STRUCTURES MANUAL

Lexington-Fayette Urban County Government
Lexington, Kentucky

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CHAPTER 1
INTRODUCTION

1.1 Purpose

1.1.1 Purpose

The infrastructure of Lexington-Fayette County must be of a consistent quality. The purpose of this manual is to assure quality in the design of structures that are to become part of the Lexington-Fayette Urban County Government (LFUCG) Infrastructure through guidance to the designers of those structures. The manual establishes uniformity in design assumptions, minimum loads, and general methods of design. Additionally, the manual sets policy regarding design specifications and standards and provides for uniform interpretation of those specifications. Finally, the manual outlines the required calculations and plan details applicable to all structures and which are required submissions for review as part of developments that are subject to approval by the LFUCG engineering staff.

For the purposes of application of the requirements of this manual, the term “infrastructure” shall include public and private streets, detention/retention basins, structures over the public drainage system of creeks and watercourses and retaining structures within the floodplain of the public drainage system of creeks and watercourses. Specifically excluded from the requirements of this manual are the following: buildings, private access easements, rural lands used for agricultural purposes, parking lot pavements and pipes and structures appurtenant to interior drainage systems of parking lots discharging into detention/retention basins.

This manual draws heavily on technical information and design policies presented in the Kentucky Transportation Cabinet’s, “Division of Bridges Guidance Manual.” Designers of structures for the Kentucky Transportation Cabinet (KTC) will find many similarities between the two manuals. However, this manual has been tailored to fit Lexington-Fayette County and contains important provisions that may be unique to this manual or modified from those in the KTC manual.

This manual is intended as general guidance and minimum requirements for ordinary structures that are routinely designed and constructed. The manual is not a substitute for rational engineering principles or judgment. More comprehensive methods of analysis and design may be required for unusual conditions not specifically covered in this manual or where otherwise appropriate from an engineering standpoint to assure public safety and quality in the infrastructure design.

1.2 Terms and Definitions

1.2.1 Terms and Definitions

The following definitions shall apply to the terms used in this manual:

AASHTO - American Association of Highway and Transportation Officials. The organization composed of representatives of all State Departments of Transportation and the authors and publishers of the *Standard Specifications for Highway Bridges*, which is the governing design specification for this manual.

Abutment - The generic term for any of the various specific types of substructure units at each end of a bridge.

ADT - Average Daily Traffic of a road determined or projected from vehicle traffic counts.

Anchored Retaining Wall - A wall that derives all or much of its capacity from tiers of anchors that are grouted or mechanically anchored into rock or soil beyond the retained mass. (Also referred to as Tie-back wall).

Border Width - The width of the area behind the curb of urban roadways that is reserved for sidewalks and utility strips and is generally only gently sloped.

Cross-Slope - Transverse slope of a road pavement.

Culvert - A conduit for conveying stream flow under an embankment. In this manual, the terms “culvert” and “box culvert” are used interchangeably and imply a reinforced concrete box-shaped structure typically under an embankment for a roadway.

Cyclopean Stone Rip-Rap - Large rock (1/4 to 1-1/2 cubic feet in size) placed as a protective covering for slopes or channel banks subject to erosion or scour.

Designated Bikeway - A path or route specifically intended and promoted by the LFUCG for use by bicyclists.

Floodplain - The land bordering a stream that is subject to inundation during a 100-year flood.

Floodway - The channel of a watercourse and the adjacent portion of the floodplain which must be reserved in order to discharge the one-percent chance flood without cumulatively increasing the water surface elevation more than a designated height (1 foot maximum).

Gravity Retaining Wall - Relatively massive, trapezoidal shaped, unreinforced concrete wall deriving its capacity from its own weight and the weight of the soil it retains.

Infrastructure - The system of streets, roads, sewers, and ancillary facilities that serve as the public works framework for a community.

LFUCG - Lexington-Fayette Urban County Government, the governing and administrative body of the municipal services and public works for Fayette County, Kentucky.

Mechanically Stabilized Earth (MSE) Wall - Retaining wall composed of strip or grid reinforcements within the soil mass and faced with vertical precast concrete panels.

Normal Pool - A stream's water surface elevation prevailing during the greater part of the year.

Ordinary Highwater - The line on the bank of a stream established by the normal fluctuations of the water surface and indicated by physical characteristics such as shelving or destruction of vegetation.

Profile Grade - The grades and elevations running longitudinally with a road.

Rural Roadway - A roadway that is generally characterized by use of shoulders and open drainage channels adjacent to the roadway.

Scour - The result of action of running water, excavating and carrying away material from the bed and banks of streams.

Semi-Gravity Retaining Wall - Reinforced concrete, inverted T-shaped wall consisting of a spread footing supporting a relatively slender vertical stem and deriving its capacity from the weight of the soil it retains, its own weight and structural resistance of the reinforced concrete.

Substructure - The portion of a bridge extending from the foundation up to and supporting the bridge's spanning members.

Subsurface Exploration - The program of drilling, sample recovery, and analysis to determine the natural and geologic conditions that exist at the foundation locations for a structure.

Superstructure - The portion of a bridge consisting of the main spanning members and deck.

Urban Roadway - A roadway that is generally characterized by use of curbs and sidewalks adjacent to the roadway.

Wing Wall Abutment - A reinforced concrete, inverted T-shaped abutment consisting of a spread footing supporting a slender vertical stem and wings that are angled back in plan from the face of the main stem.

1.3 Federal, State, and Local Permits

1.3.1 General Requirements

Construction of structures or embankments over or along a body of water will require permits from federal and state agencies charged with environmental regulation and protection of water quality and floodplains. For structures which are part of developments, documentation verifying that these permits have been obtained shall be included as part of the review submission to the LFUCG engineering staff. Documentation shall be in the form of copies of permit applications and issued permits or letters of application approval.

1.3.2 Corps of Engineers Permits

Department of the Army, Corps of Engineers Permits are required for work below the Ordinary High Water elevation of all waterways. The specific permit required varies depending on various conditions, authorizations, and current status of frequently changing environmental laws and regulations.

Lexington-Fayette County is within the jurisdiction of the Louisville District of the Corps of Engineers. For specific application requirements, contact the Corps at:

Department of the Army
Louisville District, Corps of Engineers
P.O. Box 59, Attn.: CEORL-OR-F
Louisville, Kentucky 40201-0059
Phone: (502) 582-6461

1.3.3 Division of Water Permits

Chapter 151 of the Kentucky Revised Statutes and related regulations require that a Stream Construction Permit Application be submitted and approved prior to the construction or reconstruction of any bridge, fill, or other obstruction in the floodplain of any stream in Kentucky. The Commonwealth of Kentucky Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water regulates issuance of these permits. Applications are evaluated for compliance with state laws and regulations with regard to the effects of the project on the floodway and flooding of the stream. Applications and other information can be obtained from:

Floodplain Management Section
Division of Water
18 Reilly Road
Frankfort, Kentucky 40601
Phone: (502) 564-3410

1.4 Standard Drawings and Specifications

1.4.1 Standard Details

Standard details, when used, shall be from the current edition of the Lexington-Fayette Urban County Government, Department of Public Works, *Standard Drawings*.

The standard details shall be utilized where those details are appropriate and applicable to a project in lieu of custom or non-standard designs.

1.4.2 Design Specifications

Structural design shall be in accordance with the *American Association of Highway and Transportation Officials, Standard Specifications for Highway Bridges, 16th Edition* and interim specifications through 1997, except as modified or expanded by this document.

1.4.3 Construction

Materials and construction requirements for infrastructure structures shall be in accordance with the current edition of the *Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction*.

1.5 Surveying and Mapping Requirements

1.5.1 General

All surveying and mapping shall be tied to proposed project stationing and all elevations shall be referenced to actual LFUCG Bench Mark level datum.

1.5.2 Bridge Stream Crossing

Bridge crossings over streams require, as a minimum, the following surveying/mapping to adequately determine appropriate bridge location, skew, abutment wing length and site orientation:

- Topographic survey with contours at two foot intervals extending far enough upstream and downstream to depict the flow regime (200 feet each way minimum)

- Hydraulic sections of existing bridges at or near the site

- Normal pool elevation, ordinary highwater elevation and, when highwater witnesses are available, event highwater elevations and dates

- Any field surveys required for hydraulic analyses

1.5.3 Bridge Grade Crossings

Bridge grade separation structures require, as a minimum, the following surveying/mapping to determine proposed structure span arrangement, horizontal and vertical clearances, appropriate skew, abutment wing length and toe of slopes:

- Topographic survey with contours at two foot intervals extending at least fifty feet beyond approximate slope limits and including any features which influence the span or clearances of the proposed structure

- Profile and cross-sections of the existing road or railroad over which the proposed bridge will span

1.5.4 Box Culverts

Box culverts require, as a minimum, the following surveying/mapping to adequately determine appropriate culvert location, length, skew, inlet and outlet configuration, wing length and site orientation:

- Topographic survey with contours at two foot intervals extending far enough upstream and downstream to depict the flow regime (200 feet each way minimum)

- Hydraulic sections of existing drainage structures at or near the site

- Normal pool elevation, ordinary highwater elevation and, when highwater witnesses are available, event highwater elevations and dates

- Any field surveys required for hydraulic analyses

1.6 Plan Submittal Checklist

1.6.1 General

The following checklists are provided to assist designers in assembling the required plans, calculations, and other documentation necessary for various types of structures. The submission items listed are mandatory submittals for structures that are part of developments to be reviewed by LFUCG engineering staff. The checklists are a guide only and are not all-inclusive. The checklists cannot be used as a substitute for reading and complying with all applicable provisions found elsewhere in this manual and companion specifications. For more comprehensive explanations of the submission items listed, see Section 4, "Plan Submission Requirements."

1.6.2 Checklist for Bridges

Design Computations

Yes	or N/A	
		General
☐	☐	Bound in 8.5"x11" format
☐	☐	Title sheet and designer's P.E. seal
☐	☐	Index
		Abutment Design
☐	☐	Founded on solid rock or point bearing piles
☐	☐	Special loading conditions of 2.1.7.2 checked
☐	☐	Shear force from elastomeric bearings considered
☐	☐	Overturning/sliding checked using service loads
☐	☐	Bearing pressure resultant within B/4 of center footing
☐	☐	Footing reinforcement designed using Load Factor Design
☐	☐	Stem/cap designed using Load Factor Design
☐	☐	Seismic support length requirements checked
☐	☐	Wing lengths of wingwall abuts. in accord. Exhibit 2-5
☐	☐	Integral end bent pile flanges parallel thermal movement
☐	☐	Piles spaced between 3.0 feet and 10.0 feet
☐	☐	Required minimum pile penetration met (See Sec. 3.1.3)
☐	☐	Axial pile loads computed
☐	☐	Horizontal pile resistance checked for non-integral end bents
☐	☐	Footing adjacent stream at least 2 feet below stream bed
		Pier Design
☐	☐	Loads calculated for all applicable AASHTO load groups
☐	☐	Bearing pressures or pile loads calculated using service loads
☐	☐	Footing designed using Load Factor Design
☐	☐	Top of footing at least 2 feet below finished ground
☐	☐	Web provided to 2 feet above highwater
☐	☐	Frame piers analyzed for frame action
☐	☐	Slenderness effects considered for columns

Yes or N/A		**Pier Design (Checklist continued)**
☐	☐	Column height/width ratio less than 12
☐	☐	Cap designed using Load Factor neglecting web
☐	☐	Seismic support length requirements checked
		Superstructure Design
☐	☐	Riding surface cast-in-place reinforced concrete slab
☐	☐	Deck width in accordance with Section 2.1.4
☐	☐	1/2” deducted from slab thickness for design
☐	☐	Allowance of 15 psf for future wearing surface included
☐	☐	Minimum slab thickness 5” over side-by-side box beams
☐	☐	Minimum slab thickness 8” over spread beams/girders
☐	☐	Flex. distribution of slab reinf. checked using “z” of 130 kips/in.
☐	☐	Primary reinf. top mat directly over bottom mat bars
☐	☐	Distribution reinforcement in accordance with Section 2.1.8
☐	☐	Radial reinf. provided in acute slab corners 75 degrees or less
☐	☐	Deck drains provided and spaced in accordance with Section 2.1.8.3
☐	☐	Live load distribution factors in accordance with AASHTO 3.23
☐	☐	Beam/girder design provided
☐	☐	HS25 live load used
☐	☐	Flex. strength of precast concrete members checked at each 1/10 pt.
		Attachments
☐	☐	Geotechnical Report attached
☐	☐	Hydraulic calculations attached
☐	☐	Corps of Engineers permit application attached
☐	☐	Corps of Engineers permit or letter of approval attached
☐	☐	Division of Water permit application attached
☐	☐	Division of Water permit attached

Plan Details

Yes or N/A		
		General
☐	☐	Plans on 24”x36” sheets
☐	☐	Title block all sheets
☐	☐	Sheet numbers and initials on all sheets
☐	☐	Designer’s P.E. stamp on first sheet
		General Notes
☐	☐	Required notes provided in accordance with Section 4.1.3
☐	☐	Other appropriate notes provided
		Bridge Layout
☐	☐	Centerline/baseline with stations shown
☐	☐	Pavement lines, curb, sidewalk lines etc. shown
☐	☐	Horizontal curve data shown
☐	☐	Stations of substructures shown
☐	☐	Skew angle shown
☐	☐	North arrow shown

Yes	or N/A	**Bridge Layout (Checklist continued)**
☐	☐	Berm or other grading dimensions shown
☐	☐	Slope protection limits shown
☐	☐	Stream lines and flow direction shown
☐	☐	Span dimensions shown
☐	☐	Existing contours shown
☐	☐	Toe of proposed slopes shown
☐	☐	Roadway profile data given
☐	☐	Substructure bridge seat/footing elevations etc. shown
☐	☐	Existing ground line shown
☐	☐	Rock line shown
☐	☐	Fixed/integral/expansion bearings indicated
☐	☐	Slope protection thickness noted
☐	☐	Typical deck section with dimensions shown
		Subsurface Data Sheet
☐	☐	Plan of cores and soundings shown
☐	☐	Core logs or sounding refusal elevations shown
		Abutment Details
☐	☐	Cap plan provided
☐	☐	North arrow shown
☐	☐	Front elevation view provided
☐	☐	Side or wing elevation(s) provided
☐	☐	Footing plan or pile layout provided
☐	☐	Section(s) through cap and/or stem and footing provided
☐	☐	Section(s) through wings provided
☐	☐	Plan views tied to baseline
☐	☐	Elevations of critical points given
☐	☐	Bill of reinforcement provided
☐	☐	Reinforcement detailed in accord. with Section 4.1.12
		Pier Details
☐	☐	Cap plan provided
☐	☐	North arrow shown
☐	☐	Front elevation view provided
☐	☐	Side elevation view provided
☐	☐	Footing plan provided with piles shown
☐	☐	Section(s) through cap provided
☐	☐	Section(s) through columns provided
☐	☐	Plan views tied to baseline
☐	☐	Elevations of critical points given
☐	☐	Bill of reinforcement provided
☐	☐	Reinforcement detailed in accordance with Section 4.1.12
☐	☐	Reinforcement detailed in accordance with Section 4.1.12
		Superstructure Framing Plan
☐	☐	Plan view with centerlines of beams and substructures provided
☐	☐	Baseline and skew angle shown
☐	☐	North arrow shown

Yes	or N/A	**Superstructure Framing Plan (Checklist continued)**
☐	☐	Dimensions for span lengths, beam spacings, and diaphragms
☐	☐	Bearing details provided
		Superstructure Details
☐	☐	Elevation view of beam/girder provided
☐	☐	Sections(s) through beam/girder
☐	☐	Deck slab plan with dimensions, skew, baseline shown
☐	☐	Handrail post spacings shown
☐	☐	Deck slab section with dimensions provided
☐	☐	Barrier/curb/sidewalk/handrail details shown
☐	☐	Bearing pad details provided
☐	☐	Diaphragm elevations shown
☐	☐	Diaphragm sections provided
☐	☐	Expansion device details provided
☐	☐	Approach slab details in accordance with Section 4.1.11
		Construction Elevations
☐	☐	Plan view with longitudinal and transverse grid lines shown
☐	☐	Section through deck showing locations of construction elevs.
☐	☐	Table of construction elevations given in accord. with Section 4.1.10

1.6.3 Checklist for Culverts

Design Computations

Yes	or N/A	
		General
☐	☐	Bound in 8.5”x11” format
☐	☐	Title sheet and designer’s P.E. seal
☐	☐	Index
		Geometry
☐	☐	Length of barrel verified by mathematical calculations
☐	☐	Length of wings verified by mathematical calculations
☐	☐	Design fill height determined by mathematical calculations
☐	☐	Appropriate roadway typical section maintained across culvert
☐	☐	Parapet wall 18” above top slab and fill slope 6” below top parapet
☐	☐	Top slab does not protrude into design pavement thickness
		Top Slab Design
☐	☐	Earth loads for yielding fndn. modified by Fe (AASHTO 17.6.4.2)
☐	☐	Earth loads for rock fndn. in accordance with Section 2.2.3.1
☐	☐	Varying foundation made uniform throughout culvert length
☐	☐	Live load included when appropriate in accord. with AASHTO 6.4
☐	☐	Live load impact in accordance with AASHTO 3.8.2.3
☐	☐	Top slab designed using Load Factor Method
☐	☐	Slab thickness not less than 7”
☐	☐	Flex. distribution of reinf. checked using “z” of 98
☐	☐	Same top slab thickness and design used throughout
☐	☐	Shear in slab checked at d or 1/12 span as appropriate
☐	☐	Slab thickness such that shear reinf. not required (if 20’ or less fill)
☐	☐	Lateral earth pressure for rigid frames in accord. AASHTO 3.20.2
		Bottom Slab Design
☐	☐	Same reinforcement as top slab
☐	☐	Slab thickness equal top slab plus 1” for single barrel culvert
☐	☐	Slab thickness equal top slab plus 2” for multiple barrel culvert
		Sidewall Design
☐	☐	Sidewall designed as simple beam, checked as column
☐	☐	Minimum reinforcement #4 at 12”
☐	☐	Minimum thickness 1/12 clear height but not less than 10”
☐	☐	Designed using Load Factor Method
		Interior Wall Design
☐	☐	Designed as column pinned at each end
☐	☐	Minimum thickness 10”
☐	☐	Minimum reinforcement #4 at 12”
☐	☐	Designed using Load Factor Method
		Wing Design
☐	☐	Minimum thickness 1/12 height but not less than 10”
☐	☐	Walls designed for sloping backfill with loads in accord. Exhibit 3-1

Yes	or N/A	**Wing Design (Checklist continued)**
☐	☐	Design height in accordance with Exhibit 2-6
☐	☐	Wall stem designed using Load Factor Method
☐	☐	Footing bearing pressure and overturning checked using service loads
☐	☐	Footing resists overturning and provides acceptable bearing pressure
☐	☐	Footing width not smaller than 3.0 feet
☐	☐	Footing reinforcement designed using Load Factor Method
		Attachments
☐	☐	Geotechnical Report attached
☐	☐	Hydraulic calculations attached
☐	☐	Corps of Engineers permit application attached
☐	☐	Corps of Engineers permit or letter of approval attached
☐	☐	Division of Water permit application attached
☐	☐	Division of Water permit attached

Plan Details

Yes	or N/A	
		General
☐	☐	Plans on 22”x36” sheets
☐	☐	Title block all sheets
☐	☐	Sheet numbers and initials on all sheets
☐	☐	Designer’s P.E. stamp on first sheet
		Culvert Layout
☐	☐	Centerline/baseline with stations shown
☐	☐	Pavement lines, curb, sidewalk lines etc. shown
☐	☐	Horizontal curve data shown
☐	☐	Station and skew of culvert shown
☐	☐	North arrow shown
☐	☐	Slope protection limits shown
☐	☐	Stream lines and flow direction shown
☐	☐	Existing contours shown
☐	☐	Structure plan provided
☐	☐	Toe of slopes and grading dimensions shown
☐	☐	Longitudinal section of culvert provided
☐	☐	Culvert inlet/outlet elevations given
☐	☐	Finished ground elevations at break points given
☐	☐	Existing ground line shown
☐	☐	Rock line shown
☐	☐	Design live load etc. data shown under longitudinal section
☐	☐	Required general notes provided
☐	☐	Any appropriate additional general notes provided
		Culvert Details
☐	☐	Half-plan/half-sectional plan provided
☐	☐	Reinforcement shown top and bottom slab
☐	☐	North arrow shown

Yes or N/A		**Culvert Details (Checklist continued)**
☐	☐	Longitudinal barrel section projected from plan view
☐	☐	Weep holes shown in accordance with Section 2.2.8
☐	☐	Parapet width detailed 12” with #5 stirrups at 12” centers
☐	☐	End elevation of inlet and/or outlet shown
☐	☐	Safety railing or fence provided on parapet and wings
☐	☐	Typical barrel section showing reinforcement and dimensions
☐	☐	Main slab reinforcement detailed with end hooks
☐	☐	Elevation view(s) of wings provided
☐	☐	Section(s) through wings provided
☐	☐	Bill of reinforcement provided
☐	☐	Reinforcement detailed in accordance with Section 4.1.12
		Subsurface Data Sheet
☐	☐	Plan of cores and soundings shown
☐	☐	Core logs or sounding refusal elevations shown

1.6.4 Checklist for Retaining Walls

Design Computations

Yes	or N/A	
		General
☐	☐	Bound in 8.5”x11” format
☐	☐	Title sheet and designer’s P.E. seal
☐	☐	Index
		Stability and Bearing Pressures
☐	☐	Earth loads in accord. with Exh. 3-1 for walls up to 20 feet in height
☐	☐	Hydraulic uplift considered for floodwalls
☐	☐	Sliding, overturning and bearing checked using service loads
☐	☐	Factors of safety in accordance with AASHTO 5.5.5
☐	☐	Passive soil pressures neglected for slope away steeper than 1V:6H
☐	☐	Resultant (R) within B/4 of center footing (rock) or B/6 (earth)
☐	☐	Footing reinforcement designed using Load Factor Method
☐	☐	Wall stem reinforcement designed using Load Factor Method
		Attachments
☐	☐	Geotechnical Report attached

Plan Details

Yes	or N/A	
		General
☐	☐	Plans on 24”x36” sheets
☐	☐	Title block all sheets
☐	☐	Sheet numbers and initials on all sheets
☐	☐	Designer’s P.E. stamp on first sheet
		Wall Details
☐	☐	Plan of wall tied to baseline
☐	☐	Layout dimensions and breaks in alignment shown
☐	☐	Elevation view with vertical dimension and elevations
☐	☐	Weep holes located and detailed
☐	☐	Control joint locations shown
☐	☐	Expansion joint locations shown
☐	☐	Section(s) through wall provided for each design section
☐	☐	Required general notes provided
☐	☐	Other appropriate general notes provided
☐	☐	Bill of reinforcement provided
☐	☐	Reinforcement detailed in accordance with Section 4.1.12
		Subsurface Data Sheet
☐	☐	Plan of cores and soundings shown
☐	☐	Core logs or sounding refusal elevations shown

1.7 Referenced Documents and Manuals

1.7.1 Acknowledgments

The following documents were used as references in the writing and preparation of this manual:

- *Standard Specifications for Highway Bridges, Sixteenth Edition 1996*, 1996, American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001

- "Division of Bridges Guidance Manual", 1991, Commonwealth of Kentucky Transportation Cabinet, Frankfort, Kentucky 40622

- *A Policy on Geometric Design of Highways and Streets, 1994*, 1995, American Association of State Highway and Transportation Officials, 444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001

- *Standard Specifications for Road and Bridge Construction, Edition of 1994*, 1993, Kentucky Transportation Cabinet, Department of Highways, Frankfort, Kentucky 40622

- "Standard Drawings", 1991, Lexington-Fayette Urban County Government, Department of Public Works, Division of Engineering, 200 East Main Street, Lexington, Kentucky 40507

- "Standard Drawings", 1995, Commonwealth of Kentucky Transportation Cabinet, Department of Highways, Frankfort, Kentucky 40622

- "Design of Small Dams", United States Department of the Interior, Bureau of Reclamation, Water Resources Technical Publication, 1977 United States Government Printing Office, Washington, D.C. 20402

- "Foundations and Earth Structures", Design Manual 7.2, 1982, Dept. of the Navy Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, Virginia 22332

CHAPTER 2
GENERAL DESIGN REQUIREMENTS

2.1 Design Requirements for Bridges

2.1.1 Hydraulic Studies

Bridges over streams shall be sized in accordance with the methods outlined in the *Lexington-Fayette Urban County Government Stormwater Manual* and shall satisfy requirements of the Kentucky Division of Water and the Army Corps of Engineers. Considerations which shall be given particular attention include:

- All bridges shall be sized to avoid hazardous stream velocities through their opening.
- Scour potential around substructure foundations shall be quantitatively evaluated and adequate scour protection measures shall be provided. Refer to Section 2.1.3 for minimum limits of rip-rap scour protection.
- The bridge superstructure shall be entirely above the 100 year highwater unless extraordinary site conditions make this unfeasible. Refer to Section 2.1.4.4.
- Bridges shall be located to avoid abrupt bends in streams or confluence with other bodies of water which typically present unstable bank conditions or potential for unpredictable scour.

2.1.2 Subsurface Explorations

Design of substructure foundations shall be based on <u>site specific</u> subsurface explorations. The extent of the subsurface exploration program should be the result of a collaborative effort between the bridge designer and the geotechnical engineer. Each substructure unit will require, as a minimum, one rock core and one sounding. Minimum depth of rock cores shall be 10 feet into rock.

A narrative geotechnical report of the findings of the subsurface explorations shall be written by the geotechnical engineer and included as part of the structure design calculations. The report shall include conditions encountered and rock descriptions, recommended footing or estimated pile tip elevations, allowable rock bearing pressures for spread footings, scour potential of bedrock, D50 of soil when foundation is on scourable rock and recommendations for dealing with any unusual conditions encountered.

A full size Subsurface Data Sheet depicting the boring locations, drill logs and other pertinent subsurface data shall be included in the bridge plan details. Refer to the *Lexington-Fayette Urban County Government Geotechnical Manual* for a complete description of required data and format for the Subsurface Data Sheet.

2.1.3 Scour Protection

Cyclopean stone rip-rap shall be provided at substructures and approach embankments at stream crossings. Minimum thickness of rip-rap shall be 2 feet. Minimum limits of rip-rap shall be 5 feet beyond plan footing dimensions, along embankments to 15 feet behind ends of abutment wings and up embankments from the toe of slope to 2 feet above 100 year flood elevation. These limits shall be increased where scour analyses so indicate.

2.1.4 Geometry and Clearances

Urban Roadway Bridges

Roadway width on urban roadway bridges shall equal the approach roadway width measured face-to-face of curbs.

Sidewalks on bridges shall be separated from traffic by a concrete barrier rail when the roadway design speed is greater than 35 miles per hour. Sidewalks on bridges with design speeds of 35 miles per hour or less may either be separated from traffic by a concrete barrier rail or, alternatively, a sidewalk curb height of 12 inches provided on the bridge. When separated from traffic by a concrete barrier, sidewalk width on bridges shall equal the approach sidewalk width. When no concrete barrier is provided, minimum sidewalk width shall be 2.0 feet greater than the approach sidewalk width.

Where the sidewalk over a bridge is a designated bikeway or when significant bicycle traffic can reasonably be anticipated, bicycle railing shall be provided along the sidewalk. Bicycle railing geometry and design loading shall be in accordance with AASHTO Section 2.7.

Refer to Exhibit 2-1 for further guidance regarding bridge deck geometry for urban roadways.

Rural Roadway Bridges

Roadway width on rural roadway bridges shall be evaluated on a case-by-case basis with consideration given to the potential for future urbanization and its impact on the geometry of the structure. The desirable width is the approach roadway width including effective shoulders with the minimum bridge roadway width equal to the approach pavement width plus 4.0 feet.

Railings

Refer to Exhibit 2-2 for standard bridge railing shapes and configurations.

Clearances

Vertical and horizontal clearances for grade separation structures shall be in accordance with the current edition of AASHTO's *A Policy on Geometric Design of Highways and Streets*.

Stream crossings shall have a minimum freeboard of 1.0 feet from the 100 year flood elevation to the structure low beam.

Grades on Bridges

Roadway profile grades and cross-slopes on bridges shall be established to accommodate the proposed bridge. Bridges shall be situated so as to provide positive drainage of rainfall from the bridge deck. With the exception of localized gradients either side of the high point of a crest vertical curve, roadway profile grades on bridges shall not be less than 0.5 percent. Low points of sag vertical curves shall be located off of the bridge deck. Profile grades on bridges longer than 150 feet shall be limited to no greater than 3.0 percent with the maximum profile grade for any bridge limited to 5.0 percent.

The normal cross-slope for bridge roadways shall be the same as the roadway pavement cross-slope. Superelevation in curves across bridges shall equal the required roadway superelevation, however, in no case shall the superelevation be greater than 6.0 percent. Curves requiring a superelevation greater than 6.0 percent shall not be permitted on bridges.

2.1.5 Loads

Refer to Section 3.1.2 for guidance regarding design loads for bridges.

2.1.6 Materials

General

All materials specified in the design of bridges shall be in accordance with the most current edition of the *Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction*.

Reinforced Concrete

Reinforced concrete for superstructures (except for prestressed concrete beams) and for portions of substructures above the bridge seats shall be Class ‘AA’ with a minimum 28 day compressive strength of 4000 psi. Reinforced concrete for substructures below the bridge seats shall be Class ‘A’ with a minimum 28 day compressive strength of 3500 psi. Concrete for prestressed concrete beams shall be Class ‘D’ with a required 28 compressive strength as determined by design but not less than 5000 psi and not greater than 7250 psi.

Reinforcing Steel

Steel reinforcement for concrete shall be Grade 60 deformed bars in accordance with ASTM A615 (billet) or ASTM A616 (rail). Rail steel bar reinforcement shall be used only for straight bars.

Structural Steel

Structural steel for webs and flanges of main load carrying members shall be AASHTO M270 Grade 50. Diaphragms, stiffeners and miscellaneous steel shall be AASHTO M270 either Grade 50 or Grade 36.

2.1.7 Substructure Design

Pile End Bents

Pile end bents which are integral with the superstructure are preferred over non-integral end bents and should be used when possible. Integral pile end bents may be used for bridge lengths up to 400 feet in length with skews of 30 degrees or less.

Integral pile end bents shall utilize a single row of point bearing, HP shaped steel piles with their flanges oriented parallel with the direction of anticipated thermal movement of the end bent. Approach slabs shall be provided at all integral end bents. Approach slab width shall be the gutter-to-gutter width of the bridge and the standard length shall be 25 feet with the ends skewed parallel to the end bent.

Center-to-center spacing of piles in a row and spacing of adjacent rows of piles shall be between 3.0 feet and 10.0 feet. Non-integral end bents with two rows of piles shall have the front row battered 4:12.

When designing pile end bents, the axial and horizontal pile loads for the various loading groups shall be computed neglecting passive earth pressure in front of the end bent. Unless a more conservative value is recommended based on geotechnical considerations, piles shall be designed for a maximum axial load equal to 0.25Fy over the cross-sectional area of the pile, excluding any pile tip reinforcement. For HP12x53 piles of Grade 36 steel, this translates into an allowable axial load of 140 kips.

The required horizontal resistance of a pile is the load that the pile must resist in excess of that resisted by the horizontal component (if any) of the axial pile load. The permissible horizontal pile resistance is given on the graph of Exhibit 2-4 as a function of the soil strength. The strength value to be used with the graph is the weighted average of the values for each layer of soil as presented in the geotechnical report of the subsurface exploration. The maximum allowable horizontal resistance is 10 kips. Horizontal resistance for piles in integral end bents need not be checked.

Computed values for maximum axial pile load and horizontal resistance, when applicable, shall be shown on the design plans.

Abutments and End Bents

Abutments on spread footings shall be founded on unweathered, solid rock. Footings for wingwall type abutments adjacent to streams shall be embedded a minimum of 2 feet below the stream bed and protected by a minimum of 2 feet of cyclopean rip-rap.

In addition to other applicable AASHTO loading groups, abutments and non-integral end bents shall be designed for the following loading conditions:

- Consider the abutment constructed and backfilled including a 2 foot earth surcharge but without the superstructure dead load. The factor of safety against overturning shall be 1.25 minimum.

- Consider the abutment constructed and backfilled including a 2 foot earth surcharge and with superstructure dead load only. The factor of safety against overturning shall be 1.50 minimum.

- Consider the abutment constructed and backfilled, no earth surcharge and both superstructure dead load and live load. The factor of safety against overturning shall be 1.50 minimum.

Lateral earth loads shall be obtained from Exhibit 3-1 and 3-2. Overturning, sliding and bearing pressures for footings shall be calculated using unfactored service loads. Computed bearing pressures shall be compared with the allowable rock bearing pressures multiplied by the percentage of basic unit stress given in AASHTO Table 3.22.1A. The location of the bearing pressure resultant (R) shall be within B/4 of the center of the footing (factored by the percentage of basic unit stress given in AASHTO Table 3.22.1A).

Where applicable, include the effects from the shear force of elastomeric bearings in load groups with temperature included.

Wing lengths of wingwall type abutments shall be verified by mathematical calculations considering roadway alignment and grade, approach geometry and fill slope ratio (Refer to Exhibit 2-5). The design height of wings for wingwall abutments shall be taken as the height where a 45 degree line beginning where the wall meets the abutment stem intersects the top of the wall (Refer to Exhibit 2-6).

Weep hole drains in accordance with Exhibit 2-7 shall be provided in wings and abutment stems at approximate 10 foot centers.

Abutment wings and stems shall be backfilled with compacted, select granular backfill consisting of #57 coarse aggregate to promote backfill drainage and minimize backfill settlement.

Piers

Piers of the type and geometry included in Exhibits 2-8 through 2-9 are approved for use.

Piers subject to floodwaters shall have webs extending to a minimum of 2 feet above the 100 year flood to prevent drift from accumulating between columns.

Piers shall be analyzed and designed for all applicable AASHTO loading groups. Bent (frame) type piers shall be designed for frame action unless full height web walls are utilized in which case frame action may be neglected. Pier caps shall be designed for shear and moment with no assistance from webs.

When evaluating stresses in piers due to thermal expansion or contraction, a value of 1.0 x 106 psi may be used for the modulus of elasticity of concrete. This artificially low value is suggested to more realistically account for the effects of creep which lower the stresses caused by temperature loads which are applied gradually.

The effects of slenderness shall be considered for pier columns or stems in accordance with AASHTO 8.16.5. Columns shall be sized to maintain a height to width ratio less than 12.

Tops of footings shall be a minimum of 2 feet below finished ground. Axial pile loads and bearing pressures for footings shall be calculated using unfactored service loads and compared with the allowable pile loads and footing pressures multiplied by the percentage of basic unit stress given in AASHTO Table 3.22.1A.

Epoxy Coated Reinforcement

Epoxy coated reinforcement shall be utilized in the following portions of reinforced concrete substructures:

- Dowel bars which serve to fix the superstructure and which extend from abutment or pier caps into the superstructure diaphragms.
- All reinforcement, any portion of which extends above the bridge seats of integral pile end bents.
- All reinforcement in non-integral pile end bents including wings.
- All horizontal reinforcement in the bridge seat and all reinforcement extending above the bridge seat for wingwall type abutments with backwalls.
- All cap reinforcement (excluding column reinforcement extending into caps) of piers under superstructure expansion joints.

2.1.8 Superstructure Design

Deck Slabs

The riding surface of bridges shall ordinarily be a cast-in-place reinforced concrete slab, regardless of the supporting framing system. Minimum slab thickness over spread girder systems shall be 8". When precast concrete side-by-side box beams are used, a composite slab of 5" minimum thickness shall be provided. On rural roadway bridges with design ADT less than 400, the concrete slab may be omitted on precast concrete side-by-side box beam bridges.

Slabs shall be constructed of Class 'AA' Concrete with a 28 day compressive strength of 4000 psi. Clearance to top mat reinforcement shall be 2-1/2", clearance to bottom mat reinforcement shall be 1". All slab reinforcing steel shall be epoxy coated.

When designing slabs and composite beams/girders, 1/2" shall be deducted from the slab thickness to allow for wear of the slab. Include an allowance of 15 psf for a future wearing surface in the design of slabs and supporting structure.

Slab reinforcement shall be straight bars and spacing of top and bottom mats of the primary reinforcement shall be the same with the top bars directly above the bottom bars.

Distribution reinforcement in the bottom mat shall be in accordance with AASHTO 3.24.10. Additionally, half of that percentage of reinforcement shall be provided in the top mat. Employ the shrinkage and temperature reinforcement requirements of AASHTO 8.20 in both the top and bottom mats. Negative moment reinforcement over piers is included in satisfying distribution and temperature/shrinkage requirements.

When no sidewalk is present, design slab cantilevers for a vertical wheel load and horizontal railing load in accordance with AASHTO 3.24.5. The horizontal rail load given in AASHTO may be reduced by 15 percent when a continuous barrier curb is used, due to the effects of edge stiffening provided by the barrier. Note that the wheel and railing load are not applied simultaneously.

Acute corners of slabs 75 degrees or less shall have radial reinforcement to offset shrinkage along the long diagonal dimension of the slab. The reinforcement shall be placed beneath the longitudinal and transverse reinforcement in the top mat. The placement pattern shall be as shown on Exhibit 2-10.

Expansion Joints

Expansion joints between slabs and abutments shall be avoided when possible by the use of integral end bents. Expansion joints in slabs shall be avoided by making spans continuous over interior supports when possible.

When expansion joints are required, refer to Exhibit 2-11 for size and type of joint required as a function of movement and skew. When joints are required between slabs and pile end bent backwalls, increase the size required for thermal movement by 1 inch.

Deck Drains

Deck drains shall be provided for removal of storm water from the bridge roadway and sidewalks. Spacing of deck drain inlets shall be verified with hydraulic calculations of water spread using a rainfall intensity of 4.0 inches/hour and a runoff coefficient of 0.9 and consideration of roadway grade and cross-slope. Spread of water at the gutter of the roadway shall be limited to 4.0 feet or a water depth of 1.0 inch at the curb, whichever is more restrictive.

Refer to Exhibit 2-13 and 2-14 for typical deck drain details. Thru-Wall drains are not permitted with steel girders, concrete girders over 54" in height or with side-by-side concrete box beam structures. Straight steel tube drains are preferred where sidewalks separate the gutter line from the slab edge. The use of offset scuppers (with bent throats) should be avoided.

2.2 Design Requirements for Box Culverts

2.2.1 Hydraulic Studies

Box culverts shall be sized hydraulically in accordance with the methods outlined in the Lexington-Fayette Urban County Government Stormwater Manual and shall satisfy requirements of the Kentucky Division of Water and the Army Corps of Engineers. Considerations which shall be given particular attention include:

- Alignment and location of the culvert inlet and outlet to fit the natural channel. Culverts skewed with respect to the roadway shall preferably be skewed in increments of 5 degrees.

- The potential for scour around the outlet wings and downstream channel and protective measures where necessary.

- The location of stream confluences or other drainage structure outlets which may require special considerations.

2.2.2 Subsurface Explorations

The type of culvert foundation, yielding or unyielding, and the associated design shall be based on site specific subsurface explorations. The extent of the subsurface exploration program should be the result of a collaborative effort between the structural engineer and the geotechnical engineer. Culverts will require a minimum of one rock core at least 5 feet into rock and one rockline sounding with the need for additional soundings and/or cores evaluated based on site conditions, fill height and culvert length.

A narrative geotechnical report of the findings of the subsurface explorations shall be written by the geotechnical engineer and included as part of the structure design calculations. The report shall include conditions encountered and rock descriptions, soil classifications, recommended allowable bearing pressures and footing elevations and recommendations for dealing with any unusual conditions encountered.

2.2.3 Loads

Earth Loads

Yielding Foundations - Earth loads for box culverts on yielding (earth) foundations shall be calculated based on the equivalent fluid weights for vertical and lateral earth pressures given in AASHTO 6.2.1. For cast-in-place, reinforced concrete box culverts, these loads shall be multiplied by the soil-structure interaction factor, Fe, which is calculated in accordance with AASHTO 17.6.4.2.

Unyielding Foundations - Vertical earth loads for box culverts on unyielding (rock) foundations shall be based on the following coefficients and parameters which are based on Research Report UKTRP-84-22 and illustrated in Exhibit 2-15:

A uniform load, P1, equal to 84 x H, pounds per square foot, shall be distributed over design span L1. This uniform load P1 shall be supplemented by two additional uniform loads, P2. The value of P2, in pounds per square foot, is equal to:

$$[(120 \times K1 \times K2 \times K3) - 84] \times H$$

K1, K2 and K3 are coefficients interpolated from the graphs on Exhibit 2-15 and H equals the fill height over the culvert in feet.

The moments and shears calculated using the above loading shall not be less than those resulting from a uniform load of 120 x H, pounds per square foot, distributed over design span L1.

Lateral earth loads shall be the same as for culverts on yielding foundations.

Varying Foundations - Foundations which are not uniform are undesirable in that differential settlements are likely which create unanticipated stresses in the structure. Where the foundation conditions vary over the length of the culvert such that portions of the structure will be on unyielding foundations while other portions are on a yielding foundation, the foundation shall be made uniform through one of the following options:

- The total foundation shall be made yielding by undercutting and backfilling to create a yielding material foundation.

- The culvert footings shall be extended to rock and the culvert designed as for an unyielding foundation.

Live Loads

Box culverts shall be designed for the effects of live load when warranted according to the fill height limits of AASHTO 6.4. When the fill height over a culvert is less than 3.0 feet, live load impact shall be included in accordance with AASHTO 3.8.2.3.

When live load is applied, a 2.0 foot surcharge shall be added to the lateral earth loads applied to the sidewalls.

2.2.4 Materials

General

All materials specified in the design of culverts shall be in accordance with the most current edition of the *Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction*.

Reinforced Concrete

Reinforced concrete for box culverts shall be Class 'A' with a minimum 28 day compressive strength of 3500 psi.

Reinforcing Steel

Steel reinforcement for concrete shall be Grade 60 deformed bars in accordance with ASTM A615 (billet) or ASTM A616 (rail). Rail steel bar reinforcement shall be used only for straight bars.

2.2.5 Geometry

Length of culverts and their wings shall be verified by mathematical calculations considering width of crossing roadway and sidewalks, roadway alignment and grade, fill slope ratio, culvert slope and inlet/outlet and parapet wall configuration. The required appropriate roadway typical section including sidewalks and border width shall be maintained across the culvert and not narrowed to a substandard width for the purposes of minimizing culvert length.

Parapet walls shall extend 18 inches above the top slab and the culvert length shall be such that the fill slope hits the parapet 6 inches below the top. The top slab of the culvert shall be entirely beneath the design pavement and base of the roadway. Refer to Exhibit 2-16 for additional requirements and details.

Culvert end conditions including headwall and wing configuration and the requirement for inlet/outlet paving shall be as determined by hydraulic analysis. The use of side-tapered or slope-tapered "improved inlets" which may result in a smaller culvert barrel size shall be determined by hydraulic analysis when their use is deemed appropriate.

Special structural details are required when storm sewer pipes enter the barrel sidewalls or wings. Refer to Exhibit 2-19.

2.2.6 Design Method

All reinforced concrete box culverts shall be designed using the "Strength Design" (Load Factor) Method in accordance with AASHTO 8.16.

Culverts under fill heights of 20 feet or less shall be designed assuming the top slab is a simple beam. The slab thickness shall be such that shear reinforcement is not required.

Culverts with fill heights greater than 20 feet may be designed with shear reinforcement as a simple span, as a rigid frame as shown in Exhibit 2-20, or as an arch.

2.2.7 Barrel Design

Refer to Exhibits 2-21 through 2-22 for typical barrel details.

Top Slab General

To facilitate future extension of culverts, top slabs are to be designed for the most severe loading case and a uniform slab thickness and design used throughout the length of the culvert.

All main reinforcement, any part of which lies in the bottom part of the slab, shall have hooks on each end. Longitudinal reinforcement shall be designed to transfer the full axial tension from the wings to the barrel.

Keyed construction joints, turned down, shall be provided between the top slab and sidewalls.

Top Slabs for Single Span Culverts

Unless designed as a rigid frame, design the top slab as a simply supported beam with the span length equal to the distance center-to-center of sidewalls but not greater than the clear span plus the depth of the slab. The minimum slab thickness shall be 7 inches.

If shear reinforcement is required, bend alternate bars at 45 degrees beginning at 1.5d from the face of the wall, where d is the effective depth of the slab.

Top Slabs for Multiple Span Culverts

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

A truss bar shall be used to resist both positive and negative moments. The truss bar shall be bent down at the fifth point of the clear span away from the interior support. Provide additional reinforcement, N-bars, over the interior supports and cutoff at the span centerline for fill heights of 3.0 feet or less and 12 inches beyond the quarter point for fill heights greater than 3.0 feet. Do not hook N-bars.

If shear reinforcement is required, utilize bent bars spaced with N-bars and bent up at 45 degrees beginning at 1.5d from the face of the interior support.

Bottom Slabs

Use the same reinforcement as the top slab design with the total bottom slab thickness 1 inch greater than the top slab for single span culverts and 2 inches greater than the top slab for multiple span culverts.

A construction joint is required between the bottom slab and sidewall. This joint shall be roughened unless a keyed joint is required for shear, in which case the key shall be turned down.

Sidewalls

The minimum sidewall thickness shall be 1/12 the clear height of the wall but not less than 10 inches. Minimum wall reinforcement shall be #4 bars at 12 inch centers. Extend the wall reinforcement into the top and bottom slabs without hooks for culverts less than 6 feet in height. Use dowels hooked in the bottom slab for culverts 6 feet or greater in height.

Sidewalls are to be designed as a simple beam with a design span equal to the clear height and loaded with the lateral earth pressure. The sidewall design shall be checked as a column pinned on each end and loaded with the lateral earth load and the axial load from the supported slab.

Interior Walls

The minimum interior wall thickness shall be 10 inches. The minimum reinforcement shall be #4 bars at 12 inch centers. The inlet end of interior walls shall be set back to clear the rounded portion of the inlet parapet wall.

Design the wall as a column pinned at each end and loaded with the axial load from the supported slab.

2.2.8 Wall Drains

Weep drains, 4 inches in diameter, shall be provided in the sidewalls of culverts 6 feet in height and greater and in all culverts 130 feet long and greater.

Weep drains, 4 inches in diameter, shall be provided in culvert wings 10 feet long and greater.

Weep drains are to be located 6 inches above the flowline of the culvert and spaced at approximately 8 foot centers.

2.2.9 Headwalls (Parapets)

Parapet walls shall be 12 inches wide and the top shall be 18 inches above the top of the top slab. Vertical stirrup bars, #5 at 12 inch centers, shall be provided across the length of the parapet. Two bars shall be provided in the top of the parapet, #6 bars in single span culverts and the same size as the N-bars in multiple span culverts.

Safety railing or fence, 4 feet in height, shall be provided across parapets and down the wings of culverts in urban areas. Refer to Exhibit 2-23.

2.2.10 Aprons

Aprons shall be provided along the ends of culvert wings and bottom slab or paving. Normal thickness of the aprons is 12 inches and they shall extend to 4.0 feet below the flowline on culverts 6 feet high and taller and 3.0 feet below the flowline for culverts less than 6 feet in height. On multiple span culverts, 2 bars the same size as the N-bars shall be provided in the bottom of the apron. Aprons for earth bearing culverts may be terminated at the top of rock.

2.2.11 Wing Design

Two types of wings are used for culverts. Traditional wings are flared at varying angles from headwalls which are parallel to the roadway. 30 degree flared wings are always flared 30 degrees from the centerline of the barrel whose headwall is perpendicular to the centerline of the barrel.

Minimum thickness of wing walls shall be 1/12 the height of the wall but not less than 10 inches. Wing walls of culverts 6 feet high and greater and all wings 10 feet long and greater shall have two #6 bars parallel with and along the top of the wall. Begin spacing of horizontal reinforcement 9 inches above the top of the footing.

Design walls as a retaining wall with a sloping backfill. Design height of the wall shall be taken as the height where a 45 degree line, beginning where the wall meets the barrel, intersects the top of the wall.

Wing footings shall be sized to adequately resist overturning and provide an acceptable bearing pressure based on the design height. Minimum width of footings shall be 3.0 feet. Wings 30 feet long and greater shall have footing widths tapered from that required at the design height to that required for the height at the wing ends.

2.2.12 Scour Protection

Scour protection shall be provided at inlets and outlets of culverts. Provide cyclopean stone rip-rap around wings and embankments for a minimum distance of 15 feet beyond ends of wings and extended up slopes to 2 feet above highwater. Provide additional rip-rap when indicated by hydraulic analysis.

2.3 Design Requirements for Retaining Walls

2.3.1 Wall Types

Acceptable types of retaining walls include: concrete gravity or semi-gravity, mechanically stabilized earth (MSE) walls and gabion basket walls. Anchored or tie-back systems are not permitted and MSE walls are not permitted in floodplain areas or where utilities would be constructed within the reinforced volume. Gabion baskets shall be used only as retaining structures for sides of drainage channels in low visibility areas.

2.3.2 Materials

General

All materials specified in the design of retaining walls shall be in accordance with the most current edition of the *Kentucky Transportation Cabinet, Department of Highways, Standard Specifications for Road and Bridge Construction*.

Concrete

Concrete for gravity and semi-gravity retaining walls shall be Class 'A' with a minimum 28 day compressive strength of 3500 psi.

Reinforcing Steel

Steel reinforcement for concrete shall be Grade 60 deformed bars in accordance with ASTM A615 (billet) or ASTM A616 (rail). Rail steel bar reinforcement shall be used only for straight bars.

Backfill for MSE Walls

Granular backfill for the reinforced volume of mechanically stabilized earth walls shall be #57 coarse aggregate.

2.3.3 Subsurface Explorations

The design of footings for retaining walls shall be based on <u>site specific</u> subsurface explorations. The extent of the subsurface exploration program should be the result of a collaborative effort between the structural engineer and the geotechnical engineer. Minimum requirements for subsurface investigations are those outlined in AASHTO 5.3.

A narrative geotechnical report of the findings of the subsurface explorations shall be written by the geotechnical engineer and included as part of the structure design calculations. The report shall include conditions encountered and rock descriptions, soil classifications, recommended allowable bearing pressures and recommendations for dealing with any unusual conditions encountered.

2.3.4 Loads

Lateral earth pressures for retaining walls up to 20 feet in height shall be determined using the methods presented in Exhibit 3-1 and 3-2 which are reproduced from NAVFAC DM-7.2, May 1982. Soil type 3 shall be assumed unless a special backfill material is specified.

When highway traffic can come within a horizontal distance from the top of the wall equal to one-half its height, a live load surcharge equal to 2 feet of earth shall be included in the lateral earth pressure.

2.3.5 Design and Stability

Reinforced concrete walls which frame into a supporting structure shall be designed for a height taken as the height where a 45 degree line beginning where the wall meets the supporting structure intersects the top of the wall.

The location of the bearing pressure resultant (R) on the footing shall be within B/6 of the center of the footing for soil foundations and within B/4 of the center of the footing for rock foundations. These limitations may be factored by the percentage of basic unit stress given in AASHTO Table 3.22.1A.

Factors of safety for sliding and overturning shall be in accordance with AASHTO 5.5.5. Passive soil pressures which resist overturning and/or sliding shall be neglected for soil masses which slope away from the wall steeper than 1V:6H. Bearing pressures for footings shall be calculated using unfactored service loads and compared with the allowable pressures multiplied by the percentage of basic unit stress given in AASHTO Table 3.22.1A.

Walls which serve as floodwalls (i.e. around detention basins) shall be designed for the overturning effects of water applied laterally to the wall face and also for the hydrostatic uplift force along the base. Pressures shall be based on the maximum expected water surface elevation of the basin.

One method for approximating the uplift force is Lane's Weighted Creep Theory which is an empirical method used to approximate uplift and seepage for small dams. This method involves calculation of the "weighted creep path distance" of a section through the wall as being the sum of the vertical distances of the seepage path along the base contact surface plus one-third of the horizontal distances. The upward pressure to be used in design is estimated by assuming that the drop in pressure from the headwater to the tailwater side is proportional to the weighted creep distance. This is illustrated in Exhibit 2-24. Use of aprons or cutoff walls will reduce the effects of uplift and seepage.

The maximum permissible height of detention/retention basin floodwalls, measured from natural ground line on the protected side to top of wall, shall be limited to 5.0 feet. "Natural ground" shall not include portions of fill or berms mounded behind the wall and above a line from the wall to the toe of the fill or berm and sloping away from the wall at 1V:6H. The top of the floodwall shall be set 1.0 feet above the maximum expected water surface elevation.

2.4 Design of Miscellaneous Structures

2.4.1 Design

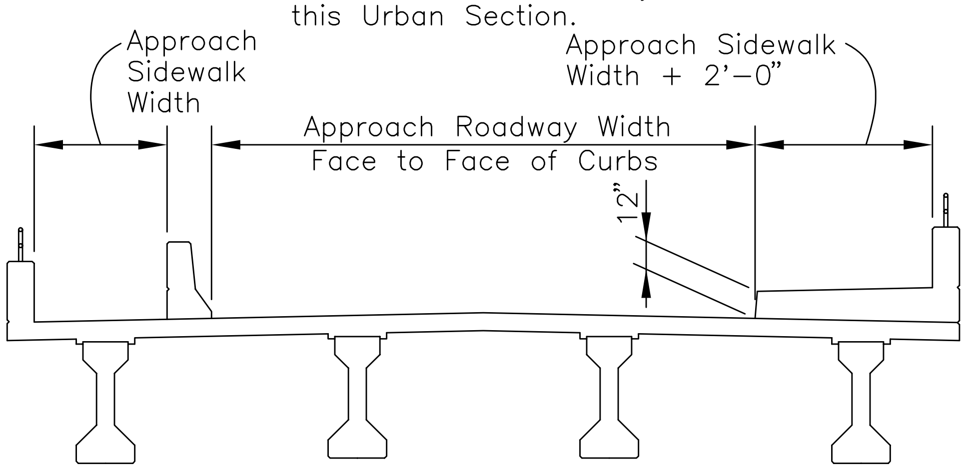
Miscellaneous structures not specifically addressed in this manual shall be designed in accordance with applicable AASHTO design specifications and/or sound structural engineering principles and methods.

2.4.2 Proprietary Structures

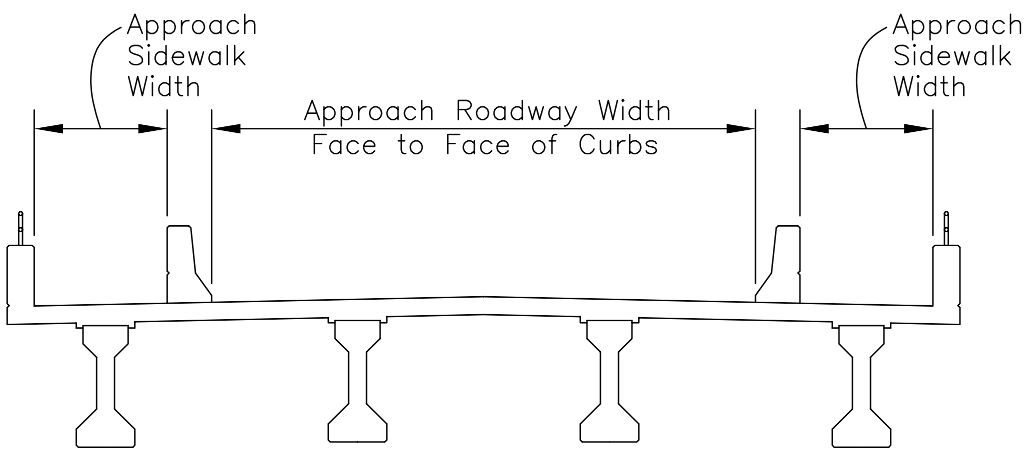
Proprietary or unique structures require the submission of clear and complete design calculations for all major elements of the structure. Calculations shall be complete, organized, neat and legible and explanatory for review of methods, loads and design assumptions with references to applicable AASHTO articles.

New products require review and approval by the Lexington-Fayette Urban County Government and additional testing or documentation may be required prior to acceptance as an approved product. Acceptance of new products shall be at the discretion of the Lexington-Fayette Urban County Government.

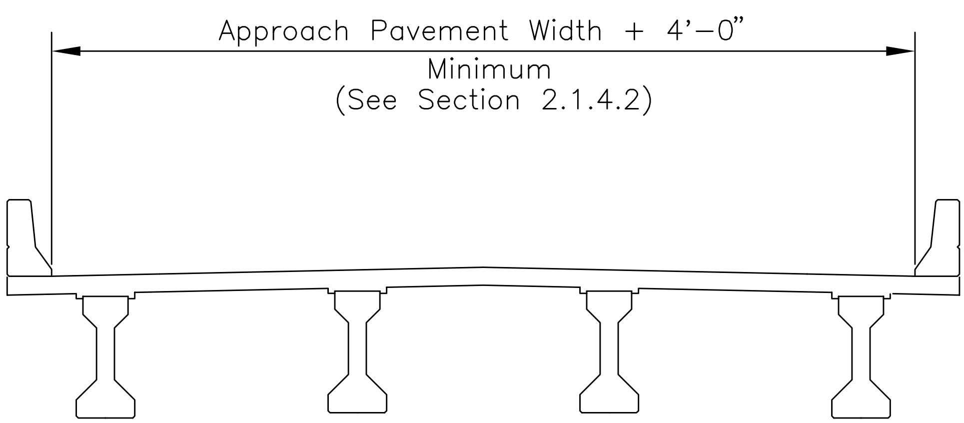
Sidewalks separated by Concrete Barrier or raised sidewalks may be used with this Urban Section.



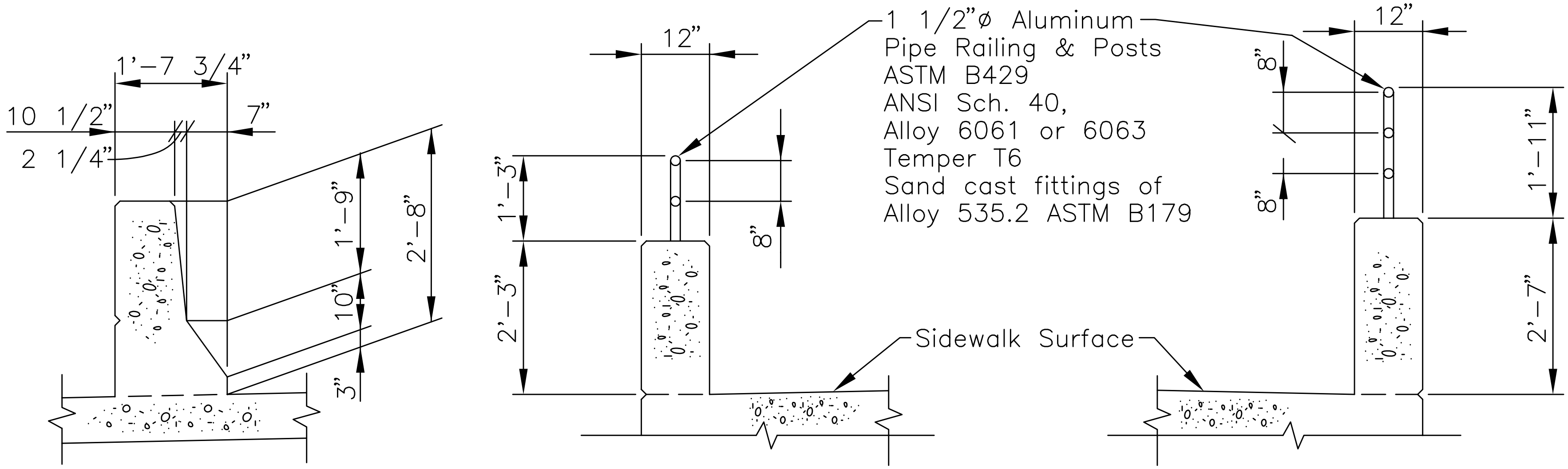
URBAN SECTION FOR DESIGN SPEEDS OF 35 MPH OR LESS



URBAN SECTION FOR DESIGN SPEEDS GREATER THAN 35 MPH



RURAL SECTION

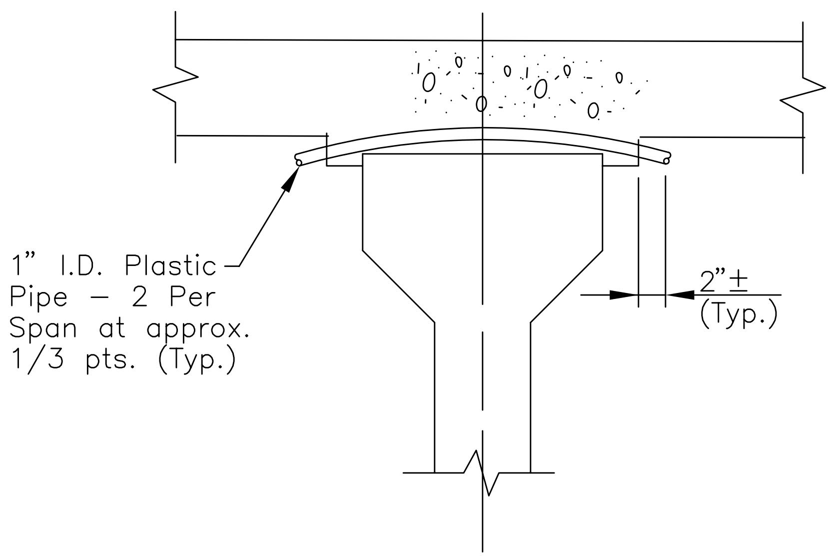


CONCRETE BARRIER

PARAPET & HANDRAIL
(Pedestrian)

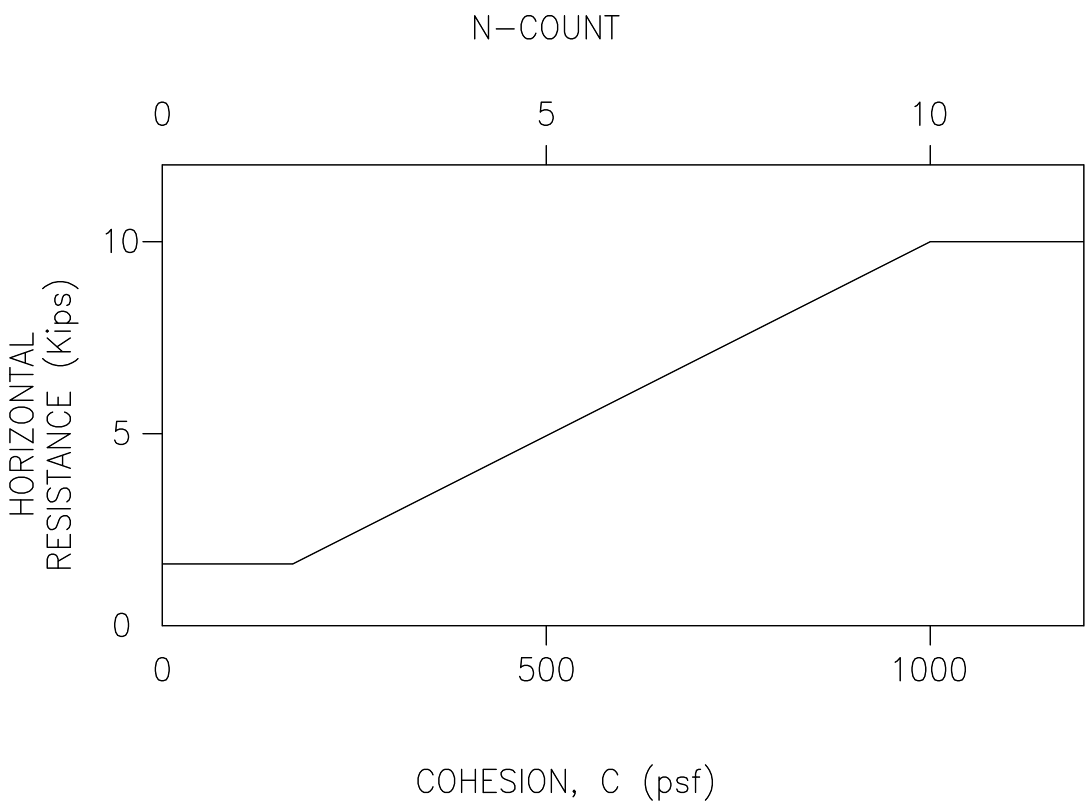
PARAPET & HANDRAIL
(Bikeway)

BARRIER AND HANDRAIL DETAILS



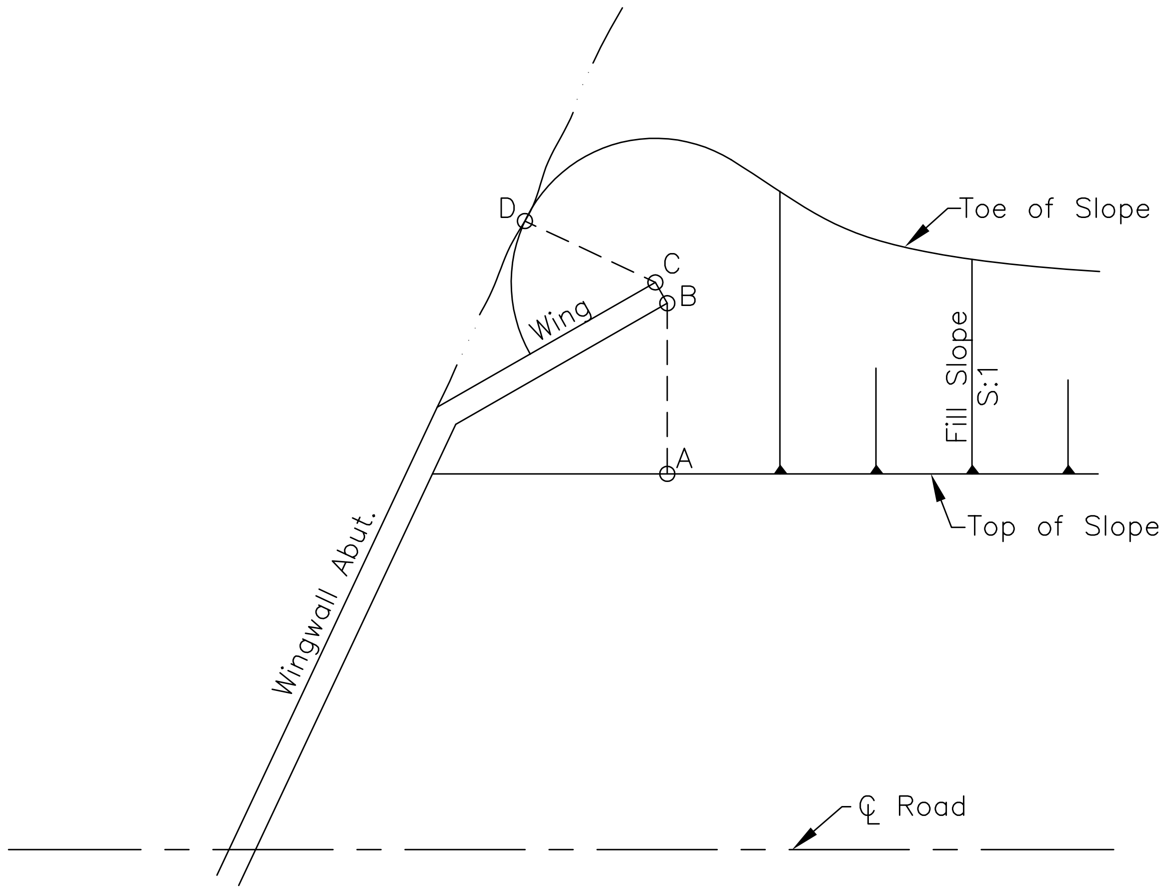
VENT DETAIL

For use to reduce bouyancy of
Superstructures below highwater



PERMISSIBLE HORIZONTAL RESISTANCE PER PILE

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL

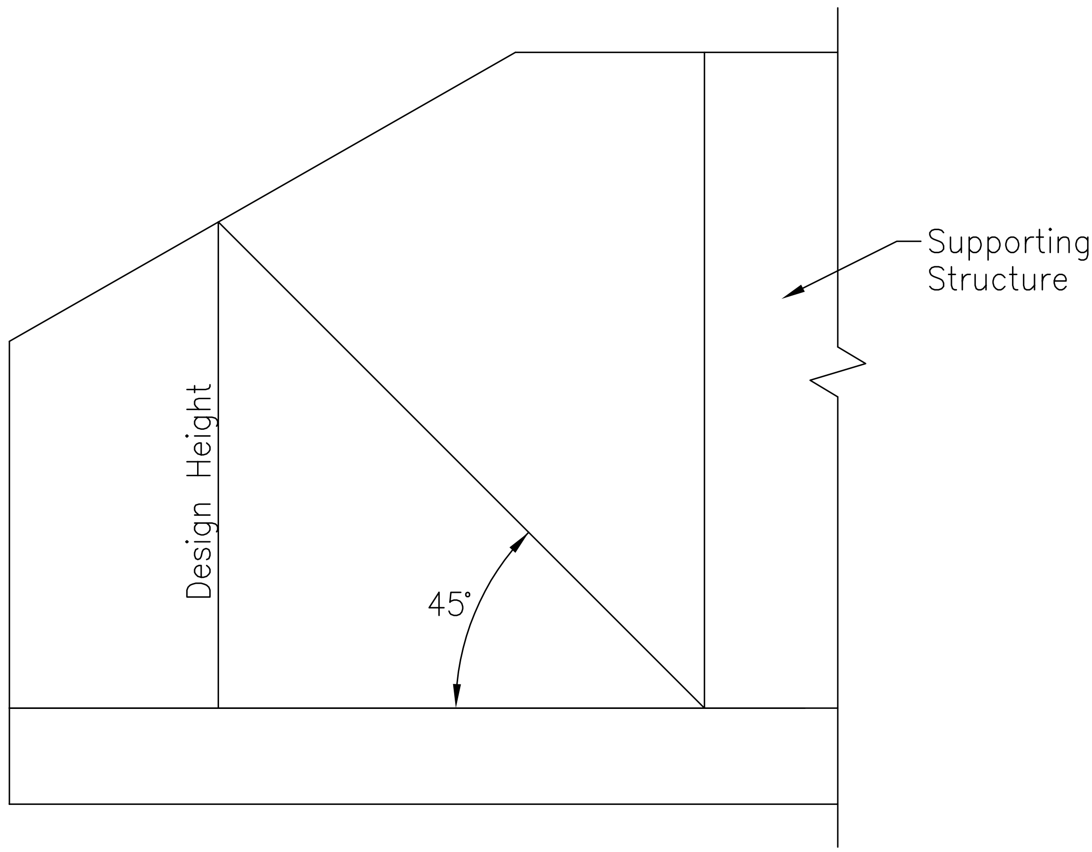


Wing Length of Wingwall Abutments shall be verified by mathematical calculations. Length shall be such that...

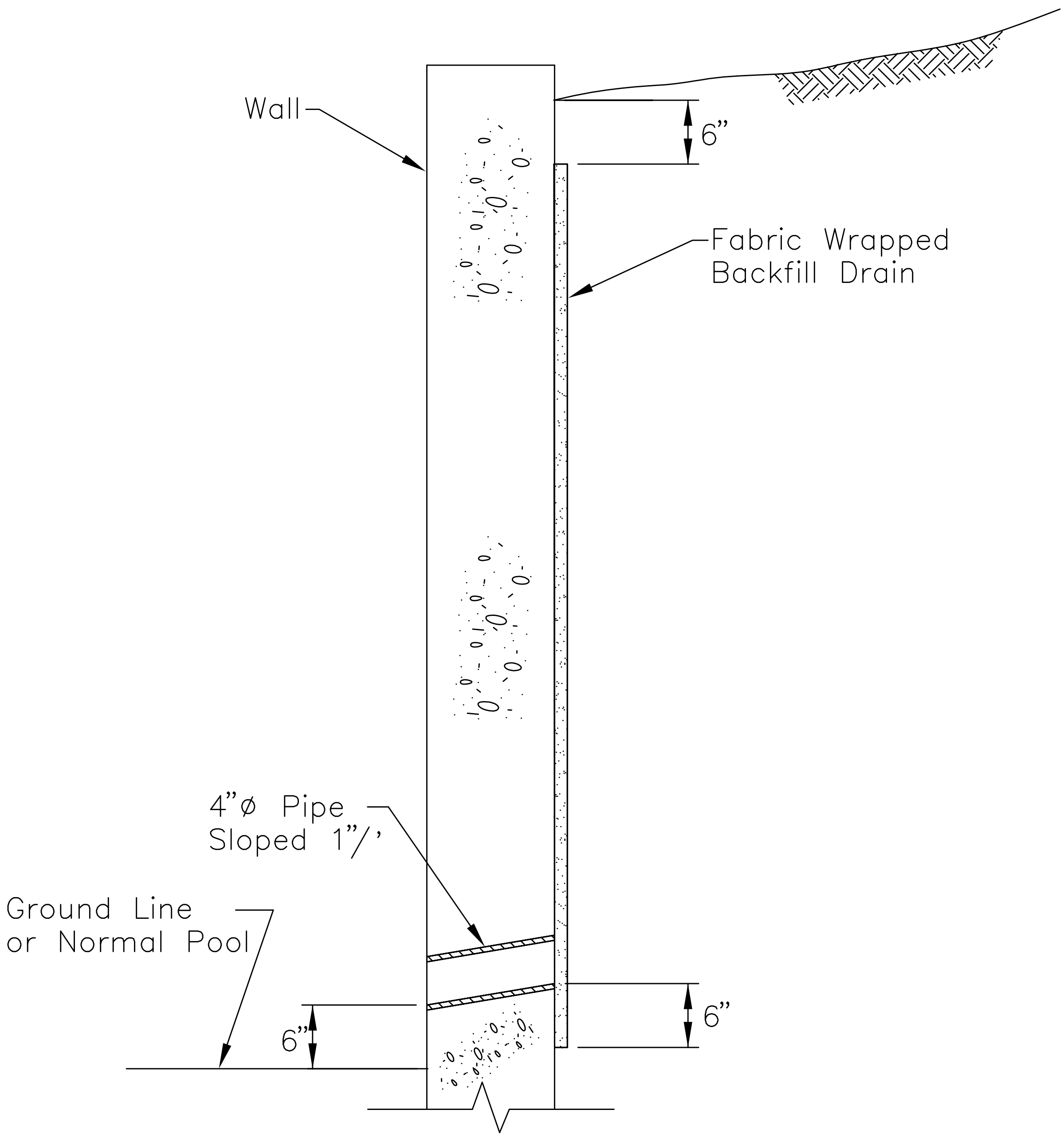
$$\text{Distance } \overline{ABCD} \geq \left[(\text{Elev. A @ Top of Slope}) - (\text{Elev. D @ exist. Ground})\right] \times S$$

Fill Slope (S) may not be steeper than 2:1

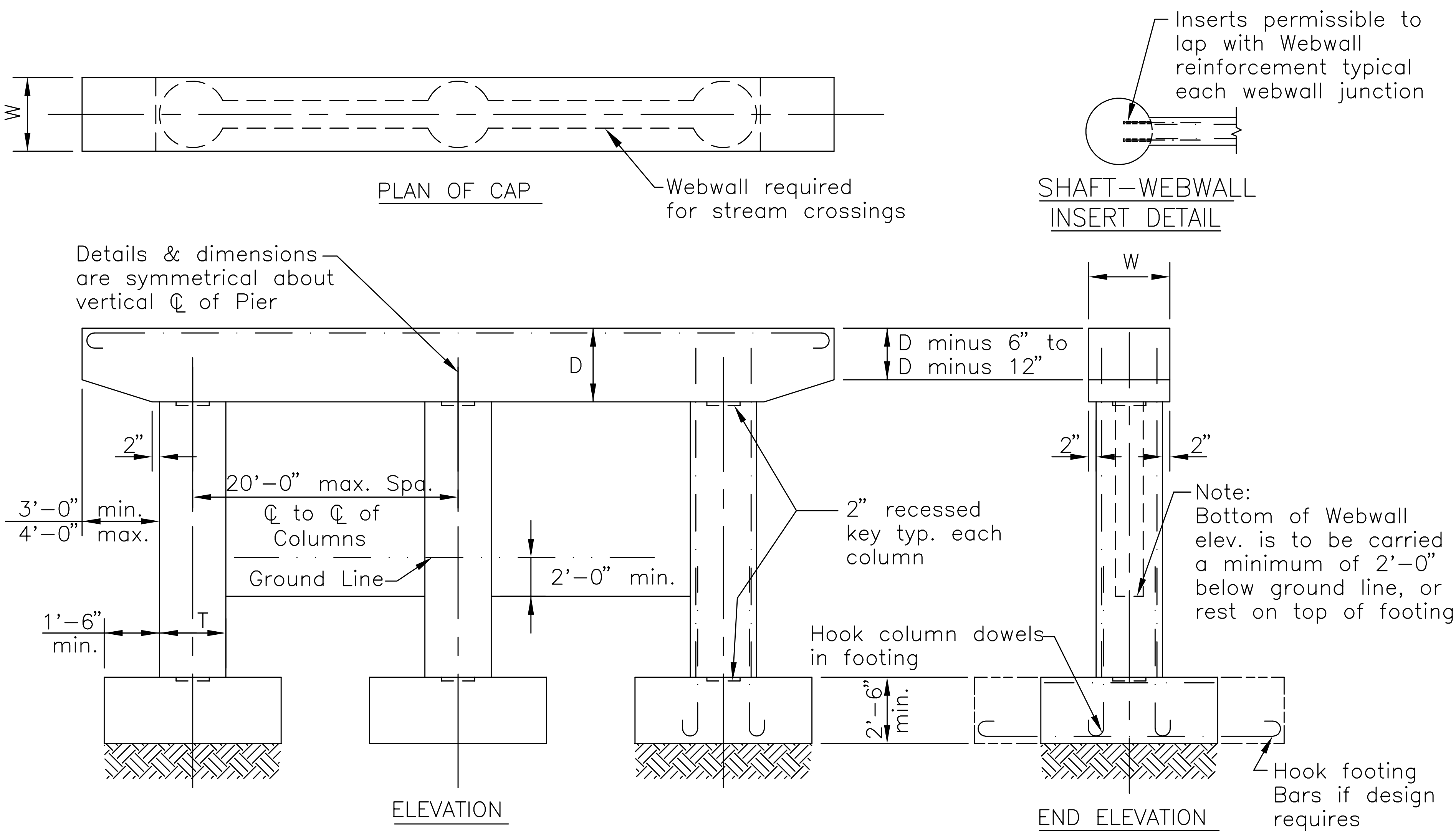
WING LENGTH – WINGWALL ABUTMENTS



DESIGN HEIGHT FOR WALLS FRAMED INTO SUPPORTING STRUCTURE



WEEPHOLE DRAIN



W = Varies between limits of 3'–4" and 5'–4" in 6" increments
D = Varies from W to W+12" but not more than 5'–0"
T = W minus 4" in 6" increments (Minimum T = 3'–0")

TYPE "L" PIER

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL

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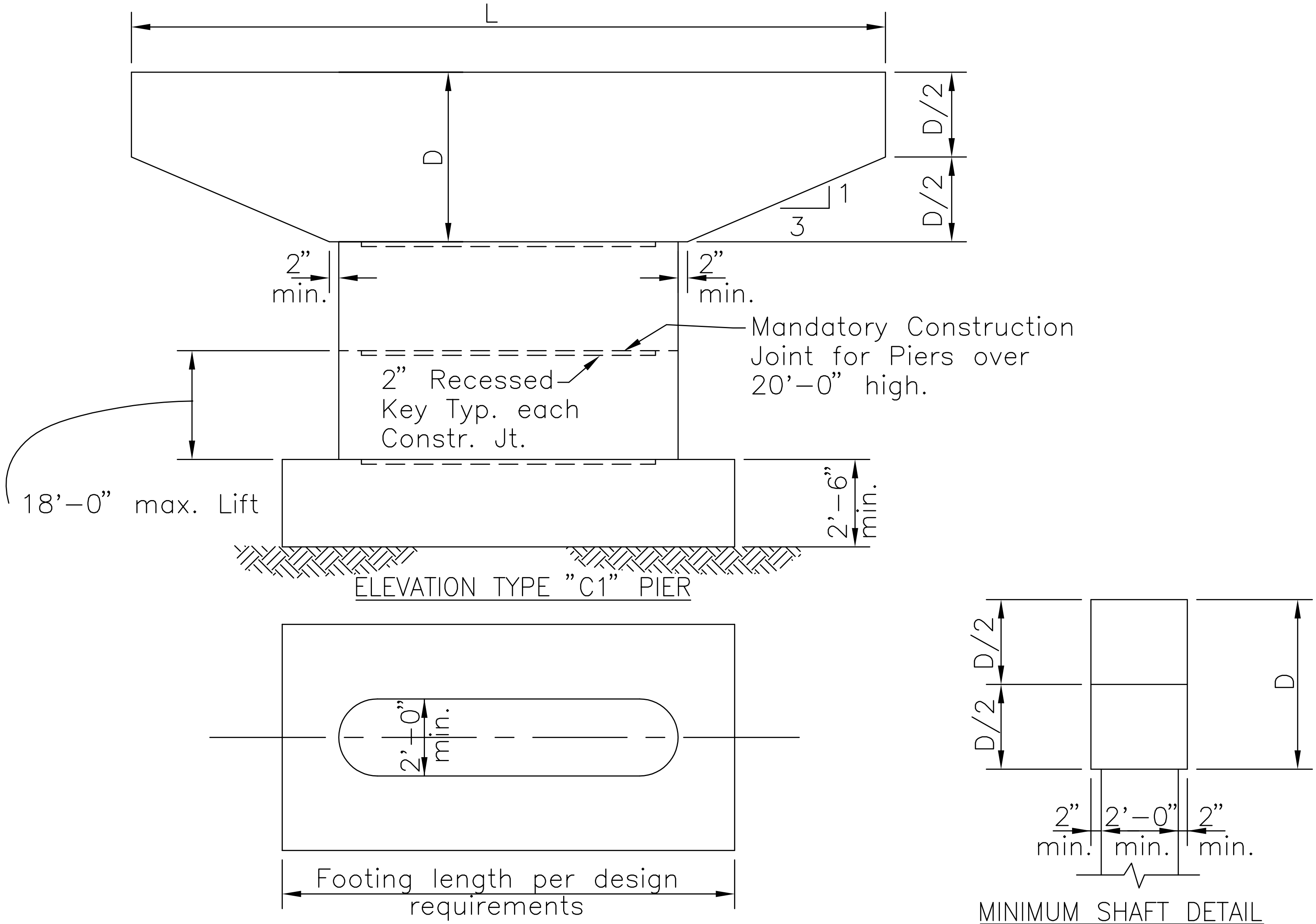

TYPE "C1" PIER

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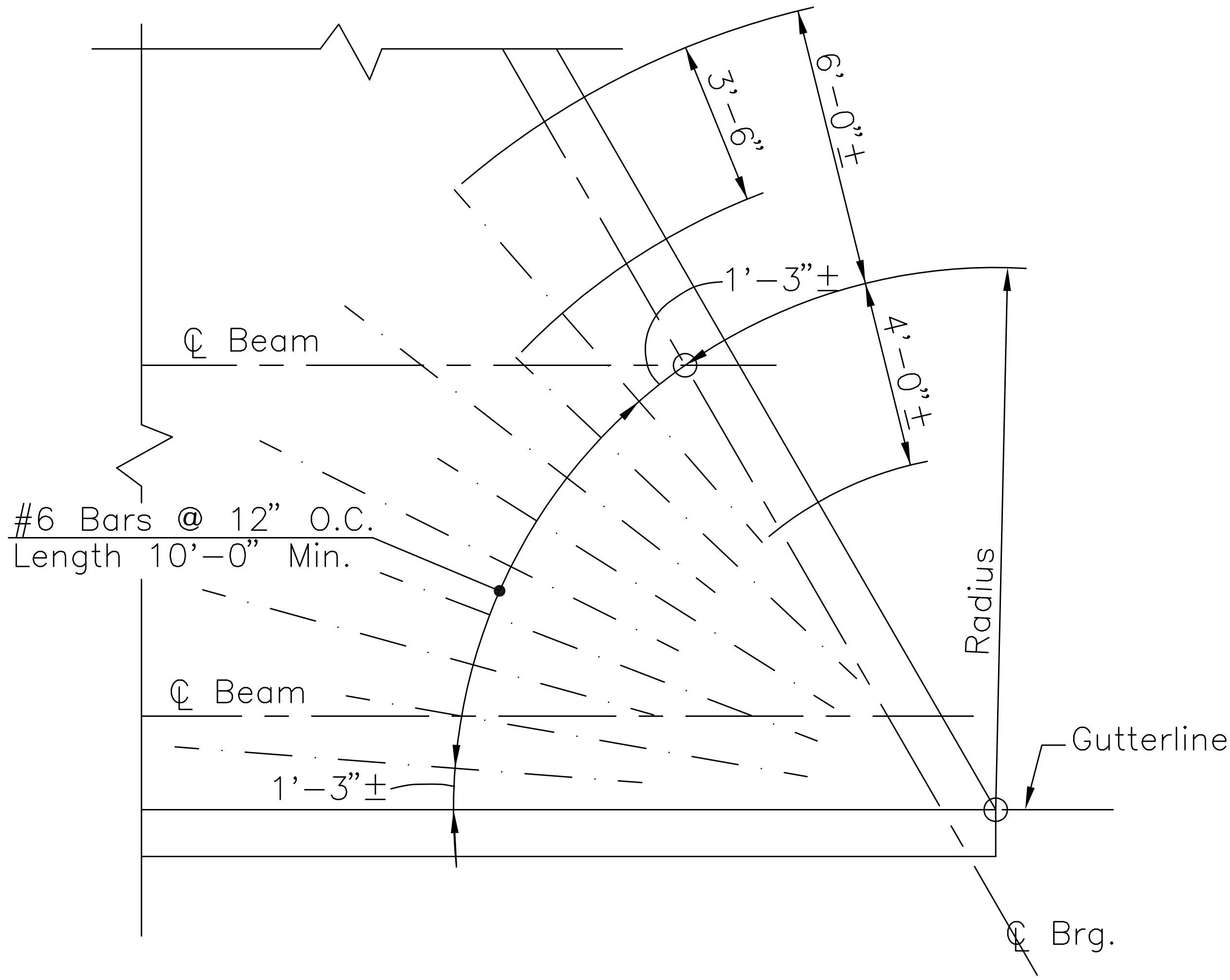


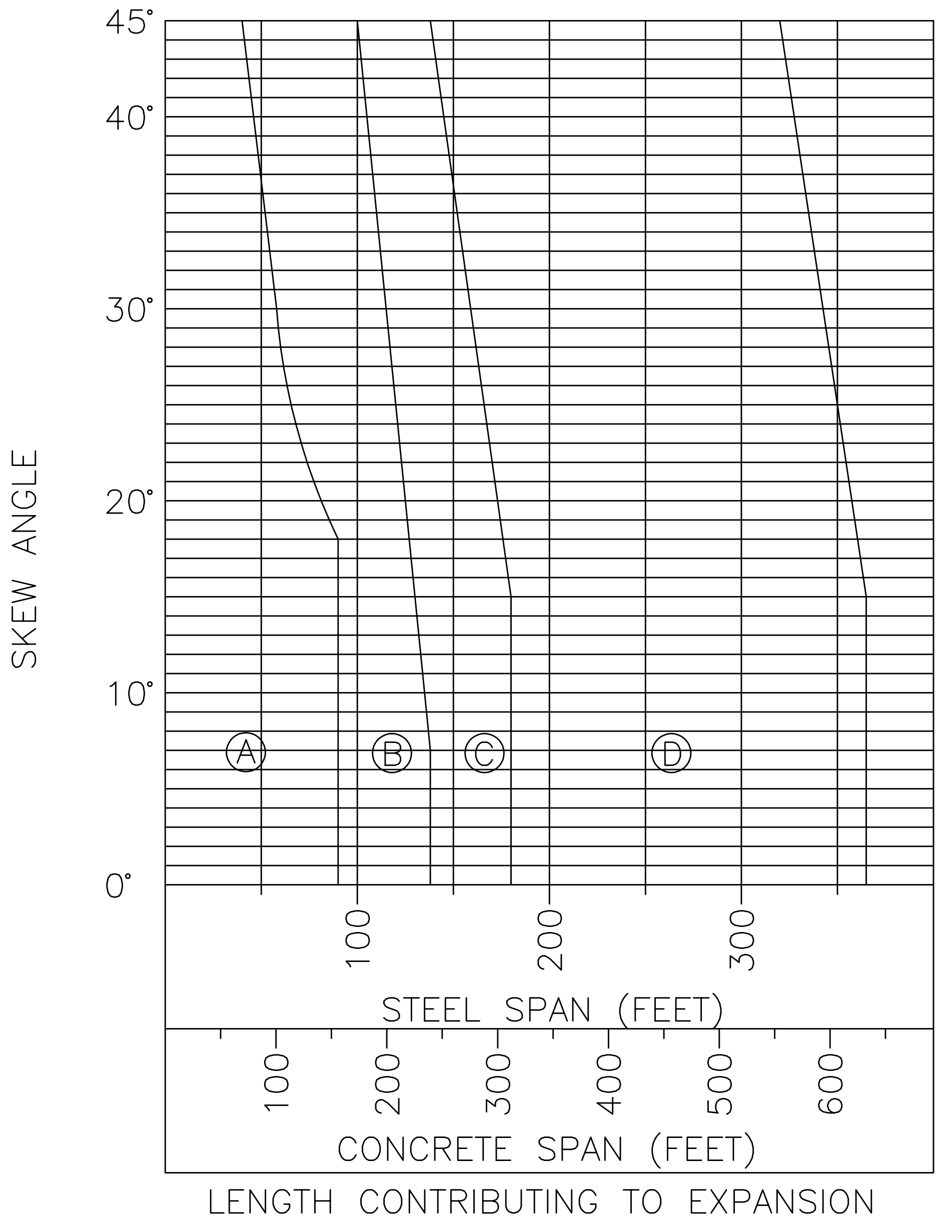
The objective of the reinforcement fan is to offset buildup of shrinkage across the long diagonal dimension of the slab which would pull a shrinkage crack across the weak corner of the slab. A portion of the bars must extend back into the corner sufficiently to terminate above the junction of the exterior beam and endwall.

A note shall be placed on the plans indicating that the corner reinforcement is to be placed beneath the longitudinal and transverse reinforcement in the top of the slab.

CORNER REINFORCEMENT DETAIL

(TYPICAL FOR SLAB CORNERS OF 75° OR LESS)

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



A 1 1/2" NEOPRENE EXPANSION DAM

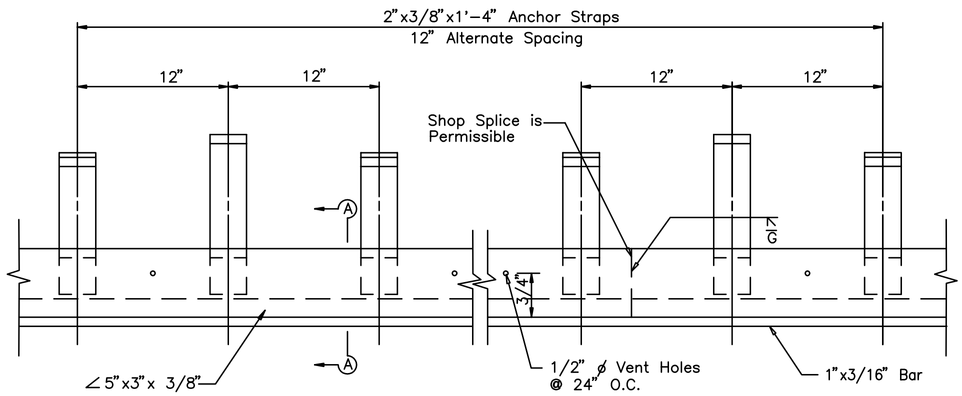
B 2" NEOPRENE EXPANSION DAM

C 2 1/2" NEOPRENE EXPANSION DAM

D 4" NEOPRENE EXPANSION DAM
(Requires Special Details)

REQUIRED EXPANSION DAM SIZE

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



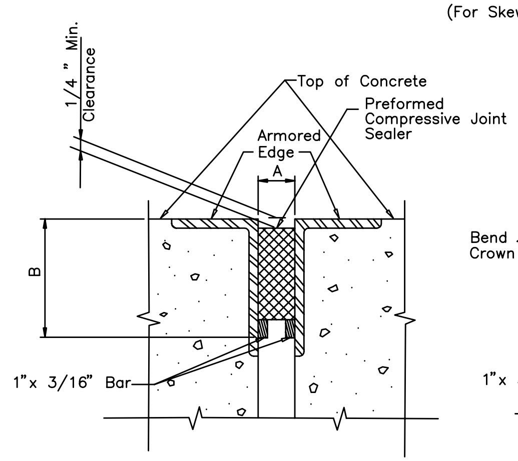
PLAN
(For Skewed Bridge)

INCREMENT FOR 10° TEMPERATURE CHANGE

CONCRETE SPAN				
0-80'	81'-140'	141'-200'	201'-260'	261'-320'
1/32"	1/16"	3/32"	1/8"	5/32"
STEEL SPAN				
0-60'	61'-100'	101'-140'	141'-180'	
1/32"	1/16"	3/32"	1/8"	

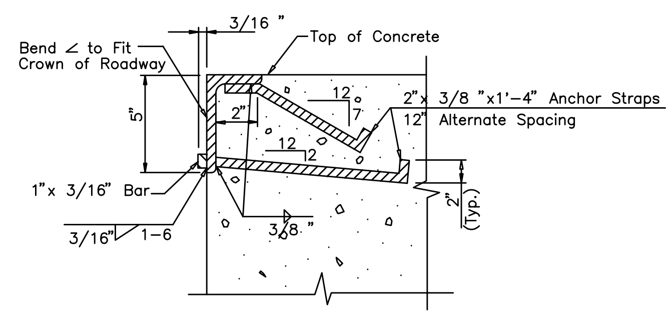
A=MINIMUM WIDTH OF JOINT OPENING AT 60° F SEE DESIGN DRWGS.	REQUIRED MOVEMENT*
SIZE=1 1/2"	1"
SIZE=2"	1 1/2"
SIZE=2 1/2"	2"

* Joint seal supplied must accomodate required movement. Dimension 'A' shall be set with temperature change correction and as recommended by sealer manufacturer to obtain required movement.



SECTION THRU DAM

B = compressed height of seal as required by manfacturer + 1/4"



SECTION A-A
Weight per foot of assembly=27.68 lbs.

GENERAL NOTES

SPECIFICATIONS The Kentucky Department of Highways Standard Specifications for Road & Bridge Construction, (c.e.) with revisions.

INSTALLATION PROCEDURE The ends of the Joint Seal shall be sealed to prevent the entrance of water and foreign material.

WELDING SPECIFICATIONS All welding materials, welding techniques, and welding procedures shall comply with joint specification ANSI/AASHTO/AWS D1.5-88 Bridge Welding Code with Revisions.

MATERIAL SPECIFICATIONS Steel material shall be new, commercial grade steel suitable for welding. Acceptance will be based on visual inspection by the Engineer. Joint sealing material, only, shall be accordance with Section 807.02.03 of the specifications.

PAINT All structural steel shall be cleaned and painted in accordance with the specifications. Except that area in contact with concrete shall not be painted.

NEOPRENE EXPANSION DAMS (1 1/2", 2", 2 1/2")

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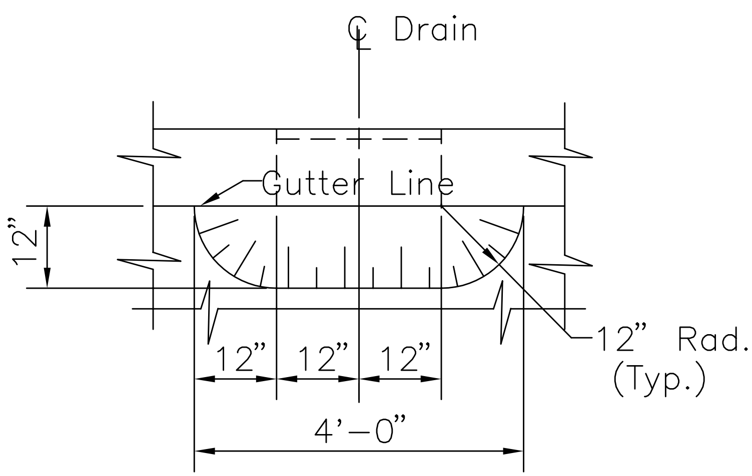
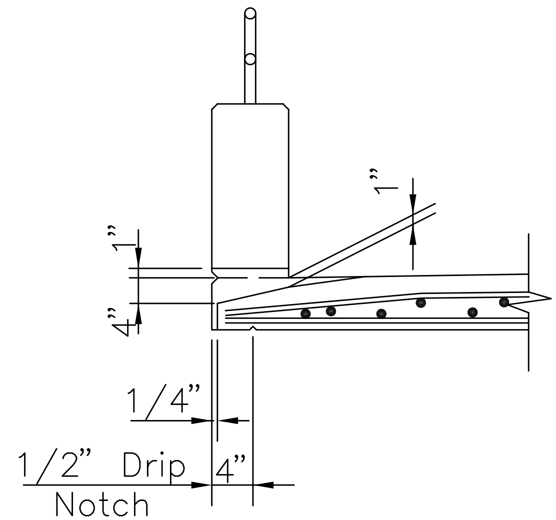


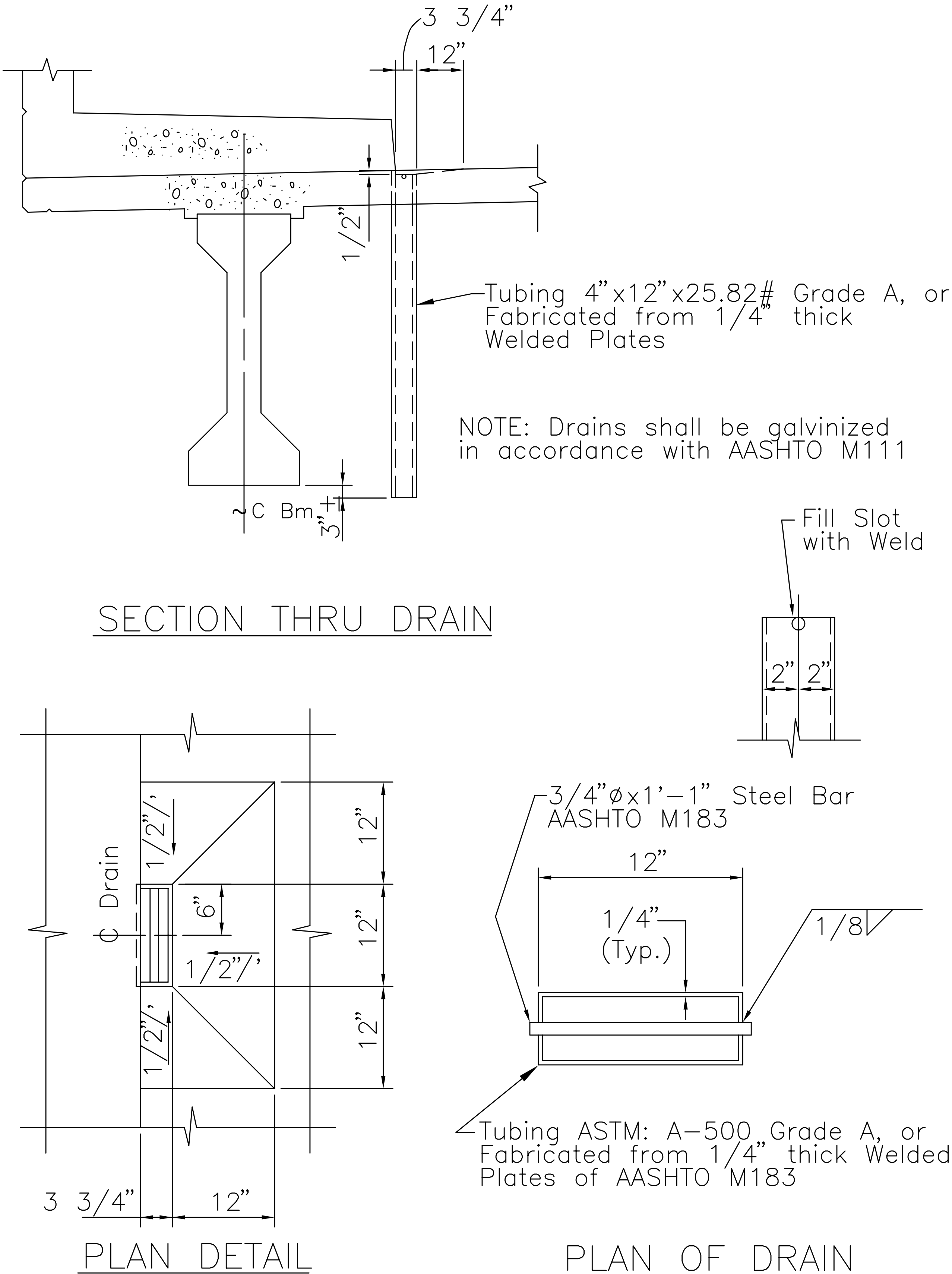
PLAN OF DRAIN



SECTION THRU DRAIN

Note: The Tranverse slab reinforcement in the area of the thru barrier drains shall be field bent down to maintain 2 1/2" of concrete cover thru the drain. The bend shall be approximately 12" from the gutter line. Transverse slab reinforcement adjacent to the drain shall not be bent and a 2 1/2" concrete cover maintained. Longitudinal reinforcement in the top mat of the slab shall not be tied to the transverse reinforcement adjacent to the drain for a distance sufficient to allow the longitudinal reinforcement to sag under the bent reinforcement in the drain area.

THRU WALL DECK DRAINS



STEEL TUBE DECK DRAIN

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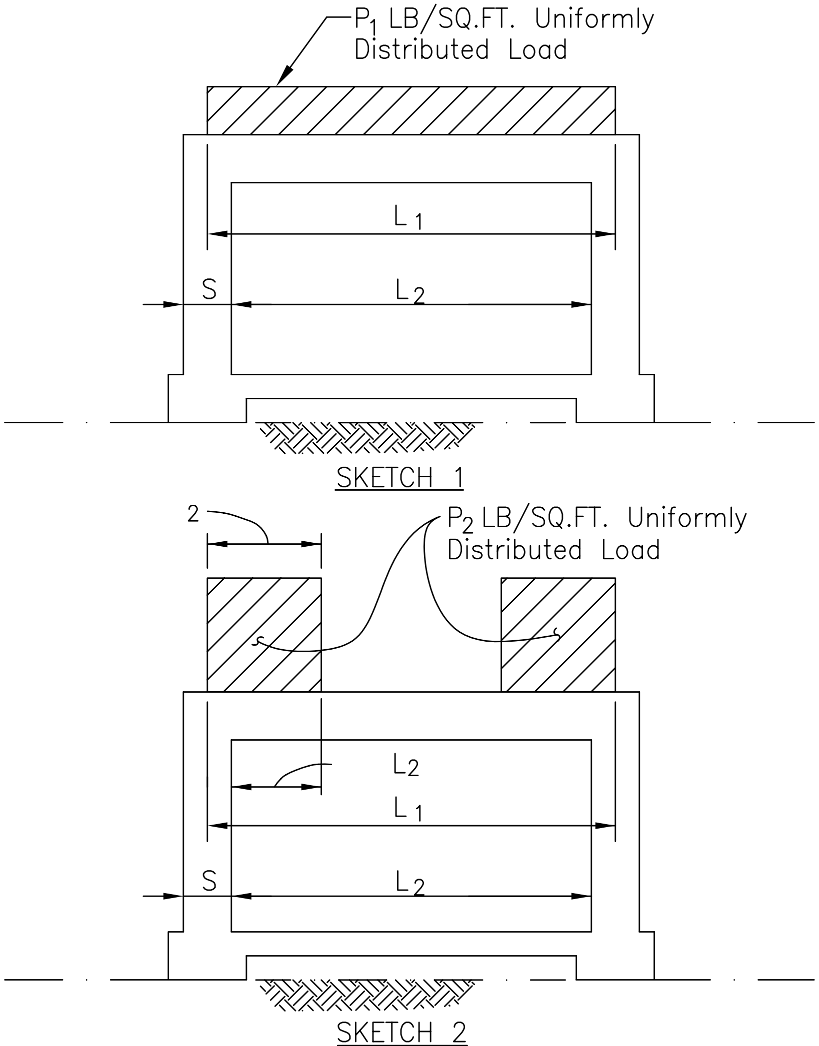

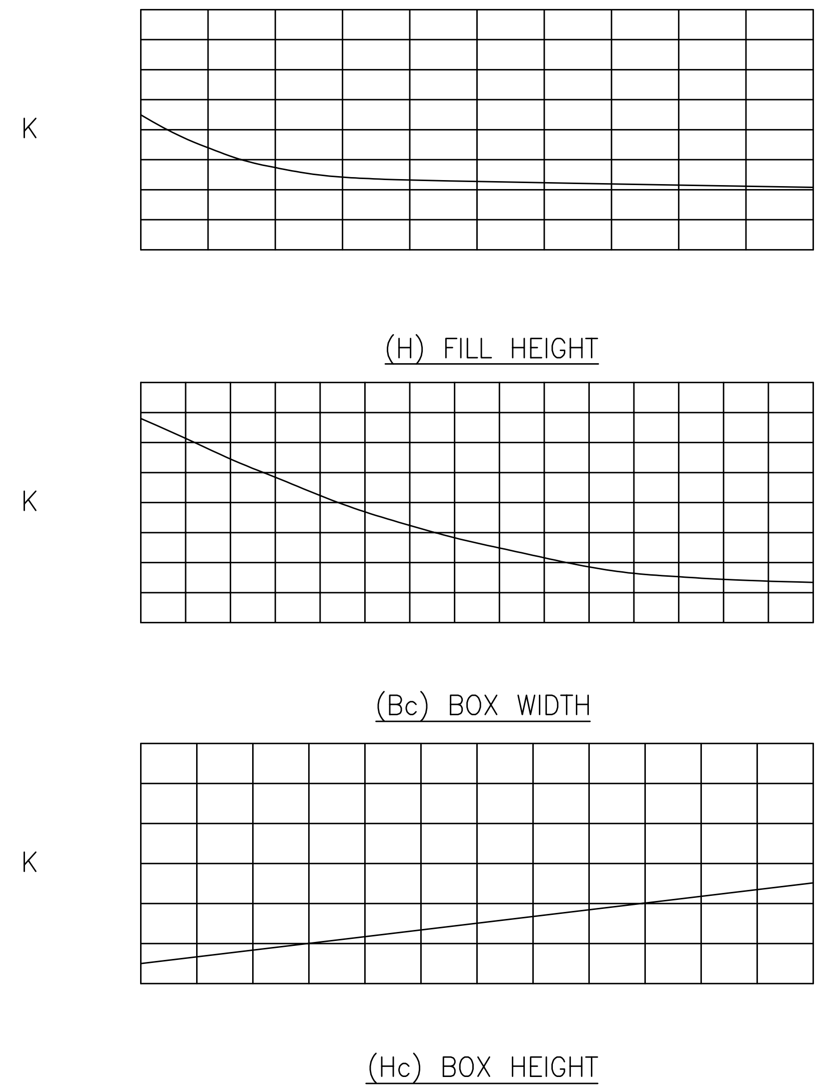

On Multiple Barrel Culverts: L_1 = Distance center to center of Exterior Walls
L_2 = Distance from inside of Exterior Wall to inside od Exterior Wall

TYPICAL DISTRIBUTION OF LOAD ACROSS TOP SLAB

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL & RESEARCH REPORT UKTRP–84–22

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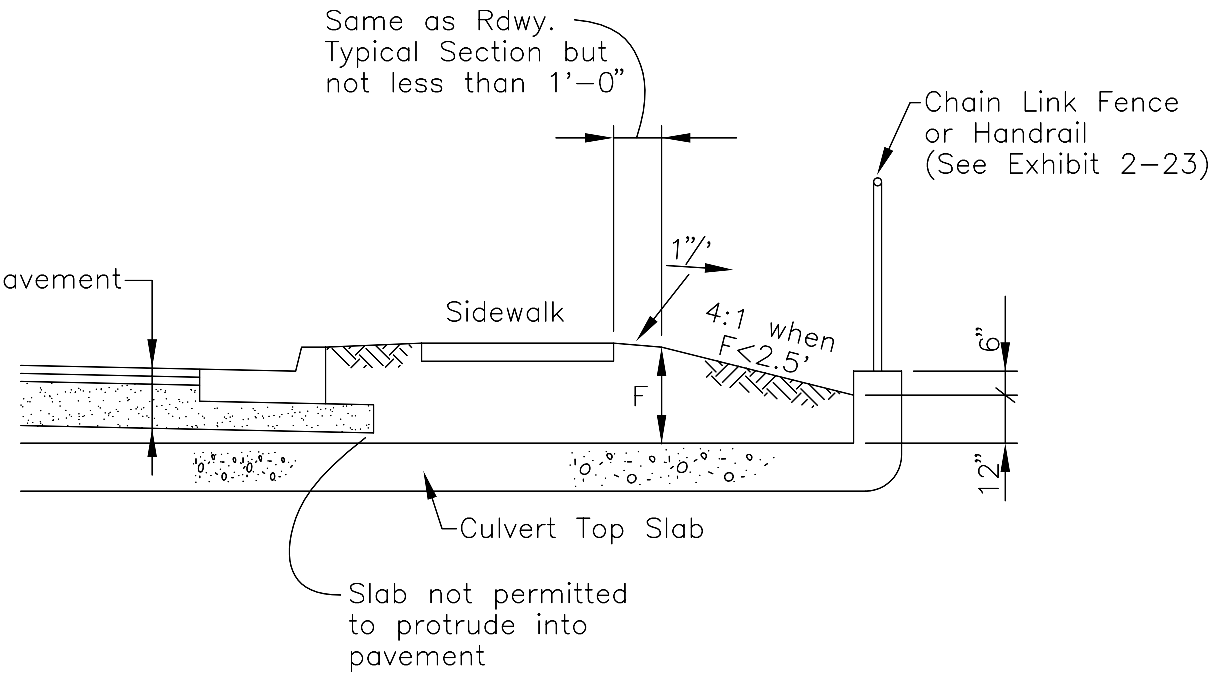
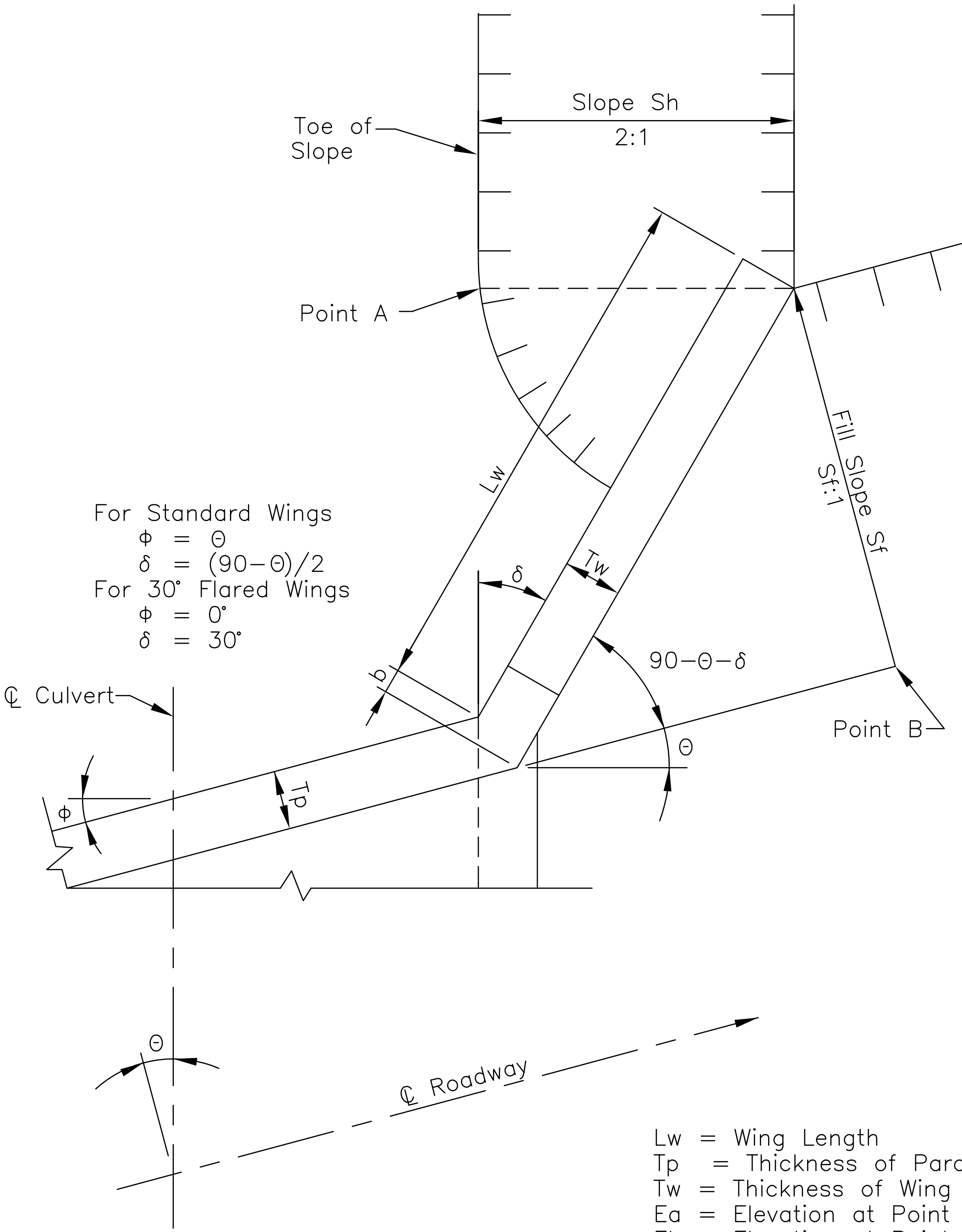


CULVERTS WITH SHALLOW FILL

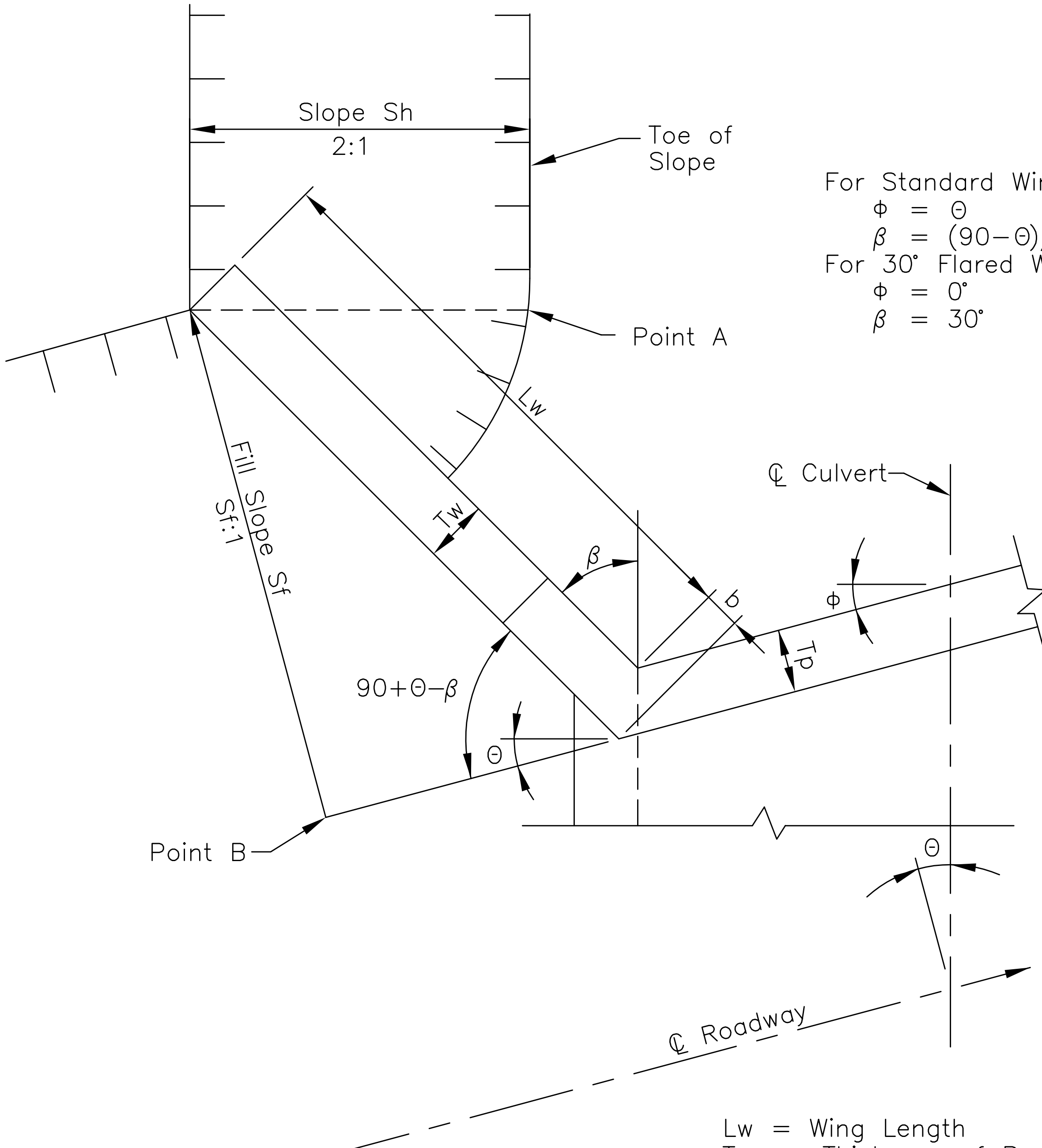


Lw = Wing Length
Tp = Thickness of Parapet
Tw = Thickness of Wing
Ea = Elevation at Point A
Eb = Elevation at Point B
Θ = Culvert Skew
ϕ = Headwall Skew
δ = Long Wing Angle

$$Lw = \frac{Eb - Ea - 1/Sh\ Tw\ COS(\delta) - b\ 1/Sf\ SIN(90-\Theta-\delta)}{1/Sh\ SIN(\delta) + 1/Sf\ SIN(90-\Theta-\delta)}$$

LAYOUT OF LONG WING FOR CULVERTS

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



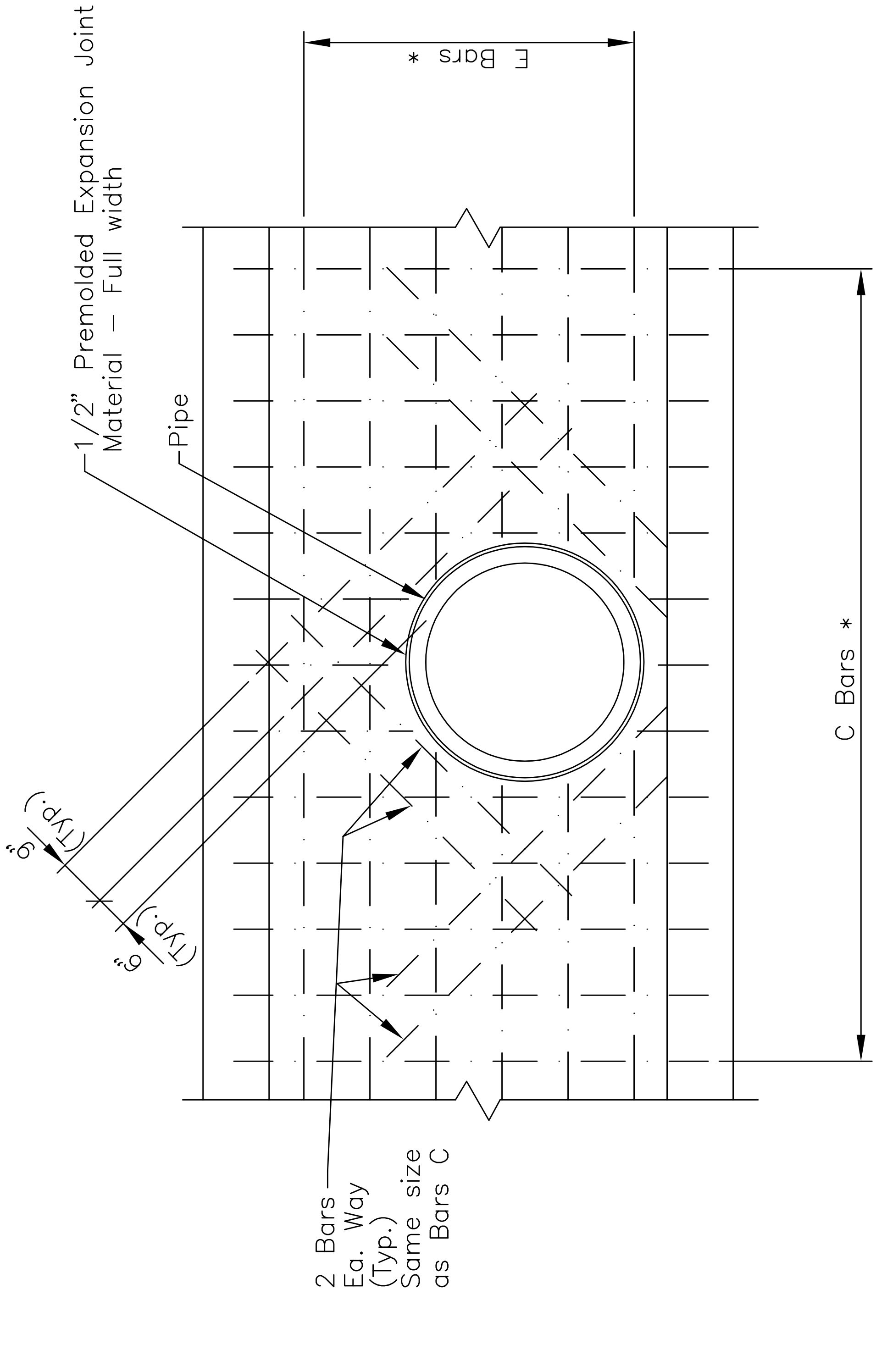
For Standard Wings
$\Phi = \Theta$
$\beta = (90-\Theta)/2$
For 30° Flared Wings
$\Phi = 0°$
$\beta = 30°$

Lw = Wing Length
Tp = Thickness of Parapet
Tw = Thickness of Wing
Ea = Elevation at Point A
Eb = Elevation at Point B
Θ = Culvert Skew
Φ = Headwall Skew
β = Short Wing Angle

$$Lw = \frac{Eb - Ea - 1/Sh\ Tw\ \cos(\beta) - b\ 1/Sf\ \sin(90-\Theta-\beta)}{1/Sh\ \sin(\beta) + 1/Sf\ \sin(90-\Theta-\beta)}$$

LAYOUT OF SHORT WING FOR CULVERTS

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



* Field Cut Bars C & E
to maintain 1 1/2" Clr.
around Pipe.

PIPE BLOCKOUT DETAIL
(For Storm Pipes entering Culvert Walls)

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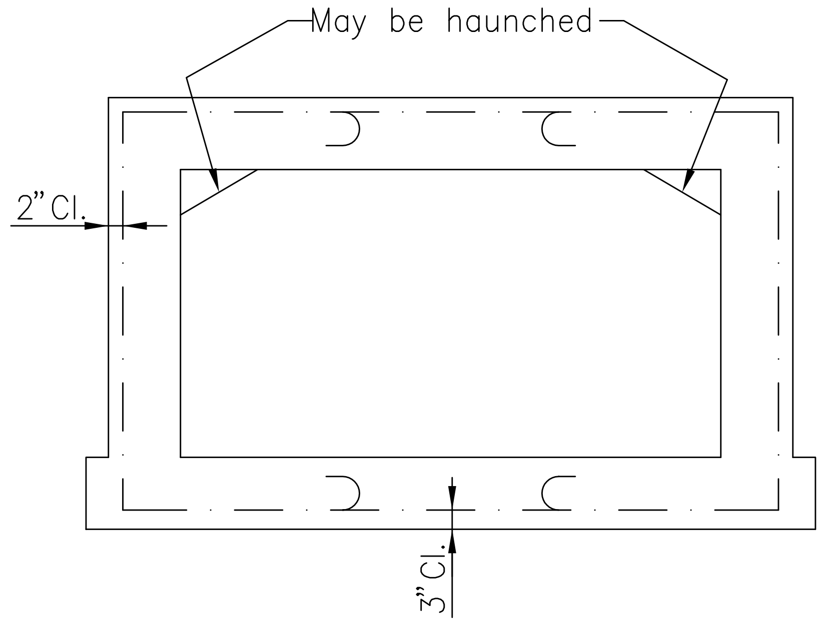
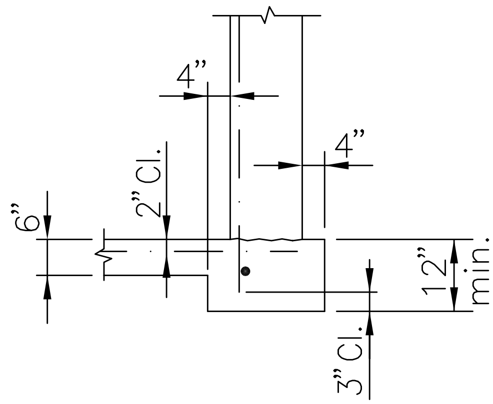
Showing only additional reinforcement for Frame Condition.



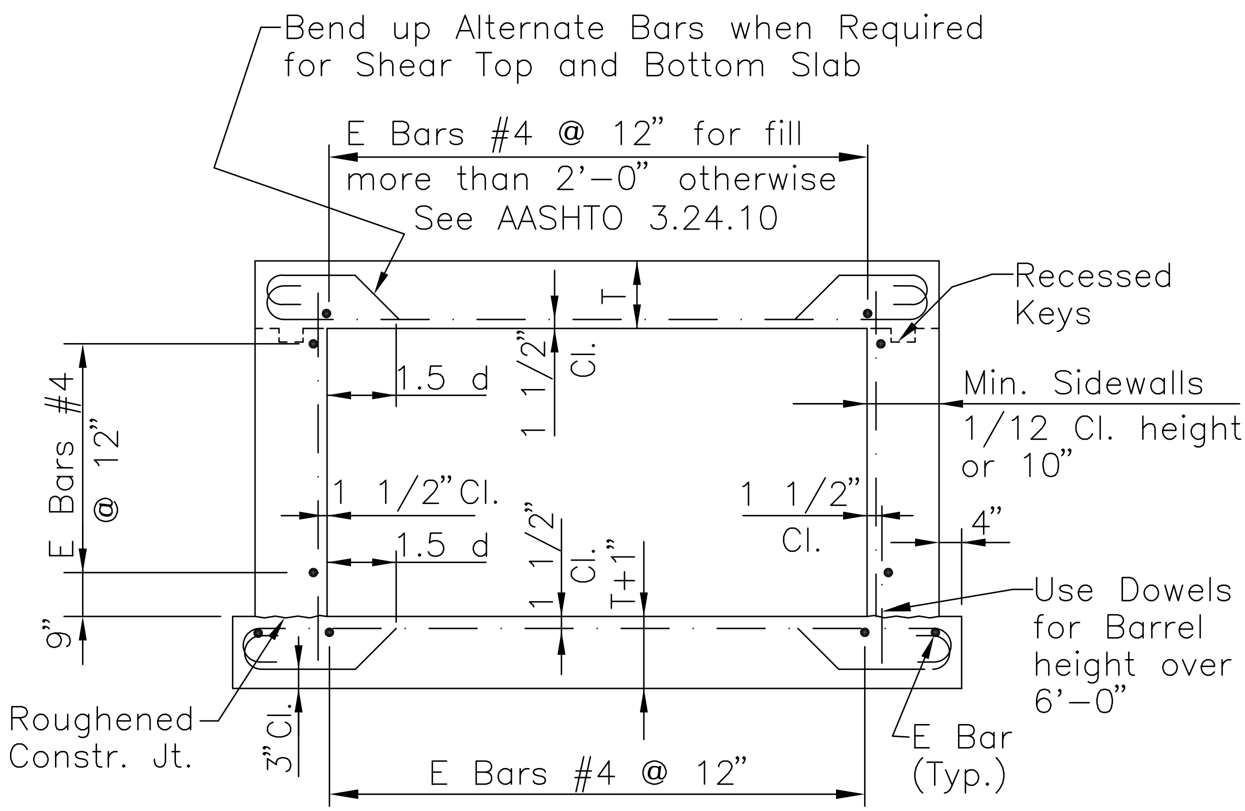
Reinforcement for Corners may be hooked rather than continuous across slab to facilitate placement.

CROSS SECTION
SINGLE BARREL RIGID FRAME CULVERT

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



(UNYIELDING)

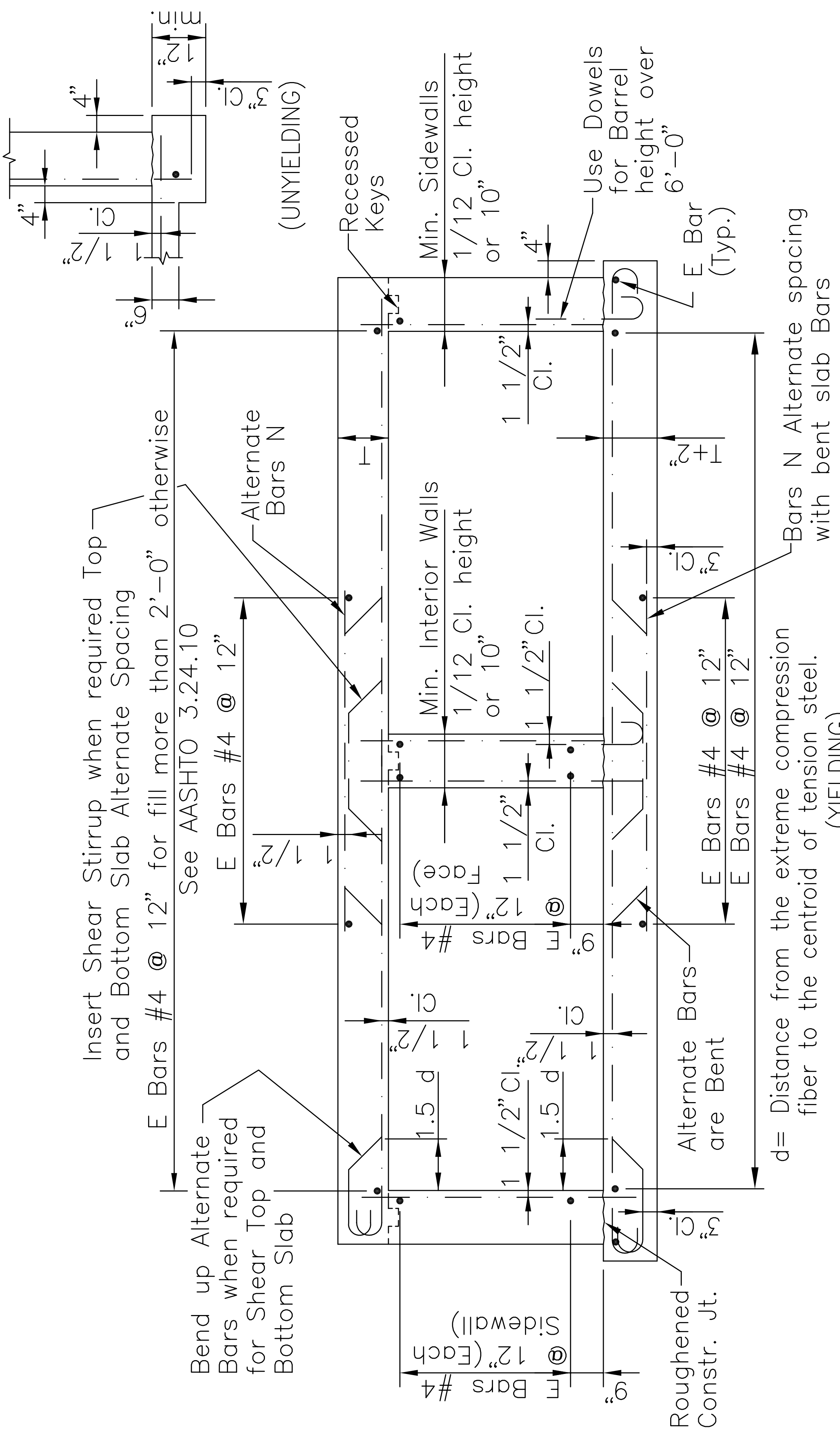


d= Distance from the extreme compression fiber to the centroid of tension steel.

(YIELDING)

STANDARD CROSS SECTION
SINGLE BARREL CULVERT

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL



STANDARD CROSS SECTION
MULTIPLE BARREL CULVERT

ADAPTED FROM KY. TRANS. CABINET DIV. OF BRIDGES GUIDANCE MANUAL

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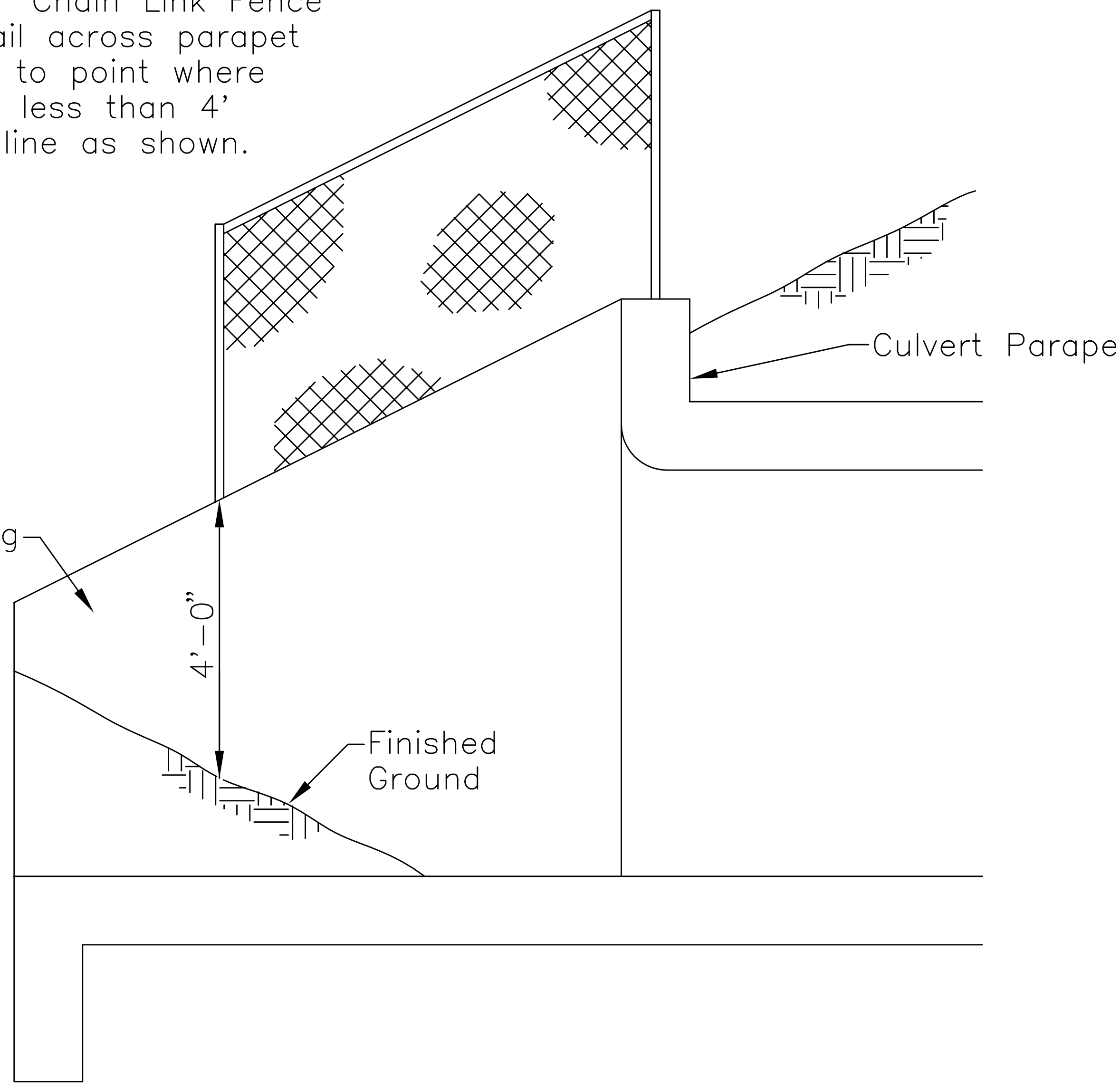
Provide Std. 4' Chain Link Fence or Std. Handrail across parapet & down wings to point where top of wing is less than 4' above ground line as shown.



FENCE/HANDRAIL ON CULVERT ENDS

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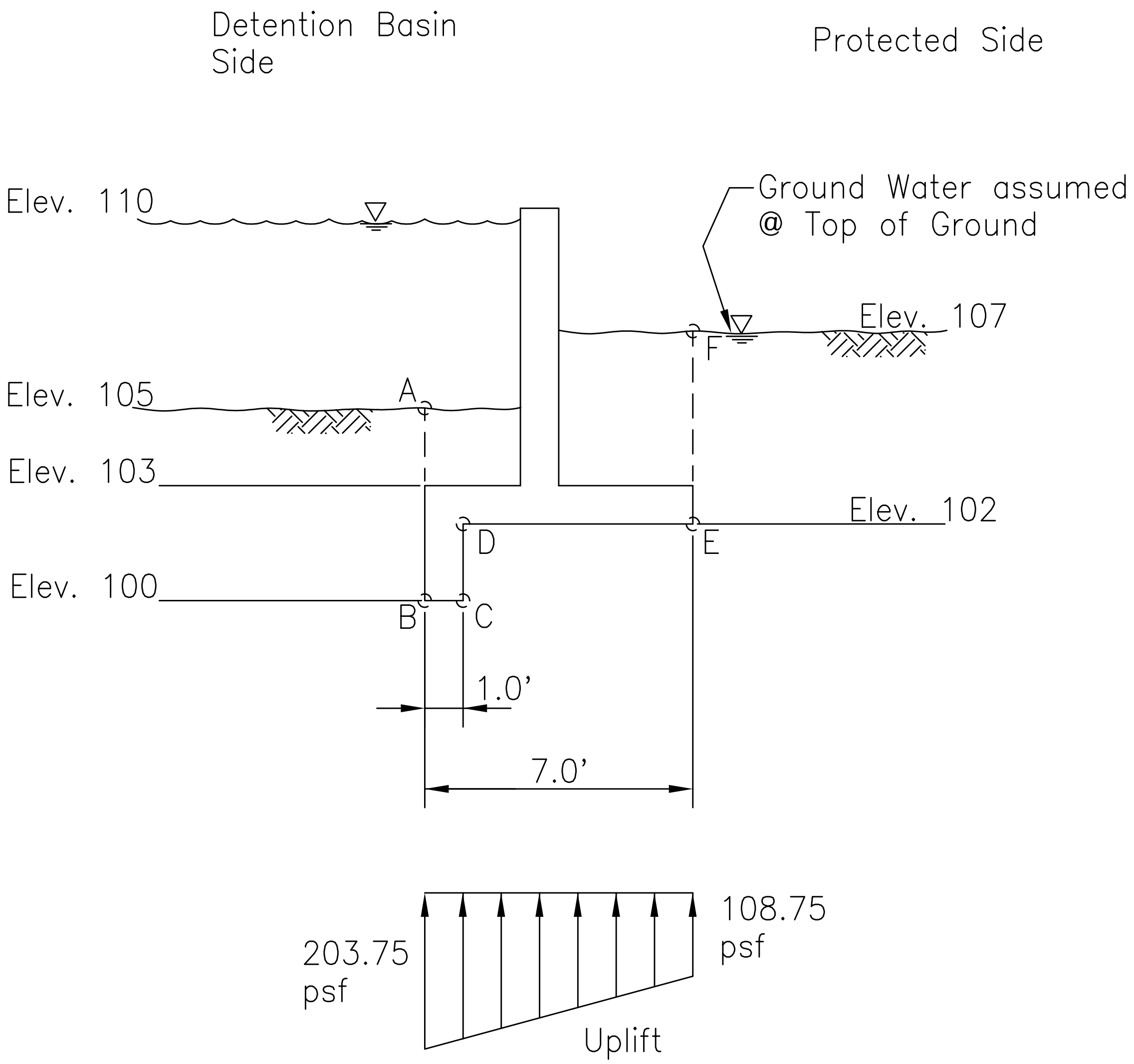


Weighted Creep Path Distance (ABCDEF)= $5+ \frac{1}{3} x1+2+ \frac{1}{3} x6+5=14.33'$

Head @ A = 110−105=5'   Pressure = 5x62.5 = 312.5 psf

Head @ B = $5-\frac{5}{14.33}x5 = 3.26'$ Pressure = 3.26x62.5 = 203.75 psf

Head @ E = $5-\frac{9.33}{14.33}x5 = 1.74'$ Pressure = 1.74x62.5 = 108.75 psf

UPLIFT – WEIGHTED CREEP THEORY

ADAPTED FROM "DESIGN OF SMALL DAMS" U.S. DEPT. OF THE INTERIOR

CHAPTER 3
INTERPRETATIONS OF AASHTO DESIGN SPECIFICATIONS

3.1 General

3.1.1 Scope

This chapter outlines specific policies or interpretations of specific articles of the AASHTO design specification that are to be implemented in the design of structures for the Lexington-Fayette Urban County Government. Not all articles are discussed or have an interpretation or policy associated. Where an article is not covered in this chapter or addressed elsewhere in this manual, the Lexington-Fayette Urban County Government has no specific policy or interpretation.

Each included article is listed by its associated AASHTO article number.

3.1.2 Loads

AASHTO Section 3.3.3 - An allowance of 15 psf shall be provided in the design dead load for a future wearing surface that is not constructed with the bridge.

AASHTO Section 3.3.5 - The top 1/2 inch of the deck slab of bridges is to be considered as a wearing surface and shall be deducted from the design thickness when calculating affected design properties or strengths.

AASHTO Section 3.7.4 - All structures subject to highway design live load shall be designed for HS25 live load that is arrived at by increasing the AASHTO HS20-44 truck and lane loads by 25 percent.

AASHTO Section 3.14.3 - The standard highway railing load is 10 kips. When designing cantilevered slabs subject to railing loads on a continuous concrete barrier, the railing load may be reduced by 15 percent due to the effects of edge stiffening provided by the barrier.

AASHTO Section 3.15 - Wind loads shall be based on a wind velocity of 100 miles per hour.

AASHTO Section 3.16 - Thermal loads shall be for a "Cold Climate" with a median temperature of 60 degrees Fahrenheit.

AASHTO Section 3.17 - Superstructures of bridges shall be proportioned such that uplift forces do not occur.

AASHTO Section 3.20 - Lateral earth pressures for walls up to 20 feet in height shall be determined using the methods of NAVFAC DM-7.2 that are presented in Exhibit 3-1 and 3-2. Assume Type 3 soil unless a special backfill material is specified. Apply the lateral earth pressure to twice the column width for pier columns above natural ground in sloping man-made fills or when the column depth (in the direction of loading) to width ratio is 3 or greater.

Refer to Section 2.2 of this manual and Exhibit 2-15 for special requirements for earth loadings on box culverts.

AASHTO Section 3.21 - Design for Seismic Performance Category (SPC) A. Special emphasis is directed to the support length requirements contained in AASHTO Division I-A, Seismic Design, Section 5.3.

AASHTO Section 3.23 - Live load distribution to straight beams and girders shall be in accordance with the empirical methods of this article.

AASHTO Section 3.24.1 - For slabs supported on precast concrete spread box beams or standard AASHTO Type I through IV I-beams, the effective span "S" equals the clear span.

AASHTO Section 3.24.10 - Apply the AASHTO percentages for distribution reinforcement in the bottom of deck slabs. Additionally, use half that percentage in the top of deck slabs. Shrinkage and temperature reinforcement shall be employed in the top and bottom of deck slabs in accordance with AASHTO Section 8.20. Negative moment reinforcement in slabs over piers can be included in satisfying the above requirements.

3.1.3 Foundations

AASHTO Section 4.1 - When designing structure foundations, stability and bearing pressures shall be checked using service loads.

AASHTO Section 4.2 - Bridge substructures shall be founded on solid rock or point bearing piles.

AASHTO Section 4.4.7 - When checking the location of the resultant of the bearing pressure (R) on the base of footings on soil, B/6 may be factored by the percent of basic stress as given in AASHTO Table 3.22.1A.

AASHTO Section 4.4.8 - When checking the location of the resultant of the bearing pressure (R) on the base of footings on rock, B/4 may be factored by the percent of basic stress as given in AASHTO Table 3.22.1A.

AASHTO Section 4.5.1.3 - Minimum penetration of piles shall be 10 feet in hard material and 20 feet in soft material. For the purposes of this article, fill material or any material at stream crossings shall be considered soft.

3.1.4 Retaining Walls

AASHTO Section 5.1 - The design height of walls that frame into a supporting structure (such as a culvert wing wall at the culvert barrel) shall be taken as the height where a 45-degree line, beginning where the wall meets the supporting structure, intersects the top of the wall. Refer to Exhibit 2-6.

AASHTO Section 5.5.6.1 - The rear projection of wall footings shall be designed for the vertical component of soil pressure of a sloping backfill.

3.1.5 Culverts

AASHTO Section 6.2 - A maximum of one-half of the moment caused by lateral earth pressure may be used to reduce the positive moment in top slabs of rigid frame culverts. This is in accordance with AASHTO 3.20.2.

AASHTO Section 6.2.1 - The earth loads in this article shall be modified by the applicable provisions of AASHTO 17.6.4.2 when designing reinforced concrete box culverts.

AASHTO Section 6.2.2 - Earth loads for culverts on unyielding foundations shall be determined in accordance with the provisions of Section 2.2.3.1 of this manual and Exhibit 2-15. When using this loading, shear in the top slab shall be checked at 1/12 the clear width of the culvert or “d” of the slab, whichever is closer, from the face of exterior walls and at “d” from interior walls. Design moments and shears shall not be less than for a uniform load of (0.120 x H) ksf over the design length “L.”

3.1.6 Reinforced Concrete

AASHTO Section 8.3 - Reinforcing bar sizes larger than #11 shall not be used.

AASHTO Section 8.14.1 - All reinforced concrete shall be designed by the “Strength Design” (Load Factor) Method.

AASHTO Section 8.16.8.4 - When checking flexural distribution of reinforcement to control cracking, the following values shall be used for “z” in Equation 8-61:

- 130 kips/inch for bridge decks
- 98 kips/inch for barrels of box culverts
- 170 kips/inch for all other structures

AASHTO Section 8.32.2 - Welded splices of reinforcement shall not be permitted.

3.1.7 Prestressed Concrete

AASHTO Section 9.2 - The maximum design compressive strength, f’c, of prestressed concrete shall be 7250 psi.

AASHTO Section 9.3.1 - Prestressing steel shall be 1/2 inch nominal diameter, 270 Grade, low relaxation or stress-relieved, uncoated seven-wire strand in accordance with AASHTO M203.

AASHTO Section 9.16.2.1.2 - Tendon relaxation during placing and curing shall be calculated by the following equation for normal 1/2 inch diameter strands:

$$\text{Loss} = [\ \text{LOG}(t) / A\ ] \times [\ (\ F_{si} / F_y\ ) - 0.55\ ] \times F_{si}$$

where:

t	is the time, in hours, between stressing and release (usually taken as 18 hours)
A	is 45 for low-relaxation strands, 10 for stress relieved
Fsi	is the jacking stress
Fy	is 0.90(catalogue ultimate) for low-relaxation strands 0.85(catalogue ultimate) for stress-relieved

AASHTO Section 9.17 - The design flexural strength of prestressed concrete members shall be calculated at each 1/10 point along the span.

AASHTO Section 9.22 - For the purposes of calculating the vertical reinforcement required in the anchorage zone to satisfy this article, total prestress shall be taken as the prestress force at the time of release.

AASHTO Section 9.23 - Design concrete strengths at release and stress transfer shall not be greater than 5800 psi.

AASHTO Section 9.28 - Development length for bonded prestress strand shall be 1.6 times the value computed in Equation 9-32. Development length for de-bonded strand shall 2.0 times the value computed in Equation 9-32.

3.1.8 Structural Steel

AASHTO Section 10.2.2 - Structural steel for main loading carrying members of bridges shall be AASHTO M270 Grade 50.

AASHTO Section 10.3.1 - Main load carrying members shall be designed as continuous and redundant (three or more girders).

AASHTO Section 10.6 - Live load deflections shall be limited to span/1200 for bridges where pedestrian traffic is expected.

AASHTO Section 10.13 - Welded cover plates are not permitted.

AASHTO Section 10.31 - The Strength Design (Load Factor) Method shall be employed wherever this option is allowed.

AASHTO Section 10.38.1.7 - Add 10 percent of the concrete dead load to allow for the weight of forms when computing steel dead load stresses due to non-composite concrete loads.

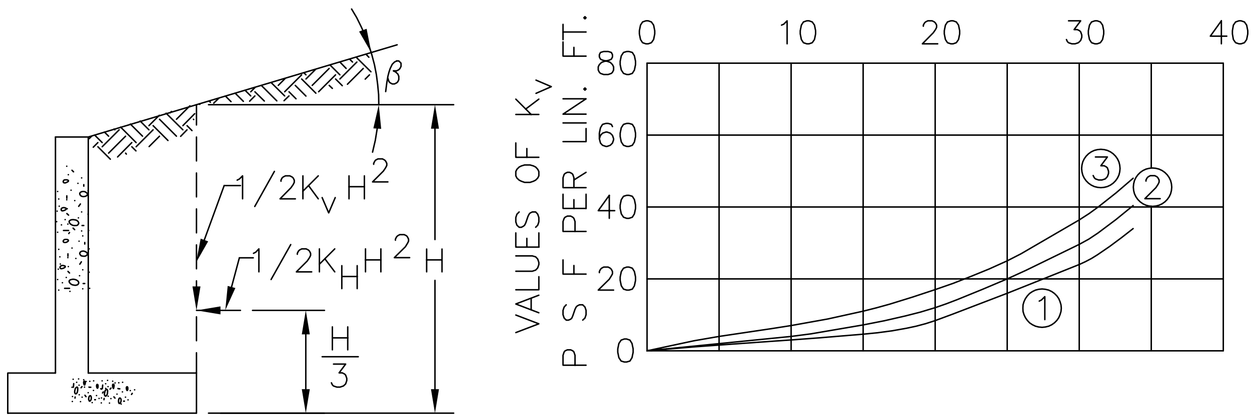
3.1.9 Elastomeric Bearing Pads

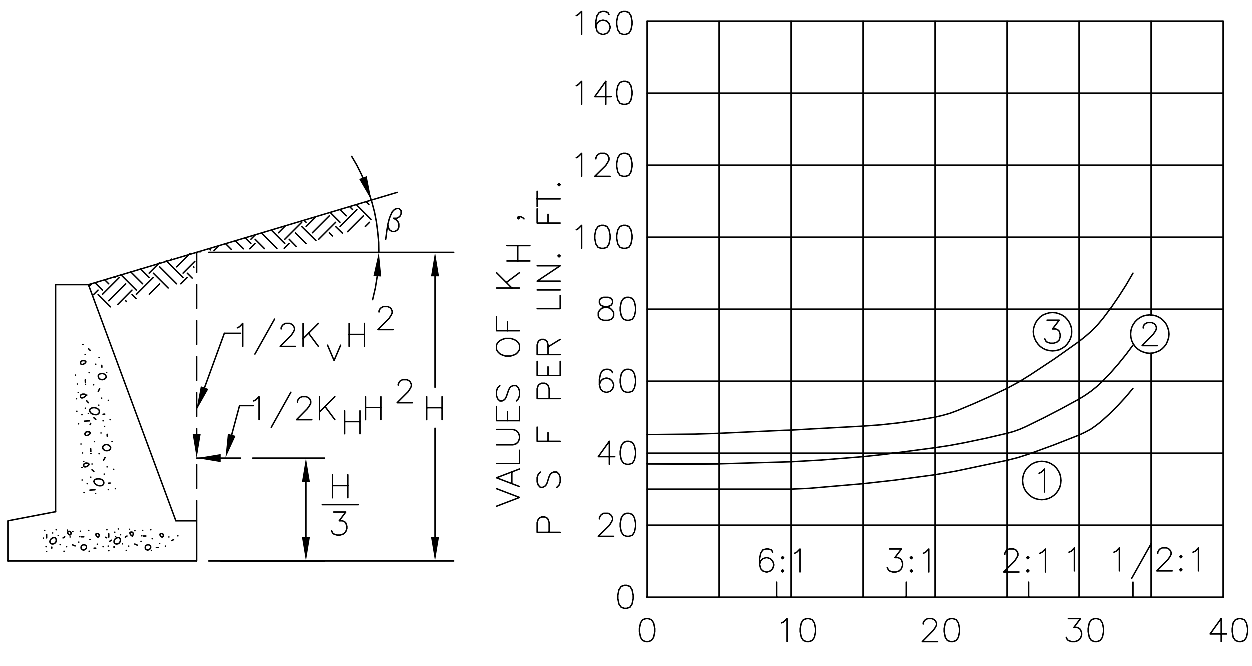
AASHTO Section 14.1 - A tapered top cover layer is permitted for bearings for concrete beams in lieu of beveled sole plates or other details to compensate for beam slope. Use the least favorable rubber thickness of tapered layers when checking adequacy of bearing.

AASHTO Section 14.3 - Design bearings for a hardness of 50 or 60.

CIRCLED NUMBERS INDICATE THE FOLLOWING SOIL TYPES:

1. CLEAN SAND AND GRAVEL : GW, GP, SW, SP.
2. DIRTY SAND AND GRAVEL OF RESTRICTED PERMIABILITY GM, GM–GP, SM–SP, SM.
3. STIFF RESIDUAL SILTS AND CLAYS, SILTY FINE SANDS, CLAYEY SANDS AND GRAVELS: CL, ML, CH, MH, SM, SC, GC.

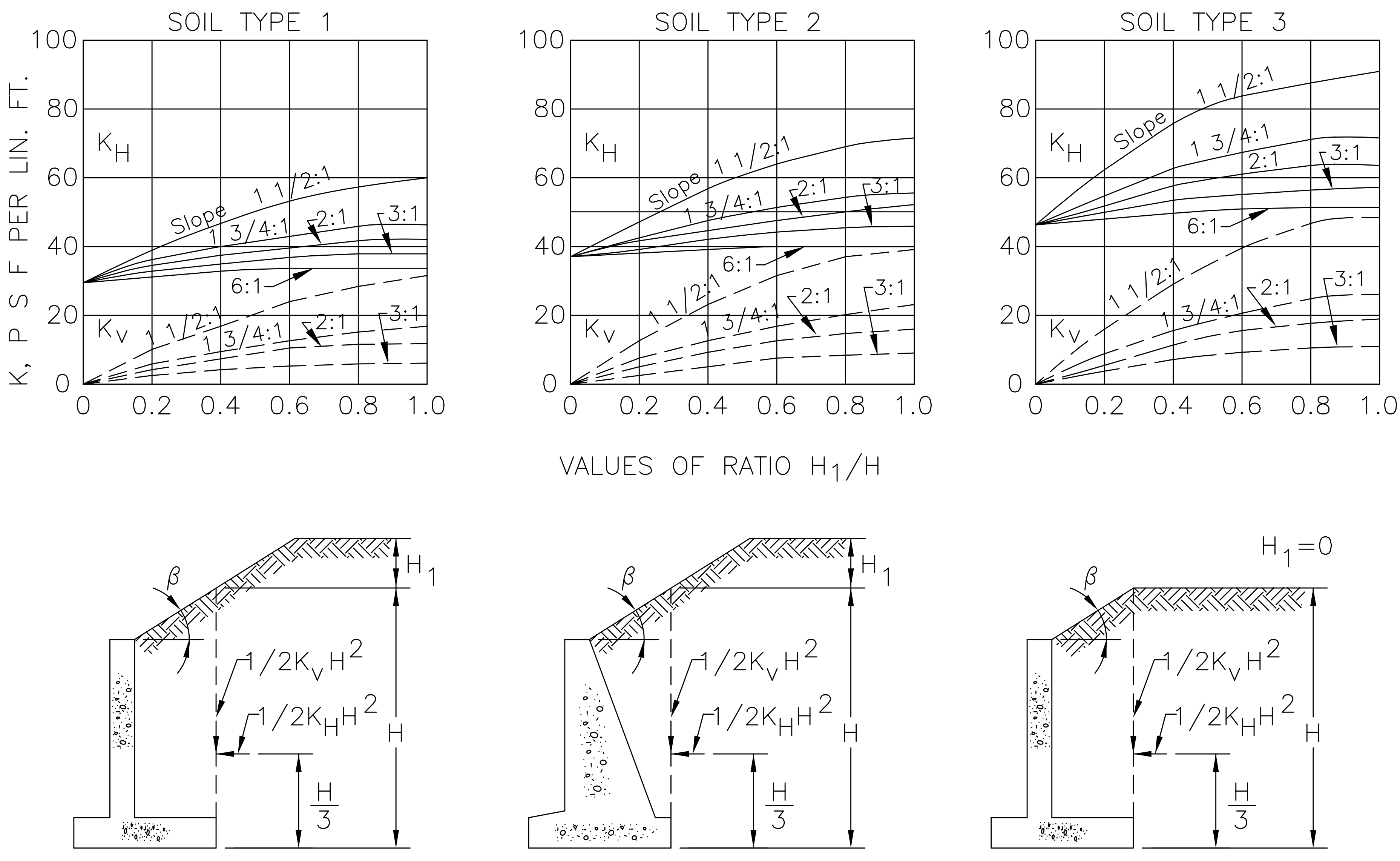




DESIGN LOADS FOR LOW RETAINING WALLS

(STRAIGHT SLOPE BACKFILL)

ADAPTED FROM NAVFAC DM7.2



ADAPTED FROM NAVFAC DM7.2

LEXINGTON-FAYETTE URBAN COUNTY GOVERNMENT, DEPARTMENT OF PUBLIC WORKS

CHAPTER 4
PLAN SUBMISSION REQUIREMENTS

4.1 Plan Requirements for Bridges

4.1.1 Design Computations

Submissions of bridge designs shall be accompanied by the design computations for all major elements of the structure including abutment footings, stems and caps, pier footings, columns and caps, pile loads, footing pressures, beam/girder, slab and negative moment reinforcement, deck drain spacing, approach slab, geometry and elevations. The computations shall be complete, neat and legible and self-explanatory for independent review of the design methods, loads and design assumptions with references to applicable AASHTO articles. Prior to submission, the calculations shall be independently reviewed by the designer's associates and checked for methodology as well as computational accuracy.

Printouts of spreadsheets and computer programs shall contain explanations of their methods, assumptions and logic either as part of the printout or, if necessary, as an accompanying document.

The above items shall be in a bound 8.5"x11" format with an index of the included items and a title sheet clearly identifying the structure location and crossing, designer's name and Kentucky Professional Engineer's stamp/seal and date. Computation sheets shall be titled to identify the specific element being designed and shall be initialed by the originator and checker. Included as appendices to the structural computations shall be the hydraulic analyses for stream crossings and the Geotechnical Report for all bridges.

4.1.2 Plan Details

Plan details for bridges shall be presented on full sized plan sheets approximately 22 x 36 inches in size. Each sheet shall have a title block in the bottom right hand corner identifying the structure location and crossing, a sheet title describing what structure element this sheet details and the initials of the designer, design checker, detailer, and detail checker. Each sheet shall be numbered consecutively beginning with one. The first sheet shall include the designer's name, Kentucky Professional Engineer's stamp/seal and date and shall also include the total number of accompanying sheets to follow. The set of details shall contain all of the applicable items as listed in the following sections.

4.1.3 General Notes

Each set of bridge details shall contain general notes that supplement or modify the Standard Specifications. These notes shall be included on a separate sheet entitled, "General Notes," and shall include, as a minimum, the following notes:

- Specifications - this note shall indicate the AASHTO Design Specification used for design of the bridge and also the governing specification for construction of the bridge (usually the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction, current edition).

Example:
Specifications - All references to the Standard Specifications are to the 1994 Edition of the Kentucky Department of Highways Standard Specifications for Road and Bridge Construction. All references to the AASHTO Specifications are to the 1996 Edition of the AASHTO Standard Specifications for Highway Bridges.

- Design Load - this note shall indicate the live loading and wind velocity for which the bridge is designed (usually HS25 live load and a wind velocity of 100 mph).
  Example:
  Design Load - This bridge is designed for HS25 live load. The HS25 live load is arrived at by increasing the standard HS20-44 truck and lane loads as specified in the AASHTO Specifications by 25 percent. This bridge is designed for a wind load based on a wind velocity of 100 mph.

- Design Method - this note shall indicate that all reinforced concrete members are designed by the Load Factor Method in accordance with AASHTO.
  Example:
  Design Method - All reinforced concrete members are designed by the Load Factor Method as specified in the AASHTO Specifications.

- Materials Design Specifications - this note shall indicate the design compressive strength of the various classes of reinforced concrete used in the structure and the design yield strength for the concrete reinforcement as well as required material specifications for any other materials.
  Example:
  Materials Design Specifications - For Class 'A' reinforced concrete, f'c = 3500 psi, for Class 'AA' reinforced concrete, f'c = 4000 psi, for steel reinforcement, fy = 60000 psi.

- Concrete - this note shall describe where the various classes of concrete are to be used in the structure.
  Example:
  Concrete - Class 'AA' concrete is to be used in the roadway slab, sidewalk, barriers, and in the portions of the substructure above the top of the caps except in the pedestals. Class 'A' concrete is to be used in the pedestals and in the substructure below the top of the caps. Prestressed girder concrete shall be in accordance with the plans and specifications.

- Foundation Pressure - this note shall indicate the maximum footing pressure, maximum axial pile load, and maximum horizontal pile shear for abutments, end bents, and piers. The pressure or load given is the actual maximum calculated load and is not to be reduced by the allowable percentages in AASHTO.
  Example:
  Foundation Pressure - Abutment footings are designed for a maximum pressure of

12200 psf. End bent piles are designed for a maximum axial load of 127 kips per pile and a maximum horizontal shear of 5 kips per pile. Pier footings are designed for a maximum pressure of 13600 psf.

4.1.4 Bridge Layout

The Bridge Layout Sheet gives the overall plan of the bridge. The sheet consists of a plan view of the bridge (typically shown with the bridge deck removed so that the layout of the substructure units can more clearly be detailed), an elevation view orthographically projected from and at the same scale as the plan view and a section through the bridge deck.

The bridge plan shall show: centerline of roadway or baseline with stations increasing from left to right, working line(s) for bridge layout if different from centerline roadway or baseline, road under centerline and stationing, road under pavement/curb/sidewalk/shoulder lines, approach roadway pavement/curb/sidewalk/shoulder lines, roadway curve data, stations of substructure units, skew angle, north arrow, berm width, limits of slope protection, stream name, normal edge of water and flow direction, span length dimensions, existing elevation contours, toe of slopes, working point layout for curved bridges, end of bridge stations and bearing of centerline or baseline.

The bridge elevation shall show: sea level datum reference line, roadway profile data, elevations given for bridge seats/footings/pile cutoffs/berms/highwater/normal pool, existing ground along centerline as dashed line, rock line along centerline, proposed profile grade, proposed ground along centerline, labels for substructure units, labels for fixed/integral/expansion bearings, slope protection thickness and vertical dimensions of substructure units.

The typical deck section shall show: beam/girder layout and spacing, deck slab thickness, barrier/curb/sidewalk/handrail dimensions, roadway centerline and lane widths, overall deck width, dimensions of any haunches or fillets and the location and type of deck drains.

4.1.5 Subsurface Data Sheet

The Subsurface Data Sheet shall show the plan location of all cores and soundings taken as part of the investigation for the bridge as well as sounding refusal elevations and core logs depicting the various strata encountered for all holes. The Subsurface Data Sheet shall be prepared as part of the geotechnical report for the structure. For more detailed information on the preparation of the Subsurface Data Sheet, refer to the *Lexington-Fayette Urban County Government Geotechnical Manual.*

4.1.6 Abutment Details

In addition to the general details required for all reinforced concrete structures and outlined in Section 4.1.12, Abutment/End Bent Details shall show: a plan of the cap with a typical detail of a bearing device in place and in its intended orientation, a north arrow, a front elevation, a side or wing elevation view, a footing plan or pile layout plan, sections through the cap, stem, footing and backwall and sections through the wings. All plan views shall be tied to the construction centerline or baseline including stationing to 0.01 feet, complete layout dimensions to the nearest 1/8 inch and skew angles. All elevation views shall include elevations for bridge seats, top of caps, bottom of footings and top of backwalls given to the nearest 0.01 feet.

4.1.7 Pier Details

In addition to the general details required for all reinforced concrete structures and outlined in Section 4.1.12, Pier Details shall show: a plan of the cap with a typical detail of a bearing device in place and in its intended orientation, a north arrow, a front elevation, a side elevation, a footing plan showing any piles and sections through the columns and cap. All plan views shall be tied to the construction centerline or baseline including stationing to 0.01 feet, complete layout dimensions to the nearest 1/8 inch and skew angles. All elevation views shall include elevations for bridge seats, top of caps, and bottom of footings given to the nearest 0.01 feet.

4.1.8 Superstructure Framing Plan

The Superstructure Framing Plan details the layout of the supporting beams or girders for the bridge superstructure and shall show: a plan view of the beams/girders, centerlines of substructures, construction centerline or baseline, north arrow, span lengths, beam/girder spacings, skew angles, location and orientation of diaphragms and enlarged details of the beams/girders at their bearings.

4.1.9 Superstructure Details

In addition to the general details required for all reinforced concrete structures and outlined in Section 4.1.12, the Superstructure Details shall show: an elevation view of the beam/girder, beam/girder sections, deck slab plan with dimensions and skew angles, construction centerline or baseline, centerlines of substructures, layout work points, handrail post spacings, deck slab section, barrier/curb/sidewalk/handrail details, details of bearing pads, expansion device details and diaphragm elevations and sections.

4.1.10 Deck Construction Elevations

Deck construction elevations shall be given to facilitate accurate placement of the slab concrete and to control the constructed slab thickness.

On bridges with spread beams/girders, a schematic plan of the deck is provided with longitudinal lines at beam centerlines, construction centerlines and gutter lines. Transverse lines are provided at substructure centerlines and deck ends along with other transverse lines to form a grid spacing of approximately eight feet. Construction elevations are provided in tabular form for each intersection of a longitudinal and transverse line. Additionally, elevations are provided at slab thickness check points located generally in the center of “slab panels” formed by two adjacent beams and adjacent diaphragms. The construction elevations presented shall include an allowance for dead load deflection of the beams/girders due to weight of deck, curbs, sidewalks, and future wearing surface. The construction elevation table presented has an entry for the calculated construction elevation and blank spaces for entering (during construction) the top of beam elevation at each beam centerline and for a computed "Dimension X." When the deck is constructed, the top of beam elevations are shot and those elevations are subtracted from the construction elevation to determine the "Dimension X" which is then used to set to screed machine template. Elevations are shot at the slab thickness control points on the bottom of slab forms and subtracted from the construction elevation at that point and the result is compared with the plan slab thickness. The slab form is then adjusted to provide the plan slab thickness.

On side-by-side precast box beam bridges, the procedure is the same as for spread girders except that elevations need only be given at gutter lines and construction centerlines. The same transverse grid spacing described above is used.

The Construction Elevation Details shall show: a schematic plan view with longitudinal and transverse lines as described above, a section through the deck indicating where the construction elevations and slab thickness control points are given, a table of construction elevations and a table of slab thickness control point elevations. All elevations are given to three decimals (0.001 feet).

4.1.11 Other Details

Bridges with integral end bents will require details of the approach slab. These details consist of a plan view showing construction centerline or baseline, skew angles, transverse and longitudinal sections, sections through edge beams and general details required for all reinforced concrete structures.

Bridges with non-standard, unusual, or unique elements will require complete detailing of those portions.

4.1.12 Reinforce Concrete Details

All reinforced concrete structures shall include the following items in the details of those structures:

- Full dimensioning, horizontal and vertical, of all concrete surfaces
- Location of all reinforcement by dimension
- Identification of all reinforcement by bar marks
- Location of required and optional construction joints and keys
- Clearance from concrete surface to reinforcement and spacing of bars

- Elevations of critical locations on substructure units
- Bar splice and embedment lengths
- Bill of Reinforcement including bending and hook dimensions

4.2 Plan Requirements for Culverts

4.2.1 Design Computations

Submissions of culvert designs shall be accompanied by the design computations for all major elements of the structure including the slab, side and interior walls, wing footings and stems, bearing pressures and the barrel and wing length geometry. The computations shall be complete, neat and legible and self-explanatory for independent review of design methods, loads and design assumptions with references to applicable AASHTO articles. Prior to submission, the calculations shall be independently reviewed by the designer's associates and checked for methodology as well as computational accuracy.

Printouts of spreadsheets and computer programs shall contain explanations of their methods, assumptions and logic either as part of the printout or, if necessary, as an accompanying document.

The above items shall be in a bound 8.5"x11" format with an index of the included items and a title sheet clearly identifying the structure location and crossing, designer's name and Kentucky Professional Engineer's stamp/seal and date. Computation sheets shall be titled to identify the specific element being designed and shall be initialed by the originator and checker. Included as appendices to the structural computations shall be the hydraulic analyses and the Geotechnical Report.

4.2.2 Plan Details

Plan details for culverts shall be presented on full sized plan sheets approximately 22 x 36 inches in size. Each sheet shall have a title block in the bottom right hand corner identifying the structure location and crossing, the culvert size and the initials of the designer, design checker, detailer, and detail checker. Each sheet shall be numbered consecutively beginning with one. The first sheet shall include the designer's name, Kentucky Professional Engineer's stamp/seal and date and shall also include the total number of accompanying sheets to follow. The set of details shall contain all of the applicable items as listed below.

4.2.3 Culvert Layout

The Culvert Layout gives the overall plan of the culvert in relation to the existing stream, original contours and proposed roadway. The sheet consists of a plan view of the culvert, a longitudinal section, and general notes.

The plan view shall show: roadway construction centerline or baseline with stations, roadway pavement/curb/sidewalk/shoulder lines, centerline curve data, station of culvert, skew angle, north arrow, existing ground contours, stream flow lines and direction of flow, structure plan, limits of slope protection, toe of slopes and fill and cut slope grading lines indicating direction of slope and slope ratio.

The longitudinal section view shall show: a sea level datum reference line, culvert structure in section through the longitudinal centerline of the culvert, inlet/outlet elevations of culvert inverts, finished ground elevations at roadway centerline and at all break points across the roadway template along the longitudinal culvert centerline, existing ground line and rock line along longitudinal culvert centerline, fill slope ratio, locations of footing steps and/or special bedding material, dimensions of inlet and outlet from roadway centerline, list under the title the barrel opening height/width/length, foundation type, skew, design live load (if any), and maximum design fill height.

Any general notes required to supplement or modify the Standard Specifications shall be placed on the Culvert Layout Sheet. The following general notes are required:

<u>Specifications</u> - All references to the Standard Specifications are to the [year] edition of the Kentucky Department of Highways, Standard Specifications for Road and Bridge Construction. All references to the AASHTO Specifications are to the current edition of the AASHTO Standard Specifications for Highway Bridges.

<u>Design Method</u> - All reinforced concrete members are designed by the Load Factor Method as specified in the AASHTO Specifications.

<u>Materials Design Specifications</u> - for Class 'A' concrete, f'c = 3500 psi, for steel reinforcement, fy = 60000 psi.

<u>Concrete</u> - Class 'A' Concrete shall be used throughout.

<u>Steel Reinforcement</u> - Steel Reinforcement shall be Grade 60, ASTM A615 (billet) or ASTM A616 (rail). Rail steel shall be used for straight bars only.

<u>Design Load</u> - Culvert slabs are designed for flexure in accordance with the AASHTO Specifications. [include the following sentence where applicable] The effective weight of fill has been modified for unyielding foundations in accordance with Research Report UKTRP-84-22. [include the following sentence where applicable] The culvert has been designed for HS25 live load that is arrived at by increasing the standard HS20 truck and lane loads, as specified in the AASHTO Specifications, by 25 percent.

<u>Footing Pressure</u> - Foundation materials for the culvert barrel shall resist a maximum bearing pressure of [maximum bearing pressure] kips per square foot.

<u>Beveled Edges</u> - All exposed edges shall be beveled 7/8 inches.

4.2.4 Culvert Details

In addition to the general details required for all reinforced concrete structures and outlined in Section 4.1.12, the culvert details shall show: a half-plan half-sectional plan showing reinforcement in the top slab and bottom slab respectively, a north arrow, a longitudinal barrel section projected orthographically from the plan, an end elevation of the inlet or outlet projected orthographically from the plan (only one end is required if the inlet and outlet are similar), a typical barrel section, elevation views of the wings, sections through the wings, fence/railing details and a bill of reinforcement.

4.2.5 Subsurface Data Sheet

The Subsurface Data Sheet shall show the plan location of all cores and soundings taken as part of the investigation for the culvert as well as sounding refusal elevations and core logs depicting the various strata encountered for all holes. The Subsurface Data Sheet shall be prepared as part of the geotechnical report for the structure. For more detailed information on the preparation of the Subsurface Data Sheet, refer to the *Lexington-Fayette Urban County Government Geotechnical Manual.*

4.3 Plan Requirements for Retaining Walls

4.3.1 Design Computations

Submissions of retaining wall designs shall be accompanied by the design computations for the factor of safety against overturning and sliding, bearing pressures, footing, and wall stem design. Where wall height varies and different designs are employed for the various heights, these computations shall be provided for each design section. The computations shall be complete, neat and legible and self-explanatory for independent review of the design methods, loads and design assumptions with references to applicable AASHTO articles. Prior to submission, the calculations shall be independently reviewed by the designer's associates and checked for methodology as well as computational accuracy.

Printouts of spreadsheets and computer programs shall contain explanations of their methods, assumptions and logic either as part of the printout or, if necessary, as an accompanying document.

The above items shall be in a bound 8.5"x11" format with an index of the included items and a title sheet clearly identifying the structure location, designer's name and Kentucky Professional Engineer's stamp/seal and date. Computation sheets shall be titled to identify the specific element being designed and shall be initialed by the originator and reviewer. Included as an appendix to the structural computations shall be the Geotechnical Report.

4.3.2 Plan Details

Plan details for retaining walls shall be presented on full sized plan sheets approximately 22 x 36 inches in size. Each sheet shall have a title block in the bottom right hand corner identifying the structure location and the initials of the designer, design checker, detailer, and detail checker. Each sheet shall be numbered consecutively beginning with one. The first sheet shall include the designer's name, Kentucky Professional Engineer's stamp/seal and date and shall also include the total number of accompanying sheets to follow. The set of details shall contain all of the applicable items as listed below.

Details for reinforced concrete walls shall include the general details required for all reinforced concrete structures and outlined in Section 4.1.12. Additionally the wall details shall show: a plan of the wall tied to an appropriate centerline or construction baseline and including layout dimensions and breaks in the wall alignment, an elevation view of the wall with vertical dimensions and elevations of bottom of footing and top of wall at all break points, locations of weep holes, locations of control or expansion joints, section(s) through the wall, general notes for governing design and construction specifications, load factor design method, materials design specifications for concrete and reinforcement, foundation pressure, any special backfill requirements and any other notes required to supplement or modify the Standard Specifications. Where reinforced concrete is used, a bill of reinforcement is required.

4.3.3 Subsurface Data Sheet

The Subsurface Data Sheet shall show the plan location of all cores and soundings taken as part of the investigation for the wall as well as sounding refusal elevations and core logs depicting the various strata encountered for all holes. The Subsurface Data Sheet shall be prepared as part of the geotechnical report for the structure. For more detailed information on the preparation of the Subsurface Data Sheet, refer to the *Lexington-Fayette Urban County Government Geotechnical Manual*.

4.3.4 Standard Drawing Gravity Wall

When a gravity retaining wall is proposed to be used from the Lexington-Fayette Urban County Government Standard Drawings and the limitations of that standard drawing are met, the above requirements may be abbreviated as follows:

- Structural design computations are not required.

- Plan details may be limited to a plan and elevation depicting sufficient detail to allow verification that the standard drawing is applicable.

- The subsurface exploration and plan/details may be omitted for walls less than 6 feet in overall height.

4.4 Requirements for Miscellaneous Structures

4.4.1 Design Computations

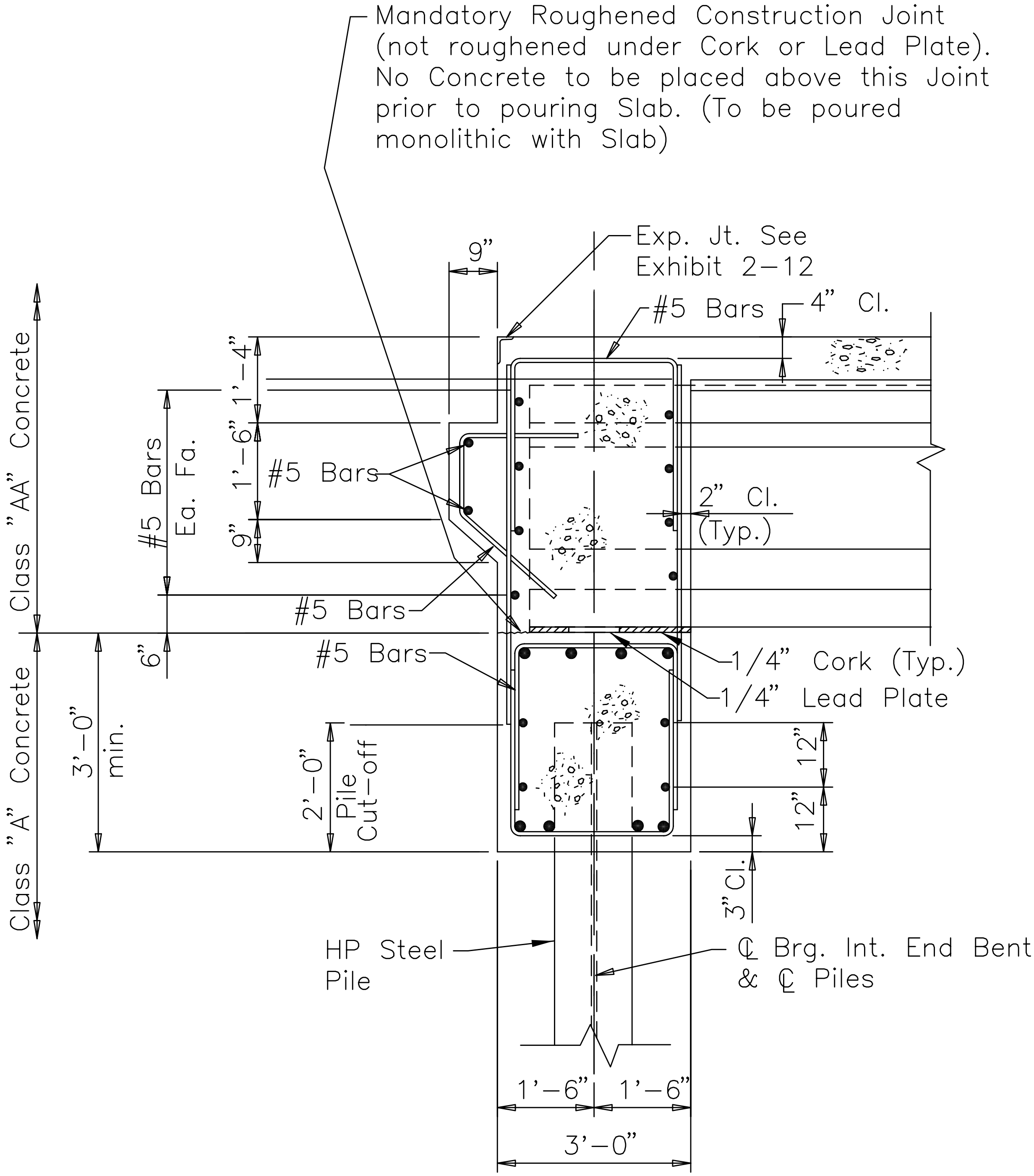
Submissions of miscellaneous structures shall be accompanied by the design computations for all major elements of the structure and, where applicable, a geotechnical report and recommendations. The computations shall be complete, neat and legible and self-explanatory for independent review of the design methods, loads and design assumptions with references to applicable AASHTO articles. Prior to submission of the plans, the calculations shall be reviewed independently and checked for methodology as well as computational accuracy.

Printouts of spreadsheets and computer programs shall contain explanations of their methods, assumptions and logic either as part of the printout or, if necessary, as an accompanying document.

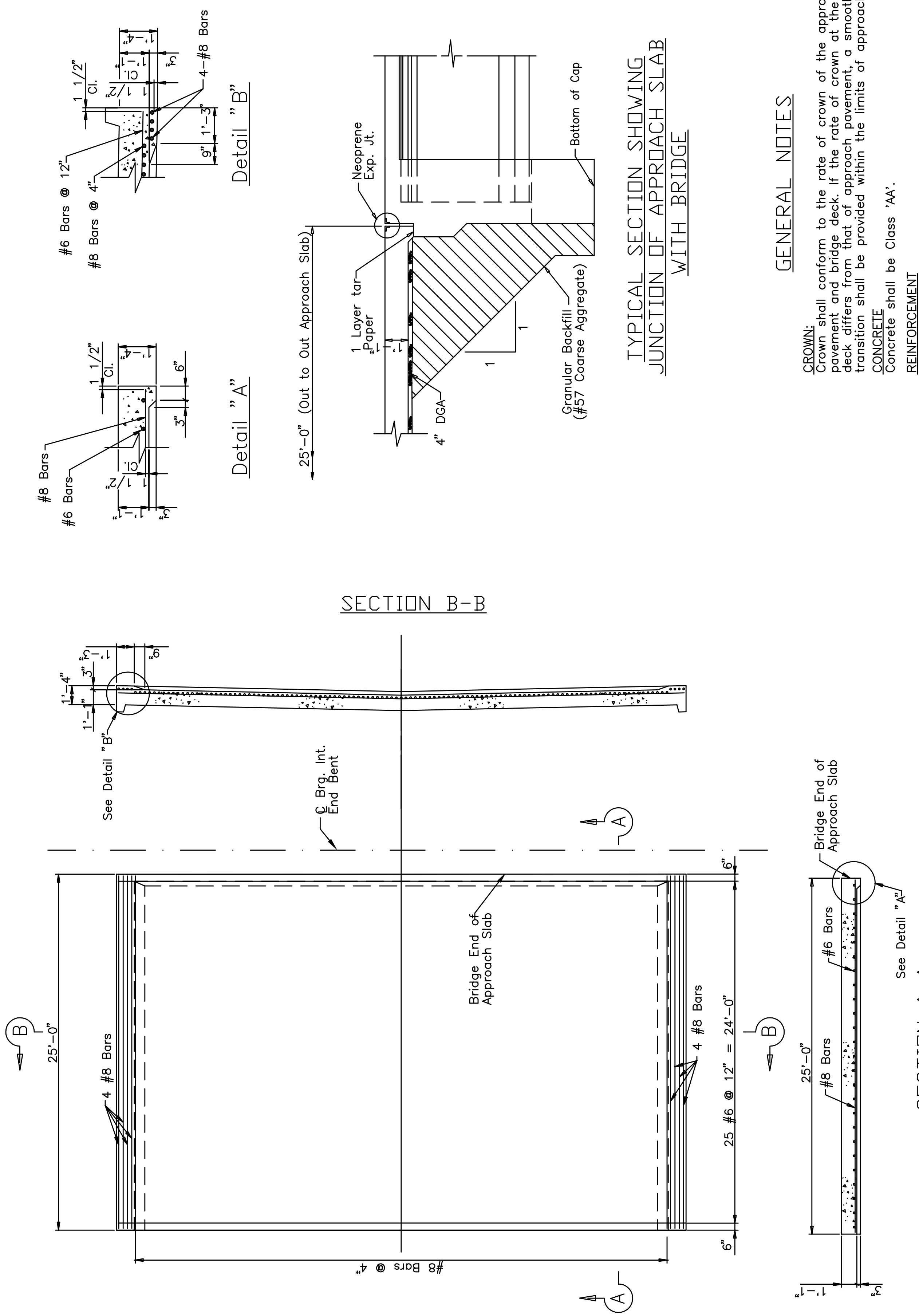
The above items shall be in a bound 8.5”x11” format with an index of the included items and a title sheet clearly identifying the structure location, designer’s name and Kentucky Professional Engineer’s stamp/seal and date. Computation sheets shall be titled to identify the specific element being designed and shall be initialed by the originator and checker. Included as an appendix to the structural computations shall be the Geotechnical Report where applicable.

4.4.2 Plan Details

Details shall generally include a plan view with complete dimensions tied to a construction baseline, an elevation view, appropriate sections and details, reinforcement spacing, bar marks and a bill of reinforcement and a subsurface exploration plan. Details shall be to a level to allow complete review of the intended design and subsequent construction and construction inspection.



INTEGRAL END BENT TYPICAL SECTION



GENERAL NOTES

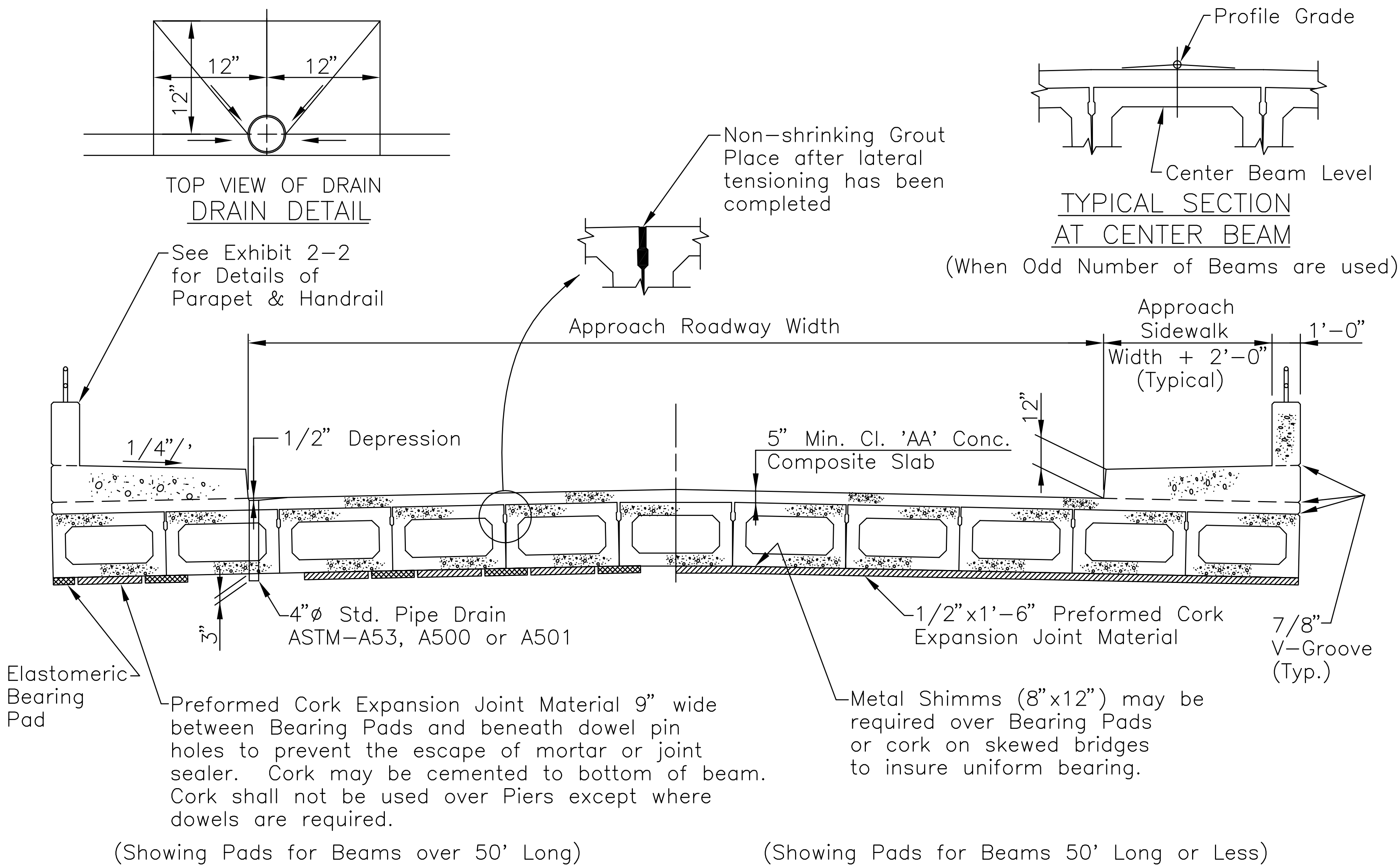
CROWN:
Crown shall conform to the rate of crown of the approach pavement and bridge deck. If the rate of crown at the bridge deck differs from that of approach pavement, a smooth transition shall be provided within the limits of approach slab.

CONCRETE
Concrete shall be Class 'AA'.

REINFORCEMENT
All bar reinforcement shall be grade 60 and Epoxy Coated.

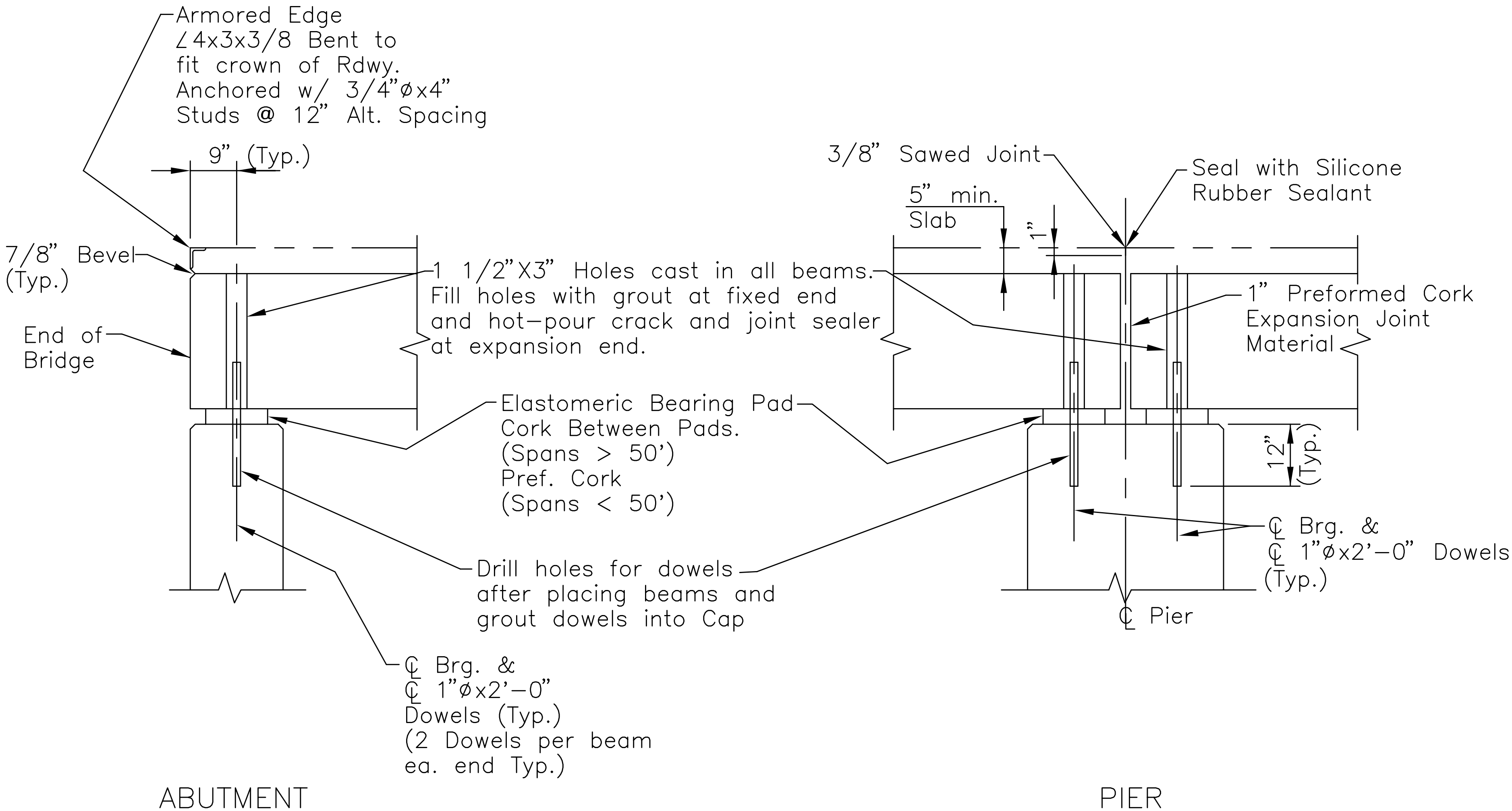
APPROACH SLAB TYPICAL DETAILS

LEXINGTON-FAYETTE URBAN COUNTY GOVERNMENT, DEPARTMENT OF PUBLIC WORKS



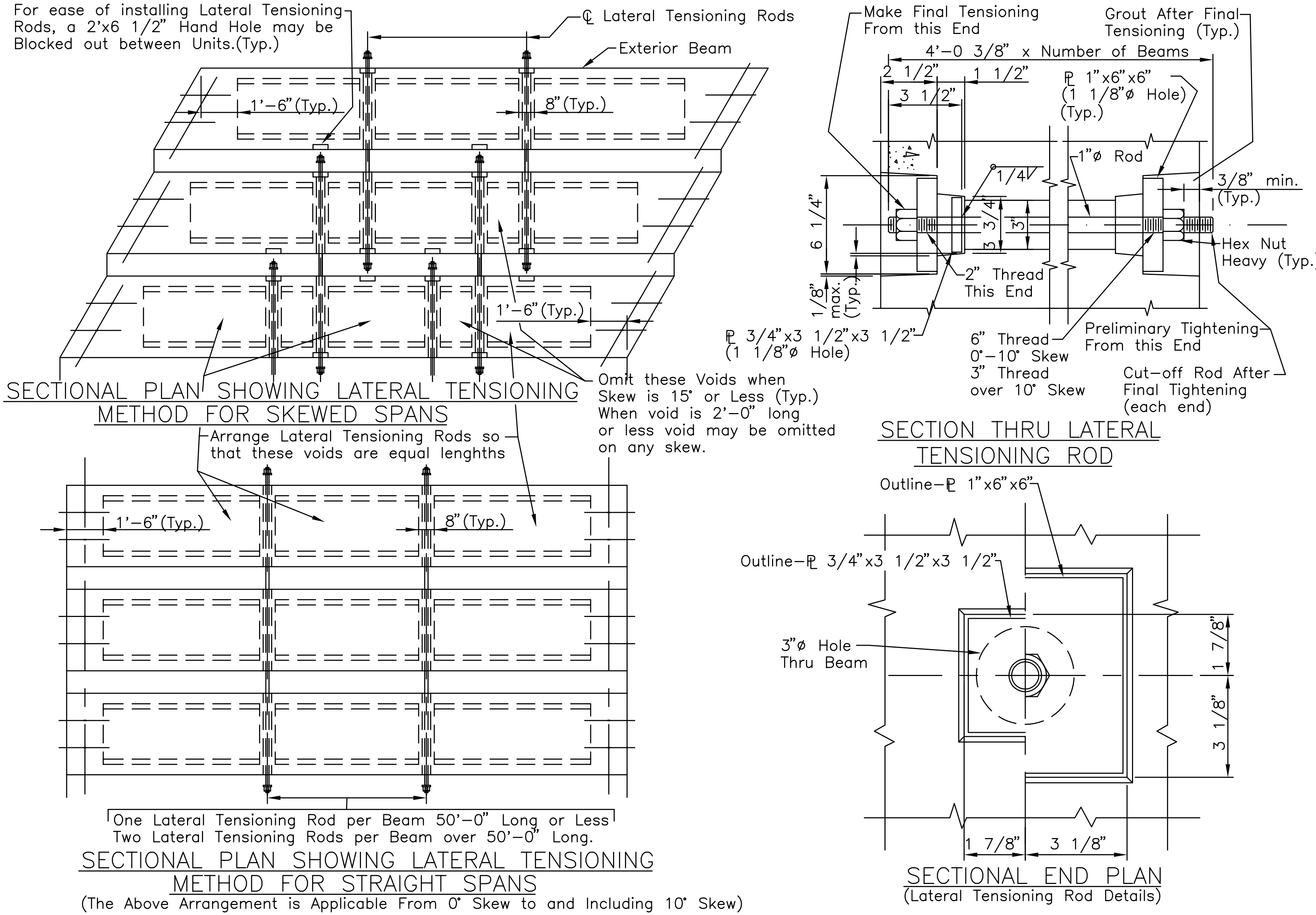
TYPICAL SECTION THRU BRIDGE
(Normal Crown)
PPC BOX BEAMS

LEXINGTON–FAYETTE URBAN COUNTY GOVERNMENT, DEPARTMENT OF PUBLIC WORKS



TYPICAL BEARING DETAILS FOR
PPC BOX BEAM BRIDGES

LEXINGTON-FAYETTE URBAN COUNTY GOVERNMENT, DEPARTMENT OF PUBLIC WORKS



PPC BOX BEAM BRIDGES LATERAL TENSION RODS DETAILS

LEXINGTON-FAYETTE URBAN COUNTY GOVERNMENT, DEPARTMENT OF PUBLIC WORKS