORCING STEEL)

## DIAPHRAGM DETAILS



## CONNECTION DETAIL AT CONTINUITY DIAPHRAGM

### NOTE A

DOWELS IN THE CAP SHALL BE GALVANIZED NO. 35 DEFORMED REINFORCING STEEL. PRIOR TO POURING THE CONTINUITY DIAPHRAGM, EACH DOWEL SHALL BE SHEATHED BY 45 mm I.D. RIGID SLEEVE WITH A 12 mm THICK COMPRESSIBLE CAP ABOVE THE TOP OF THE DOWEL TO ALLOW THE GIRDERS TO DEFLECT ON THEIR BEARING PADS UNDER FUTURE LOADS.

TO FACILITATE PLACEMENT OF GIRDERS, THE CONTRACTOR MAY SET THE NO. 35 DOWELS BY ONE OF THE FOLLOWING METHODS:

- 1) SETTING DOWELS IN APPROVED NON-SHRINK GROUT IN PREFORMED HOLES HAVING A MINIMUM DIAMETER OF 75 mm.
- 2) SETTING DOWELS AT INITIAL CASTING OF CAP.

### NOTE B

RISERS AT FIXED BENTS SHALL BE SLOPED TO APPROXIMATE TANGENT GRADE AT CL BENT. ELEVATIONS SHOWN FOR THESE RISERS ARE AT CL BENT.

CONNECTION DETAIL AT CONTINUITY DIAPHRAGM

## DIAPHRAGM DETAILS

9. The curb and railing dead load will be placed on the composite section of the exterior girder only.
10. The steel section of exterior girders shall have at least the same structural capacity as the interior girders for future widening purposes.
11. For the design of friction type connections surface condition "A", (clean mill scale) will be assumed.
12. Structural steel may be A 709 Grades 250, 345 or 345W. Gusset plates, stiffeners, bracing and other secondary members are generally designed using Grade 250.
13. Utilize plastic design when allowed.

## DETAILING

1. The haunch shall be set so there is no encroachment by cover splice plates and their connectors into the deck.
2. Cantilevered deck slabs shall have their bottom surface aligned with the bottom of the girder flange.
3. The flange widths shall preferably be specified in multiples of **50 mm**. Flange thickness will be specified in multiples of **5 mm** for  $t < 60 \text{ mm}$  and **10 mm** multiples for  $t \geq 60 \text{ mm}$ .
4. The web plate heights shall be specified in multiples of **50 mm**. Web thickness will be designed as follows:

$$\begin{array}{ll}
 10 \text{ mm} \leq t \leq 22 \text{ mm} & 2 \text{ mm increments from } 10 \text{ mm} \\
 t > 22 \text{ mm} & 5 \text{ mm increments from } 25 \text{ mm}
 \end{array}$$

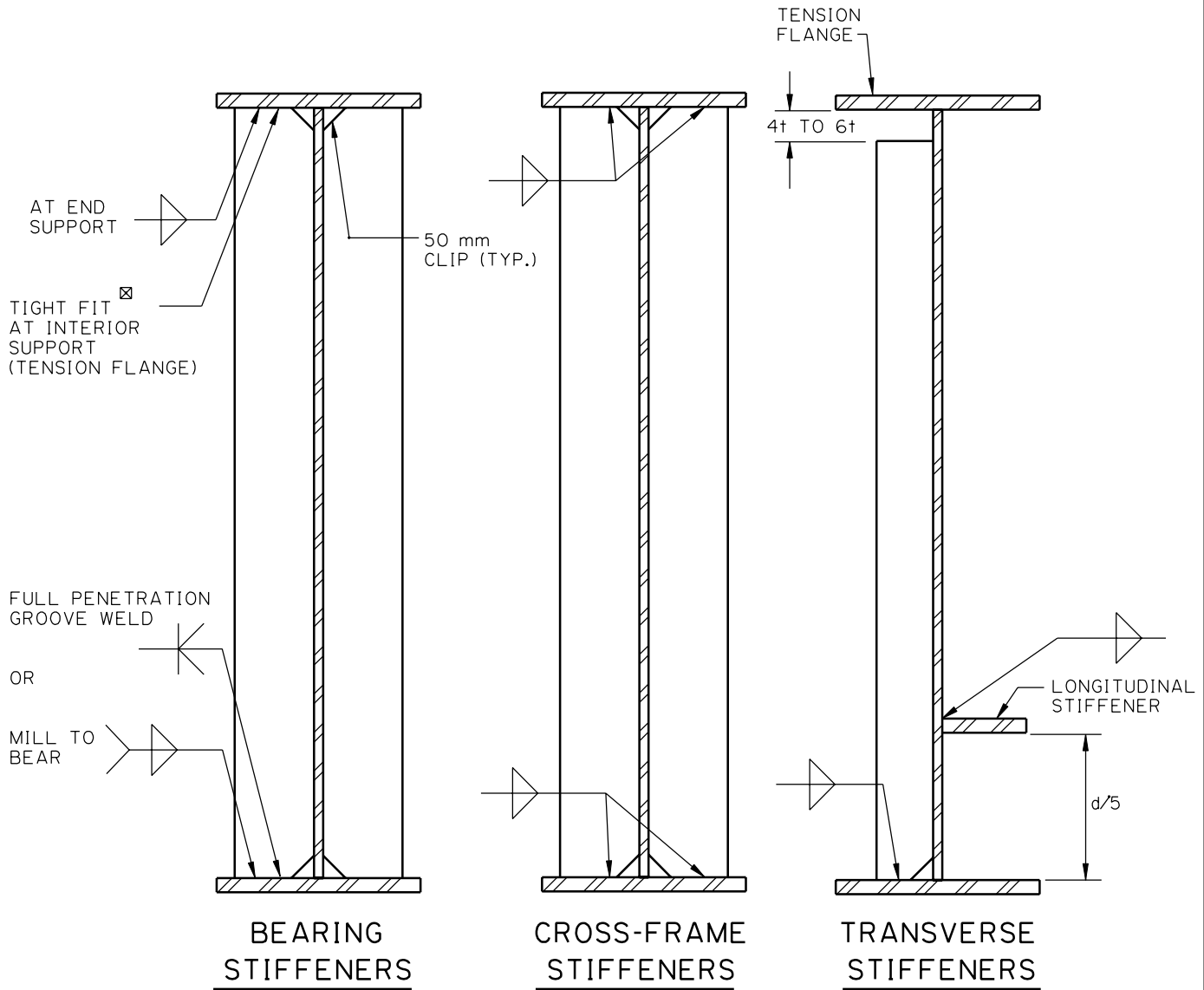
5. The location of "permissible welded shop splices" in girder web and flange plates shall be shown on the girder sheets. Generally, the limit of plate lengths without splices is **15 m**.
6. Full penetration groove welded connections at transitions in thickness or in width shall have slopes no steeper than 1 to 5.
7. When applicable, the following note shall be added to the plans:

THE CONTRACTOR MAY PROPOSE ALTERNATE SPLICE LOCATIONS FROM THOSE SHOWN IN THE PLANS, OR BOLTED FIELD SPLICES IN LIEU OF WELDED SPLICES, ALL AT NO ADDITIONAL COST TO THE DEPARTMENT AND SUBJECT TO THE APPROVAL OF THE ENGINEER PRIOR TO INCLUSION IN THE SHOP DRAWINGS.

31. Swing Spans are not considered to be fracture critical by the bridge design section. Load case II for swing spans shall use temperature difference between top and bottom chords of **15°C** and a short span uplift equal to **25 mm**. *Dead load plus impact* shall be added to case II worst wedge reaction for total case II design loads.
32. All bolting for structural steel bridge members shall utilize Direct Tension Indicator (DTI) washers during installation. When DTI s are used, the bolts are tightened until the bolt tension collapses the washer protrusions to the specified 127 µm. gap. This will ensure proper bolt tension. Inspection is accomplished by means of a 127 µm feeler gage inserted to the washer gap.

The DTIs will always be galvanized with the additional requirement that for use on unpainted weathering steel, DTI shall be epoxy coated to prevent accelerated sacrificial galvanized coating loss.

33. For simple span steel girder designs, dead load camber shall be increased by a factor of 15% to account for observed camber loss due to dissipation of residual stresses.



AT END SUPPORT

TIGHT FIT AT INTERIOR SUPPORT (TENSION FLANGE)

FULL PENETRATION GROOVE WELD

OR

MILL TO BEAR

50 mm CLIP (TYP.)

TENSION FLANGE

4t TO 6t

LONGITUDINAL STIFFENER

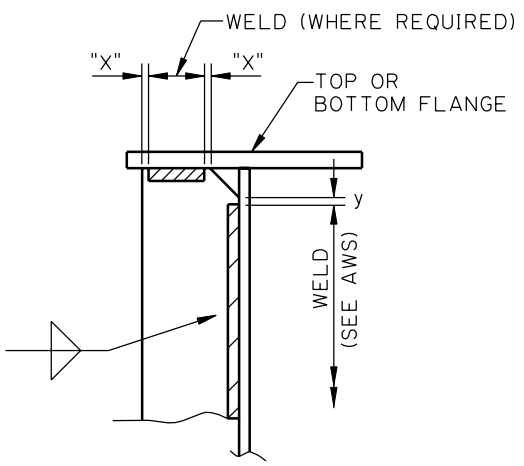
d/5

**BEARING STIFFENERS**

**CROSS-FRAME STIFFENERS**

**TRANSVERSE STIFFENERS**

☒ ADD FILLET WELD WHEN BEARING STIFFENERS ARE USED AS CROSS-FRAME STIFFENERS. PROPER FATIGUE CATEGORY SHALL BE USED.



**TYPICAL WELDING DETAIL**

"X" = 6 mm ± 3 mm  
 "y" = 12 mm ± 6 mm

**TYPICAL SECTIONS THRU GIRDER**

**STIFFENERS**



PAD		PLAIN	REINFORCED	REFERENCE
VARIABLE				
HARDNESS		70	60	SHORE "A"
F <sub>c</sub> TL(N/mm <sup>2</sup> )		10.8 × 10 <sup>-6</sup>	1.38	14.4.1.1
G	G <sub>c</sub>	1.38	0.90	T 14.3.1
	G <sub>s</sub>	2.07	1.38	T 14.3.1
B		1.8	1.4 outer	14.2
		1.8	1.8 inner	14.2
CREEP		45%	35%	T 14.3.1

Design (Method A)

- $W \approx b_f$  =  
 $TL = (P_{dl} + P_{ll})$  =  
 $L \geq TL \div (F_{cTL} \times W)$  =  
 $\sigma_c = TL \div (L + W)$  =
- $h_{ri} \leq G_c \times (L \times W) \div [2 \times \sigma_c \times (L + W) \times \beta]$  = compression  
14.4.1.1
  - $h_s = 1.6 \text{ mm}$   
 $F_y = 227.5 \text{ N/mm}^2$  Std Spec 1018.14(a)
  - $F_{all} = 0.55 F_y$  T10.32.1A  
 $\leq 165 \text{ N/mm}^2$  T10.3.1A, 2 million cycles
  - $2) h_{ri} \leq (F_{all} \times h_s) \div (1700 \times 4.448 / 25.4)$  = shim strength  
14.4.1.6
  - $\leq 16.9 \text{ mm}$
  - $\Delta h = [\infty(\Delta T) + \text{Shrink}] \times l$  = DOTD & FHWA use  
total\_T

7.  $\Delta s \approx \_h$  =  $\Delta h$  modified for pier flex. |

8.  $n =$  No. of inner layers =

3)  $h_{ri} \geq (2 \times \_s) \div (n + 2/1.4)$  = shear 14.4.1.3

4) select  $h_{ri}$  and  $n$  to satisfy equation 1,2,& 3

$h_{ri} =$

$n =$

select  $h_{ro} \approx h_{ri}/1.4 =$

check stress:  $h_{crit}/\beta \geq h_{ri}/1.0 \geq h_{ro}/1.4 =$

$S/\beta = (W \times L) \div [2(W + L)(h_{crit}/\beta)] =$

$\sigma_c < G_c(S/\beta) =$

5)  $h_{rt} = n \times h_{ri} + 2 \times h_{ro} =$

$h = h_{rt} + (n+1) \times h_s =$

$\leq L/5$  (plain) =

$\leq L/3$  (reinforced) =

stability check 14.4.1.5

6)  $H = G_s(L \times W)(\Delta s/2) \div h_{rt}$   
 $\leq 0.2P_{dl}$

slip check 14.6.1  
 (if no slip apparatus is used) |

7)  $\epsilon_{ci}^{TL} = f(S/\beta, \sigma_c) =$  See figure F14.4.1.2B or

$$= \left[ \frac{\sigma_c}{2.3 \left( \frac{S}{\beta} \right)^{1.63}} \right]^{\left( \frac{1}{1.15 + 0.0286 \left( \frac{S}{\beta} \right)} \right)}$$

International Bridge Conference 88-17 Eq 37

$\leq 0.07$  FHWA Region 3 SCEF Comm.10

$\Delta_c^{TL} = n \times h_{ri} \times \epsilon_{ci}^{TL} + 2 \times h_{ro} \times \epsilon_{co}^{TL}$   
 $\leq ?$  mm agency instantaneous deflection limit

$\Delta_c^{DL} = n \times h_{ri} \times \epsilon_{ci}^{DL} + 2 \times h_{ro} \times \epsilon_{co}^{DL} (1 + \text{creep})$  (agency long term deflection limit)  
 $\leq 3$  mm

GD = grade difference between riser and bottom of girder

$$1. \quad \theta^{TL} = (\theta^{DL} + \theta^{LL}) \approx w_{DL}L^3/24EI + 1/400 \pm GD$$

## **CORROSION PROTECTION METHODS**

### **GENERAL**

Details given in Chapter V provide adequate corrosion protection for the average application. For those locations where severe corrosion potential exists (exposure to coastal splash zones, deicing chemicals, areas where there is a history of corrosion problems), the Bridge Design Engineer will determine the method to protect the concrete reinforcing steel, including direct treatments (galvanizing or epoxy coatings), corrosion inhibitors (calcium nitrite), and silica fume or fly ash for reducing concrete permeability.

### Fly ash

A pozzolan is a by-product of pulverized coal-fired electric power generation. It is physically smaller than the average cement particle and is round.

### **PROS:**

- 1) Improves workability (pumping and ease of flat-work finishing) of fresh concrete
- 2) Reduces peak temperature of mass concrete
- 3) Long term reaction products help fill in spaces between hydrated cement particles, thus lowering permeability to water and aggressive chemicals
- 4) Reduces required water in mix for given slump
- 5) Increases long-term strength of concrete if moist environment and moderate temperatures maintained
- 6) Low cost
- 7) Allows reduction in cement content

### **CONS:**

- 1) Reduced early strength, increases setting time (both initial and final)
- 2) Decreases entrained air
- 3) Class C can cause corrosion (use Type F)

Column Bents come in a variety of configurations. The most common is the two-column bent with round columns, normally used on two lane bridges.

Hammerhead column bents are often used on ramp structures. For bridges with column heights greater than 15 m, tapered columns are often used for greater economy.

Inverted T-caps are sometimes used for aesthetics, but primarily, where vertical clearance dictates their need. Inverted T-caps should be used only with approval of the Bridge Design Engineer.

## **RIVER PIERS AND COFFERDAMS**

Where bridges cross major stream or river crossings and pile bents are not feasible, the use of a column bent constructed with a cofferdam is most commonly used. For major Mississippi River Bridge crossings, caissons are commonly used. As an alternate, large diameter drilled shafts should be investigated when deemed appropriate for the site.

All bridge crossings subject to navigational traffic should be investigated for the appropriate protection system due to vessel impact. This may include placing the piers out of the channel when it is feasible, designing the piers for vessel impact, or placing protection systems such as fenders and/or dolphin islands around the piers. The AASHTO "Guide Specification and Commentary for Vessel Collision Design for Highway Bridges" should be referred to for more information.

## **PERMANENT OR TEMPORARY SHEET PILE WALLS**

Steel sheet pile walls are commonly used for both permanent and temporary applications. For sites where a permanent bulkhead is needed such as a navigational waterway, permanent sheet pile walls are often used. They are commonly designed either as a cantilever or tied back wall.

The departmental policy on sheet pile walls is as follows:

1. Permanent Sheeting: Where required by the plans, permanent sheeting shall be of the design shown in the contract plans. Sheeting shall be new and shall receive corrosion protection as specified in accordance with the Standard Specifications. Payment shall be as per Section 803 of the Standard Specifications.
2. Temporary Sheeting: Temporary Sheeting for excavations shall be in accordance with Section 802 of the Standard Specifications. The contractor will be responsible for the design and details of the sheeting. There will be no direct payment for sheeting unless a pay item for cofferdams is included in the plans. Sheeting may be new or used, does not require corrosion protection and will be removed when no longer required.

3. Construction Sheeting: Where contract plans require sheeting to facilitate the sequence of construction and to support traffic carrying facilities, the contract plans shall specify the required design for sheeting. Sheeting may be new or used and will not require corrosion protection. Typically, construction sheeting will be removed when no longer required; however when impractical to remove or when required in the plans, sheeting may remain in place in the completed work. Payment for construction sheeting shall be by "S" item, Lump Sum.

## **DRIVEN PILES**

### **INTRODUCTION**

The most commonly used driven pile types are precast-prestressed concrete, cast-in-place concrete, steel "H", steel pipe and timber. This section is a guide to methods of pile foundation design and details.

It is conceded that the problem of foundation analysis is a highly complex one and that sometimes experience and intuition will be the better part of analysis. In this light, if any analysis and soil boring interpretation is followed blindly, serious errors in estimating foundation capacities can result.

The bridge designer normally proposes the type and length of pile foundation during preliminary plans. The Geotechnical and Construction sections should be consulted both during preliminary and final design to review and make comments on the proposed pile lengths, pile type and field-testing.

### **PILE DESIGN**

Soil borings are required on all bridge projects for which piling is involved. In cases where an existing bridge will be widened or replaced on an existing alignment, the engineer should evaluate the following information first from the existing bridge records.

- a) Existing bridge borings.
- b) Existing test pile reports.
- c) Existing pile driving records.

On projects for which all or some of the above information is available and contains sufficient information for the design of the foundation, there will be no need to order new borings.

Should the existing information not be sufficient or is not available, new borings must be ordered. New borings must be ordered through our Geotechnical Section. Information on

how to order new borings and a boring request form can be found in chapter 1 or you may contact the Geotechnical Section. Any existing deep boring data should be attached to the boring request. The date when the complete geotechnical data (borings, consolidation and settlement analysis) are needed, should be included in the request. In the absence of this information, priority will be established by the preliminary plan date.

Piles shall be designed using service loads excluding live load impact. The maximum pile loads (design load) should always be shown on the construction drawings, normally with bent details or on the pile data sheet. Piles can be designed as friction piles, bearing piles, or a combination of both. The weight of the pile is normally neglected except in special cases involving large diameter piles and when cofferdams and tremie seals are used. The pile lengths for both on-system and off-system bridges are determined using the appropriate safety factors which are selected based on field-testing, type and amount of soils data and geotechnical analysis, type of project, static and dynamic load test and method of modeling pile installation. See Field Testing for more information on safety factors.

In order to set the plan pile lengths, a static analysis to determine ultimate pile capacity is normally performed on each boring for friction and bearing capacity. Due to the variety of soil conditions, this manual will not attempt to describe the analysis procedures. The engineer should confer with the Geotechnical Section when performing a static analysis. The design engineer will normally use the total soil shear strengths determined from either unconfined compression tests or standard penetration tests to determine the pile friction and end bearing for various piles and loads. If economically feasible, the engineer should attempt to tip end bearing piles in very dense sands ( $n > 50$  blows). The end bearing piles should penetrate a minimum of 1.5 m into the 50 blow count material.

The plan pile lengths are established when the design event ultimate pile capacity divided by the required factor of safety is equal to or greater than the design load.

Pile sizes should be proportioned so that the following criteria are met.

- a) As a general rule, the maximum slenderness ratio of  $L/d \leq 20$  should be maintained.

$L$  = pile unsupported length (mm). The unsupported length is measured down below the channel bottom or ground line accounting for estimated scour, if appropriate (1.5 m minimum), plus a distance to the assumed point of pile fixity. In general, pile fixity can be assumed at 1.5 m below scour line or ground line. See figure on page 25.

$d$  = the least dimension or diameter of the pile section (mm).

The maximum unsupported pile lengths based on a  $L/d = 20$  are as follows:

The following typical splices are approved to be used on precast concrete and steel piles.

Pile Type	Pile Size (mm)	Pile Splice Type
Precast Concrete	350, 750	Cement dowel
Precast Concrete,	350,400,450	Dyna-a-splice (proprietary)
Precast Concrete,	600	ABB (proprietary)
Steel	All sizes	Full penetration butt weld

Standard details are available for the precast concrete pile splices, except for ABB splices.

- g) For piles with a diameter less than 0.6 m, an 6.10 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.
- h) For pile diameters equal to or greater than 0.6 m, a 7.62 m minimum pile penetration should be provided for stream crossings below the estimated scour elevation.

Battering piles is an expensive process and should be specified only when necessary. The exterior pile in bents should be battered when the unsupported pile length is excessive. Battering footing piles provides the necessary lateral support that is sometimes required to resist excessive lateral loads transferred from the column to the footing. This is particularly true for short column bents due to cap shrinkage. Maximum batter is usually 1 on 4 for footing piles and 1 on 8 on pile bents.

The allowable strength of precast concrete piles is seldom, if ever, exceeded by the design loads. Pile handling and transportation govern the design, thus establishing the maximum casting length and pick up point locations.

Cast-in-place concrete piles are used primarily in south Louisiana and are designed either as friction piles or combination friction and bearing piles. When cast-in-place piles are included as an alternate for precast piles, the pile lengths should be set based on the cast in-place pile, and only precast piles will be allowed in the end bents.

When hard driving is anticipated, particularly where jetting is not desirable, such as footing piles, the designer should consider non-displacement piles such as open-ended pipe or H piles. The designer should discuss this with the Geotechnical section.

The pile group capacity will be considered in foundation analysis if the center to center spacing is less than three pile diameters. Under normal situations, this is not allowed.

The consolidation settlement shall be computed for all pile groups. The pile group settlement shall be the same as shown for drilled shafts on page 19.

All timber piles for permanent structures shall be treated timber according to the Standard Construction Specification. Coastal treatment should be considered for use at locations south of I-10/I-12 line. Where coastal treatment is used, it should be clearly specified in the plans. Temporary structures such as detour bridges shall use treated timber piles.

## PILE DETAILS

1. The following pile standard details are available and shall be included in the plans when applicable.

Standard Detail	Description
CS - 216(M)	Precast-Prestressed Piles
Concrete Pile Alternates	Cast-in-place Concrete Piles
Pile Splice Details	Cement Dowel, Dyna-a-Splice

2. Steel pipe piles shall generally be driven with open ends only.
3. Pile lengths should normally be shown on the general bridge plan. Pile tips, cutoff elevations, pile lengths and design loads should be shown on a pile data table.
4. For moderate to complex projects involving skews, horizontal curves, interchanges, etc., or where interaction with existing foundations is present, the plans should include a foundation layout. The layout must show bents and/or footing pile locations and referenced to the centerline or P.G.L. Existing structures or substructures that may conflict with the pile driving must be clearly shown. Boring locations as well as test piles, CPT probings, PDA monitor piles and indicator piles must also be shown.



- a) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE DEPARTMENT IN ACCORDANCE WITH SECTION 804 OF THE SPECIFICATIONS.
- b) CPT PROBINGS: CONE PENETROMETER TEST (CPT) PROBINGS WILL BE REQUIRED AT THE LOCATIONS NOTED IN THE GENERAL PLANS OR FOUNDATION LAYOUT AND AT TEST PILE AND INDICATOR PILE LOCATIONS. CPT PROBINGS WILL BE PERFORMED BY THE CONTRACTOR.

When the CPT probings are performed by the contractor, (note b), the maximum CPT penetration elevation should be specified in the plans as follows:

- a) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR ALL CPT PROBINGS SHALL BE \_\_\_ (*elevation in meters*).
- b) THE MAXIMUM CPT PROBING PENETRATION ELEVATION SHALL BE \_\_\_ (*elevation in meters*). FOR CPT PROBINGS TAKEN AT BENTS (##) THROUGH (##).
- c) THE MAXIMUM CPT PROBING PENETRATION ELEVATION FOR TEST PILE (##) SHALL BE \_\_\_ (*elevation in meters*).

#### Pile Driving Analyzer, (PDA)

PDA may be used to monitor the pile driving installation of Test Piles, Indicator Piles, and Monitor Piles. A note similar to the following note should be placed in the **General Notes of the bridge plans**. It should be modified as needed.

DYNAMIC MONITORING: THE PILE DRIVING ANALYZER (PDA) WILL BE REQUIRED AT EACH TEST PILE, INDICATOR PILE, AND MONITOR PILE OR AS DIRECTED BY THE ENGINEER.

When Dynamic Monitoring is required use the appropriate item number from section 804 and include an S-item for Dynamic Analysis.

#### Indicator Piles

Indicator Piles may be used to determine the final pile order lengths. In this case, an Indicator Pile is driven in advance of the production piles. The difference between Indicator Piles and a standard test pile is that loading Indicator Piles is not anticipated. Indicator piles should be cast long enough to be redriven, if necessary, to the plan tip elevation of the piles at the nearest bent or as determined necessary by the CPT probing. Indicator Piles are usually piles tipped on marginal end bearing soils. The Indicator Pile is used to access pile driveability problems such as hard driving which may require jetting or predrilling and to assess the bearing capacity of marginal bearing soil. The Indicator Pile driving installation is monitored with the PDA to evaluate the pile driving equipment

performance and to monitor the pile driving stresses. Pile bearing capacity and driving criteria will be developed from data obtained from the PDA monitoring. The location of these piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The indicator pile is paid for as a modified test pile (i.e. Item 804(05)(A) Precast Concrete Test Pile (Indicator Pile)). Pay items for each type of indicator pile used should be shown in the plans.

Redriving of indicator piles is paid for under Item 804(11), Redriving Test Piles. If it is determined from the driving records and PDA monitoring that the indicator pile should be load tested, each load test shall be paid for under Item 804(09)(A).

The following note should be placed in the **General Notes of the bridge plans**.

INDICATOR PILE: INDICATOR PILES WILL BE REQUIRED AT THE LOCATIONS SHOWN ON THE GENERAL PLANS OR FOUNDATION LAYOUT.

### Monitor Piles

A Monitor Pile may be used to monitor the pile driving installation with the PDA. This is usually accomplished by monitoring the first permanent pile of its type and size to be driven at each bridge structure or at a specified bent location. The location of these Monitor Piles is generally based on the type and size of pile to be driven and the anticipated subsoil profile at each bridge structure. The PDA is used to evaluate the pile driving equipment and to monitor the pile driving stresses. Pile driving criteria will be developed from this information. The Monitor Pile is paid for as a permanent pile. The dynamic monitoring is paid for with the Dynamic Monitoring item and the Dynamic Analysis S-item. One of the following notes should be placed in the **General Notes of the bridge plans** depending on where the indicator pile(s) is located.

- a) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT EACH BRIDGE SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- b) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENT NO. (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).
- c) MONITOR PILES: THE FIRST (*size, type*) PILE DRIVEN AT BENTS (##) THROUGH (##) SHALL BE MONITORED WITH THE PILE DRIVING ANALYZER (PDA).

### Permanent Piles

Permanent Piles are those piles that are furnished by the contractor in accordance with an approved order list for use in production driving of foundation piles for the final substructure. If the driving resistance of a permanent pile should not correlate with the test pile or be less than that of the test pile, the engineer may require a static load test among other courses of action.

The following plan note should be placed in the **General Notes of the bridge plans**.

PILES: ALL PILE REQUIREMENTS INCLUDING SIZE, TYPE AND MAXIMUM DESIGN LOAD AND TEST PILE REQUIREMENTS AS TO LOCATION AND TEST LOADING SHALL BE AS DESCRIBED ON THE PLANS OR IN THE SPECIFICATIONS. SEE STANDARD DETAIL CS 216(M). THE MINIMUM PILE TIP ELEVATIONS WILL BE PLAN PILE TIP ELEVATIONS UNLESS NOTED ON THE PLANS OR OTHERWISE AS DIRECTED BY THE ENGINEER.

In addition, one of the following pile length notes shall be included as needed in the PILES: note in the plans.

- a) PILE LENGTHS SHOWN IN THE PLANS ARE ORDER LENGTH PILES.
- b) PILE ORDER LENGTHS WILL BE PROVIDED AFTER COMPLETION OF THE CPT PROBINGS AND/OR TEST PILE LOAD TESTING AND/OR INDICATOR PILE INSTALLATION AND EVALUATION AS REQUIRED BY THE PLANS.

### Jetting

When appropriate, jetting may be used to facilitate pile installation. This practice shall be predominately used when hard driving is anticipated during pile installation of end bearing piles. Jetting should not be allowed for friction piles, piles in footing, header banks or where stability of embankment or other improvements may be endangered. When jetting is allowed or required, the following note shall be added to the Special Provisions

JETTING: JETTING MAY BE REQUIRED IN ACCORDANCE WITH SECTION 804.08(B) AT (list of the locations).

The note above amends the Standard Specifications sub section 804.08(B), Water Jets.

For more specific information on this subject as well as appropriate plans and specifications requirements including pay items, refer to the latest DOTD's Standard Specifications.

## Types of Field Load Testing

1. **Static Load Test:** This work consists of applying static loads at predetermined intervals to Test Piles and in some cases to Indicator Piles or Permanent Piles. The static loads are applied in increments of 10 to 15 percent of the design load and held for an interval of 5 minutes. The loads are increased until pile failure occurs or three times the design load is reached. The ultimate pile capacity is determined through the analysis of the load settlement curve then a safety factor of 2.0 is applied to determine adequacy of pile tip elevation. Test piles will be loaded unless otherwise directed by the engineer. Test piles shall remain undisturbed for at least 14 calendar days after driving, unless otherwise directed by the engineer, to required penetration before beginning loading operations.
2. **Dynamic Monitoring:** This work consists of assisting the Department in obtaining dynamic measurements with the Department's Pile Driving Analyzer (PDA) of test piles, indicator piles, and permanent piles during initial pile driving and during pile restrikes. The cost of equipment mobilization or any delays due to dynamic monitoring shall be at no direct pay. To allow space for attachment of instrumentation when dynamic monitoring is specified on test piles, indicator piles, and monitor pile, the piles shall be long enough to allow access to the top 2.5 pile diameters or side dimension of the pile at the end-of-driving penetration. The dynamic monitoring shall be performed for the purpose of obtaining the ultimate pile capacity, pile driving stresses, pile integrity, and pile driving system efficiency.

## Types Of Pile Capacities

1. **Static Load Test Capacity:** This is the computed ultimate pile resistance that we are anticipating during the static load testing of a test pile, indicator pile, or permanent pile. The soil resistance will depend on the as-driven conditions such as overburden of the scour zone, scour zone soil resistance if it has not been cased or excavated, etc. The reaction system shall be sized to resist three times this estimated Static Load Test Capacity shown in the plans or as directed by the engineer.
2. **Ultimate Pile Capacity:** This is the ultimate pile capacity that has been determined from either a static or dynamic test of a test pile, indicator pile, or permanent pile.
3. **Design Load:** Is the maximum computed working load that the pile foundation is anticipated to support during the life to the structure.
4. **Design Event Ultimate Pile Capacity:** This is the computed static ultimate pile resistance that should be available after neglecting the scour zone and accounting

## DESIGN

1. All projects involving drilled shafts will be approved prior to design, by the Bridge Design Engineer Administrator.
2. As a general rule, size the drilled shaft for a compressive stress of **3 MPa** across the cross section of the shaft. However, the soil characteristics and the design requirements for the shaft to sustain both axial and lateral loads will determine the final size and length of the required shaft.
3. Side friction will be utilized, i.e., the shafts will be constructed with the casing extracted, unless otherwise approved by the Bridge Design Engineer Administrator.
4. For drilled shaft design, Class S concrete will be used and the concrete compressive strength will normally be limited to  $f'c = 18 \text{ MPa}$ .
5. All drilled shafts, where the concrete or slurry is placed under water, will be constructed with access tubes to allow for cross-hole sonic logging, CSL. The test will determine if anomalies are present in the shaft, which may reduce its capacity. If the shaft has a reduced capacity the payment and/or rejection will be based on the CSL testing. The acceptance or rejection of the shaft will be based upon CSL test results and the analysis by the Geotechnical Design Unit.
6. Drilled shafts used in abutments shall have a minimum diameter of 600 mm, however, a diameter of 750 mm is preferable.
7. A minimum reinforcement of 1% of the gross shaft area shall be extended to the bottom of the shaft.
8. Drilled shafts are available in 150 mm increments from 450 mm to 3600 mm. Some shafts may be available in the 4800 mm range.
9. Drilled shafts should be spaced center to center a minimum of three (3) times the shaft diameter, however, shafts can be placed closer if group capacity is accounted for in the foundation analysis.
10. Battered drilled shafts will not generally used.
11. Belled footings will not be used.
12. Detailed clearances for the reinforcement to the outside of the drilled shaft will be 75 mm for shafts with a diameter of 750 mm or less and 150 mm for shafts greater than 750 mm.

For further design information consult the Pavement and Geotechnical Design Section and AASHTO.

5. Double stirrups shall be used in all pile bent caps exceeding 750 mm in width.
6. Stirrups shall be spaced at a maximum of 300 mm. The stirrups adjacent to piles shall be located at a maximum of 75 mm from the face of the pile and the first space shall be a maximum of 150 mm. The size of stirrups shall be a minimum of No. 10 bars.
7. The centerline at the top of the exterior pile shall not exceed more than 460 mm beyond the centerline of the exterior girder.
8. The pile bent design should account for two (2) adjacent piles each being mislocated a maximum of 150 mm in the direction parallel to the cap.
9. Pile bent caps shall have a minimum depth of 600 mm for all slab span supporting bents and all single row pile bents with less than 600 mm piles and 700 mm for all single row pile bents with 600 mm piles or larger. Double row pile bents shall have a minimum cap depth of 750 mm.
10. The minimum longitudinal cap steel shall be in accordance with the AASHTO Specifications.
11. As a general rule,  $l/a$  in pile bents should not be over 20. See further discussion under driven piles.
12. The top and bottom reinforcement in caps shall be the same.
13. The concrete quantity for the pile cap shall not include the volume of concrete displaced by the pile embedment.
14. Spacing for double row pile bents shall be determined on an individual basis.

3. Wingwalls, breast walls and the bent as a unit shall be designed to resist active earth pressure under the appropriate group loads.
4. The reaction of the approach slab to the shelf of the end bent is based on the same assumption as in Items 1 and 2.

## DESIGN DETAILS

1. Wingwalls with stabilizing piles are required for all end bents on fills with the exception of slab span bridges and concrete girder spans with Type II girders.
2. Double-row, battered piles are required on all end bents except those for slab spans. Pile batter shall be 1 on 8.
3. On double row pile end bent caps, a 300 mm thick baffle shall extend 600 mm below the cap between rows of piling to prevent the movement of the soil confined by the bent.
4. On skewed or normal end bents, the roadway end of the approach slab is to be squared off for both rigid and flexible pavements.
5. Slab span end bents should be designed as interior bents.
6. Negative skin friction, caused by the consolidation of the fill and in situ soil in contact with the piles, is assumed to be insignificant because pilot holes are used for piling driven through a compacted fill. Granular material is used to fill the void between the pilot hole and the pile.
7. Pile supported approach slabs are continuous slabs supported by rows of timber piles on 3 m centers. The spacing between the piles along the cap is between two (2) and three (3) meters. The timber piling shall be varied in length from row to row by a constant amount. Piling shall penetrate the footing to resist the tension required to hold the slab in its deformed configuration after settlement has occurred. Pile supported slabs are designed as one way slabs spanning between transverse grade beams at the pile rows.
8. When pile supported approach slabs are used, the barrier rail shall be extended the full length of the approach slab. This will prevent potential guardrail problems caused by embankment settlement in the deep pile region of the approach slab.
9. Prestressed girders end bent caps shall have a depth of 750 mm .
10. In south Louisiana, sand embankments are terminated by a shell plug, which eliminates erosion, formation of cavities, and settlement problems related to sand

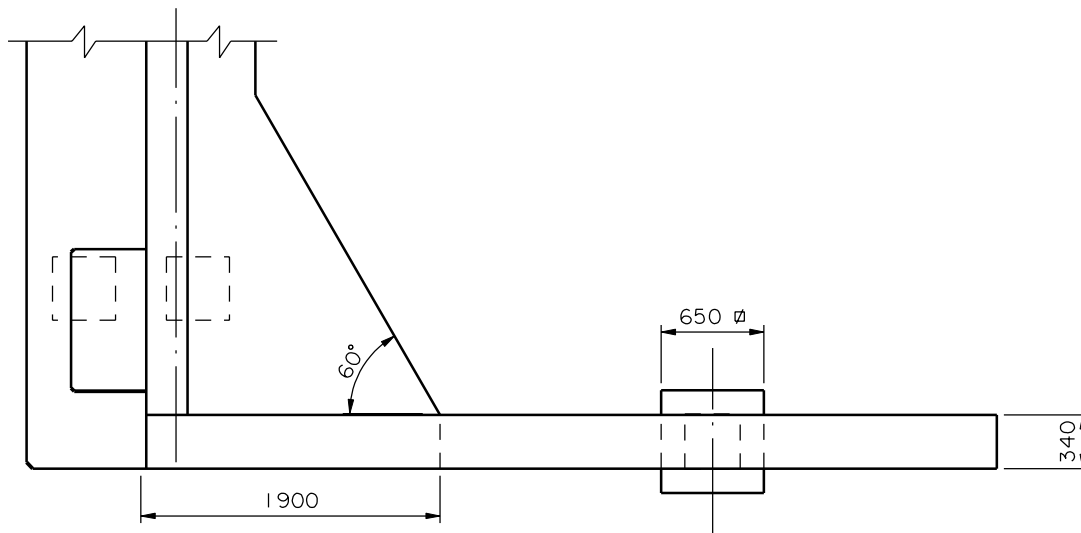
embankments and sand header banks. In north Louisiana, where shell is not readily available, sand embankments are to be terminated by a clay plug at structure header banks in the same manner a shell plug is used in south Louisiana.

11. The following criteria will be used in determining slab lengths:

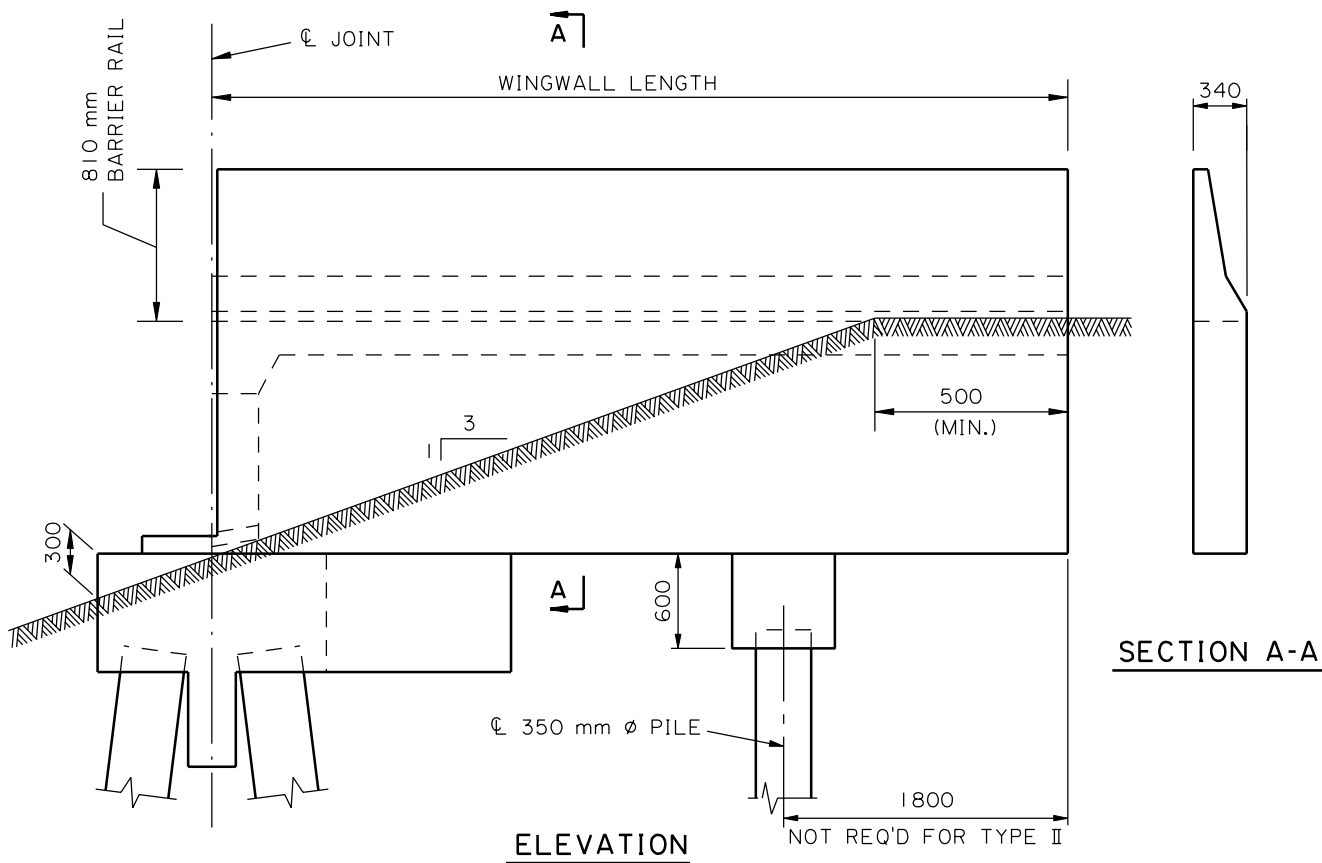
On fill sections, use 12 m long approach slab.

On cut sections, use 6 m long approach slab.





**PART PLAN**



**ELEVATION**

**SECTION A-A**

GIRDER TYPE	WINGWALL LENGTH
II	4800
III	5500
IV	6200
BT	7700
IV-M	6700

VALUES SHOWN ARE FOR BENTS ON 90° CROSSINGS WITH EXTERIOR RISERS OF 100 mm. ADJUST LENGTHS AS REQUIRED FOR BENTS WITH HIGHER RISERS AND ROUND UP TO THE NEAREST 100 mm INCREMENT.

**WINGWALL DETAILS**

## SEISMIC REQUIREMENTS

### GENERAL

In order to design to resist the effect of earthquake motions, the designer is referred to by AASHTO Standard Specifications for Highway Bridges, Section 3.21 to Division 1-A. The provisions in this section apply to bridges of conventional steel and concrete girder and box girder construction with spans not exceeding 150 m. Suspension bridges, cable-stayed bridges, arch type and movable bridges are not covered.

From the contour map of horizontal Acceleration Coefficients (A) provided in AASHTO's Section 3.2, Louisiana has coefficient values that range from about 2 to 4 percent of gravity. Bridges additionally are assigned an Importance Classification (IC) [Section 3.3]. Based on "A" and "IC", all bridges in Louisiana are placed into Seismic Performance Category (SPC) "A" [Section 3.4].

Category "A" requires the least analysis [Section 4.2] and is covered in Section 5. The two requirements which must be met are:

1. Minimum support length

Provide minimum bearing support length (N) for expansion end of all girders.

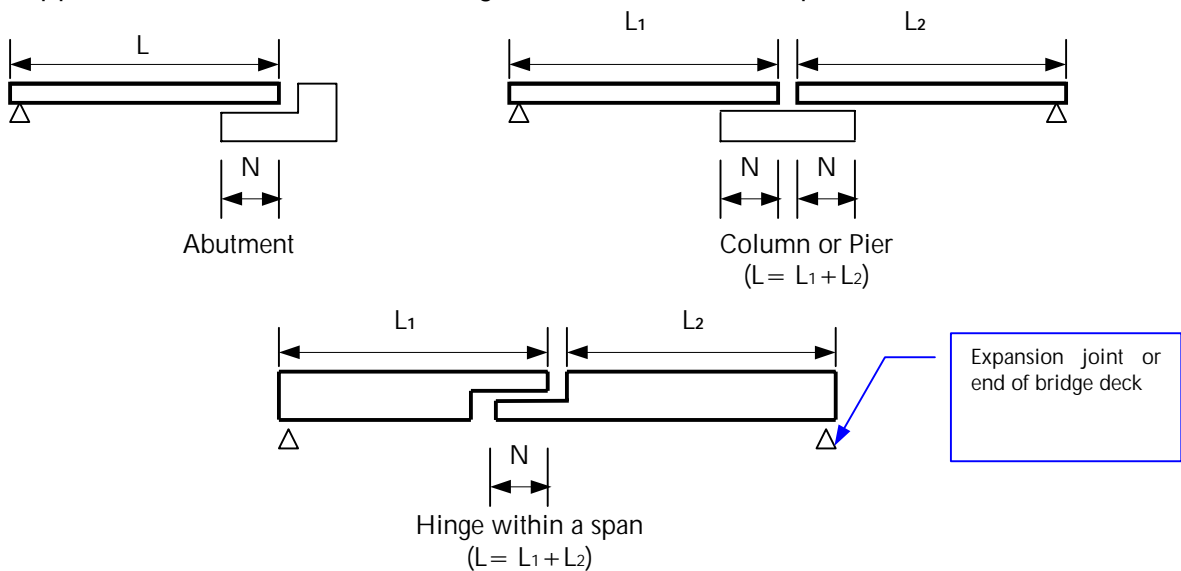
N = Minimum bearing support length for expansion end of all girders in mm.

$$= (203 + 1.67L + 6.66H)(1 + 0.000125S^2) \text{ where}$$

L = Length (m) as shown. ( $L_1$ ,  $L_2$ , &  $L$  = continuous bridge deck lengths).

H = Average (m) height of columns supporting the bridge deck to the next expansion joint. (Assume distance from bearing elevation to ground fixity).

S = Angle of skew, in degrees, measured from the line connecting bearings along support to a line normal to the longitudinal centerline of span.



DIMENSIONS FOR MINIMUM SUPPORT LENGTH REQUIREMENTS

## **SHOP DRAWINGS**

### Introduction

The fabricator prepares shop drawings and erection drawings by interpreting the engineering drawings in the contract plans. The engineer who prepares the engineering drawings shall generally be responsible for checking of the corresponding shop drawings.

### Scope

This article covers the responsibilities of the Engineer regarding shop drawings review. The Engineer's responsibilities include two requirements, expediency and completeness, in checking the shop drawings for conformity to contract plans, specifications and special provisions.

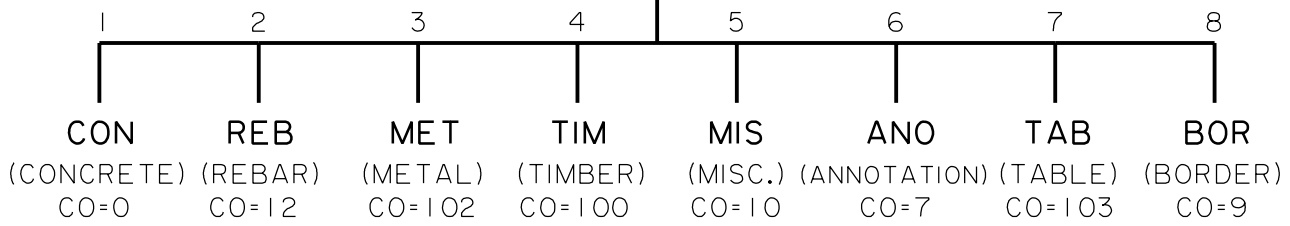
### Commentary

An engineer charged with checking shop drawings for the first time often asks or wonders, "How complete or to what detail should the drawings be checked? The answer to this question is as variable as are the details prepared by the engineer. As the engineer gains experience in checking shop details, he acquires working knowledge of what must be checked and what may be scanned over. The remainder of this article may serve as a guide to the inexperienced checker and a reminder to the experienced engineer.

### Guidelines, Shop Drawing Review

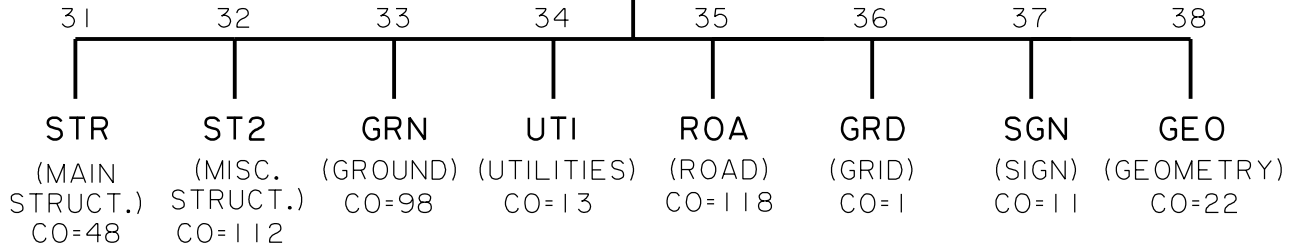
1. Always check shop drawings to the extent you are satisfied that the structure described can be fabricated and erected according to the governing plans and specifications.
2. Shop details shall have top priority unless you are otherwise instructed. This rule is needed to avoid costly delays in the bridge construction.
3. The amount of time to be spent checking shop details should be proportional to their complexity and quantity of sheets involved.
4. For final approval, each shop drawing shall be stamped, initialed, and dated.
5. Shop drawings involving structural steel shall be stamped "Approved for Size of Material and Strength of Connection".
6. Shop drawings involving concrete prestressed girders, and other details shall be stamped "Approved Subject to Satisfactory Installation and Operation".

DETAIL ← LEVEL GROUP



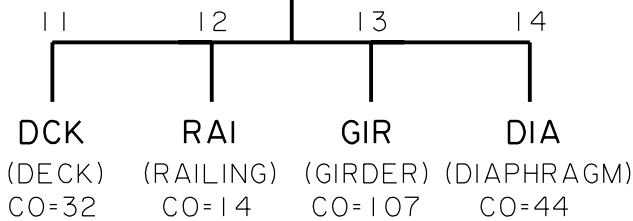
DESIGN DETAILS

PLAN

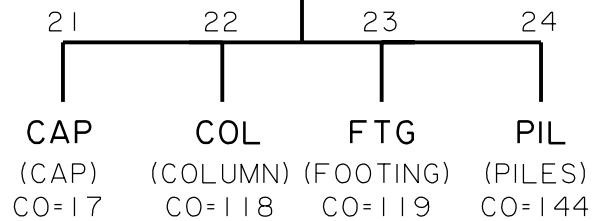


PLANS AND LAYOUTS

(SUPERSTRUCTURE)  
SUP



(SUBSTRUCTURE)  
SUB



PRELIMINARY WORKING DRAWINGS

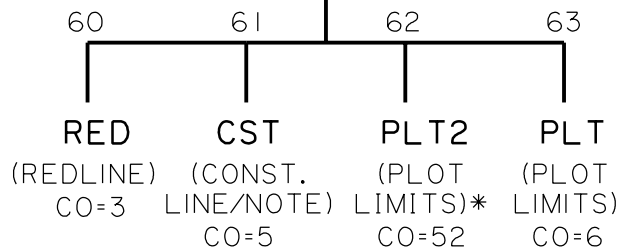
NOTES:

STANDARD SEED FILES CONTAIN LEVEL STRUCTURE. WHEN USING DESIGN FILES NOT CREATED FROM SEED FILES, LOAD THE STRUCTURAL LEVEL FILE, STR.LVL, AND SAVE SETTINGS.

FOR CONSISTENCY AND CONVENIENCE, IT IS RECOMMENDED THAT THE SIDEBAR MENU, BR-MI, BE USED TO SET LEVEL AND COLOR.

TOPOGRAPHY LEVELS SHALL BE AS ADOPTED BY THE ROAD DESIGN SECTION. TOPOGRAPHY SHALL BE REFERENCED TO THE PLAN SHEET.

CONST



CONSTRUCTION

\* CONSULTANT PLOTTING

**STRUCTURAL LEVELS**

## STRUCTURAL METALWORK

### APPROACH SLABS:

END DAM PLATE (PL 12x130) . . . . .	12.25 kg/m
ANCHOR STUDS (M16 x 200 mm) . . . . .	0.36 kg EACH
CLIP ANGLE (L 203x102x12.7 x 130) . . . . .	3.80 kg EACH

### END BENTS:

#### ANCHOR BOLTS (STRIP SEAL OR END DAM)

ANCHOR BOLTS (M24 x 510 mm) . . . . .	1.95 kg EACH
HEX NUTS (2 PER BOLT) . . . . .	0.18 kg EACH
CUT WASHERS (2 PER BOLT) . . . . .	0.09 kg EACH

#### ANCHOR BOLTS (BEARING ASSEMBLY)

ANCHOR BOLTS (M30 x 450 mm) . . . . .	2.50 kg EACH
HEX NUTS (1 PER BOLT) . . . . .	0.34 kg EACH
CUT WASHERS (1 PER BOLT) . . . . .	0.12 kg EACH

### INTERMEDIATE BENTS:

#### ANCHOR BOLTS (BEARING ASSEMBLY)

ANCHOR BOLTS (M30 x 450 mm) . . . . .	2.50 kg EACH
HEX NUTS (1 PER BOLT) . . . . .	0.34 kg EACH
CUT WASHERS (1 PER BOLT) . . . . .	0.12 kg EACH

### SPANS:

#### END DAM ASSEMBLY (WHEN USED)

END DAM PLATE (PL 12x130) . . . . .	12.25 kg/m
ANCHOR STUDS (M16 x 200 mm) . . . . .	0.36 kg EACH
CLIP ANGLE (L 152x102x12.7 x 130) . . . . .	3.13 kg EACH

### GIRDERS:

#### BEARING ASSEMBLY

THREADED INSERTS (2 PER ANGLE) . . . . .	0.40 kg EACH
CAP SCREWS (M24 x 90 mm) (2 PER ANGLE) . . . . .	0.40 kg EACH
WASHERS (2 PER ANGLE) . . . . .	0.09 kg EACH
ANGLE (L 127x127x12.7 x 230) . . . . .	5.54 kg EACH

#### ANCHOR BOLTS (STRIP SEAL OR END DAM)

ANCHOR BOLTS (M24 x 300 mm) . . . . .	1.20 kg EACH
HEX NUTS (2 PER BOLT) . . . . .	0.18 kg EACH
CUT WASHERS (2 PER BOLT) . . . . .	0.09 kg EACH

#### THREADED RODS

ALL THREAD RODS (25 mm $\phi$ X 965 mm)(EXTERIOR GIRDERS)	3.79 kg EACH
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## STRUCTURAL METALWORK WEIGHTS (SUMMARY)

## ANALYSIS AND DETAIL INFORMATION

### Analysis

1. Ground mounted Multiple post sign supports are considered as cantilever beam-columns that are fully supported against lateral and torsional buckling at sill connections.
2. Ground mounted single post signs are designed as cantilever beam-columns that have unsupported length from the base to the center of pressure of the sign mounted on them.
3. A uniform soil bearing capacity of 143 kPa was used for ground mounted roadside signs.
4. Overhead type II sign trusses are designed as pin connected and simple supported for wind and dead load trusses. The columns for the overhead type II trusses are designed fixed at the base.
5. Structure mounted supports for type II or cantilever overhead sign trusses must be designed and detailed on an individual basis.

### Details

1. Ground mounted single-post signs have a breakaway slip base which is beveled such that the sign is given an upward component of acceleration when hit such that the sign will pass over the top of the colliding vehicle without further contact.
2. Ground mounted multiple-post signs have a breakaway slip base which are beveled such that the sign is given an upward component of acceleration when both posts are hit simultaneously. This probability is deemed to exist when the post spacing is 2.1 meters or less.
3. The directional slip bases should be placed such that their operational characteristics will be the most probable direction of high-speed collision where practical.

## LOUISIANA PRACTICE

### Barriers

Details of several crash- tested roadway barriers have been shown in this chapter. Among these barriers, the double-face thrie beam and the sloped-face concrete barriers are considered by FHWA as "Innovative Barrier". When required by FHWA, these barriers may be used in lieu of the more conventional type.

Barriers shown here are in two basic categories. First, the permanent barriers second the temporary barriers. Temporary barriers are commonly used in construction zone. When temporary barriers are utilized on bridge structures a positive connection to the bridge deck shall be provided, unless it is determined that a considerable lateral deflection of the barrier system can be tolerated. The blunt ends of temporary barriers shall be made crashworthy by means of either an end treatment device or by flaring away from traffic and carrying beyond the clear zone distance.

### Guardrail

Virtually all information pertaining to guardrail is contained in the Standard Plan G.R-200(M). This Standard provides information to the designers for the purpose of determining the "Length of Need" and to the contractors, for the purpose of constructing the guardrail.

In addition to G.R-200(M), Standard Plan G.R-201(M) and G.R-202(M) are provided to aid the designers with specific applications of guardrails. By using these particular standards the designers may show the dimensions which are unique to a specific condition on a simple sketch in the contract plans and make reference to a detail on the standard plan to provide the more generic information. Standard plans G.R-201(M) and G.R-202(M) shall always be used in conjunction with Standard Plan G.R-200(M).

Although guardrail standard plans adequately provide the necessary information to construct the guardrail system, it is very important that plans provide all information necessary for the specific site condition. For example, plans shall always show the total length, the length of each pay item, the location, the flare rate, the type of end treatment and any special notes or details.

When bridge construction is considered as "Spot Replacement", often there is little or no road construction, and in such cases minimum guard rail length shall be provided to make the bridge rail blunt ends crashworthy. In these situations, it is not necessary to design "length of need" to provide protection for the full "clear zone" distance behind the bridge rail. An exception to this is when the existing road in the vicinity of the structure provides the design "clear zone" distance, in which case the guardrail for the bridge ends shall provide protection consistent with that "clear zone" distance. The decision whether the minimum length or the standard length is to be utilized shall be made at the Plan-In-Hand meeting after the road condition is examined. The final decision shall be included in the