DESIGN CRITERIA FOR BOX CULVERTS AND BOX CULVERT EXTENSIONS

1. DESIGN SPECIFICATIONS

Design all new culverts in accordance with the requirements of the AASHTO LRFD Bridge Design Specifications. Use the HL-93 live loading and all vehicles as required by the SCDOT Load Rating Guidance Document (LRGD).

The Contractor may design extensions of existing culverts in accordance with the Seventeenth Edition of the AASHTO Standard Specifications for Highway Bridges if the existing culvert was designed using the AASHTO Standard Specifications for Highway Bridges. If this option is selected, design for HS 20-44 Loading or an Alternate Military Loading of two axles four feet apart with each axle weighing 24,000 pounds, whichever produces the greater stress.

Comply with the LRGD for load rating of bridge-length box culverts. An update to the previous load rating is required when a bridge-length box culvert is extended.

Hydraulically design culverts that convey water in accordance with the requirements of the SCDOT Requirements for Hydraulic Design Studies and the RFP Hydraulic Design Criteria.

Perform subsurface investigations for culverts in accordance with the requirements of the SCDOT Geotechnical Design Manual.

Consider seismic effects for new culverts as required by the SCDOT Seismic Design Specifications for Highway Bridges.

2. MATERIALS

Use Class 4000 concrete for cast-in-place elements of culverts and use Class 5000 concrete for precast elements of culverts.

Use reinforcing bars conforming to the requirements of AASHTO M 31, Type W, Grade 60. Use Welded Wire Fabric that meets the requirements of AASHTO M 336.

3. DESIGN AND DETAILING REQUIREMENTS

3.1 General

Culverts will not be allowed as a substitute for bridges specified in this project. Construct culverts with four sides and using reinforced concrete.

Reinforcing bars in all reinforced concrete members in tension shall be distributed to control cracking. Use Class 2 exposure condition when designing for crack-control unless a more severe condition is warranted.

Establish the length of the culvert so that, at the end of the culvert, the theoretical fill slope is 1 foot below the top of the top slab. Locate the culvert headwalls outside of the clear zone where practical or shield the exposed portions of the structure appropriately.

Detail rip rap and geotextile fabric at both ends of the culvert in accordance with SCDOT Standard Drawing No. 804-205-00.

From the beginning of construction until the end of the 75-year design life of the culvert, limit the total settlement to 6 inches. Limit the maximum allowable differential settlement along the length of a culvert to 1 inch per 50 feet of culvert length. If deep foundations are used to limit the settlement of a culvert, limit the longitudinal (direction of travel) differential settlement between the culvert and the adjacent paved approach embankments to a maximum of 1 inch in 50 feet.

Detail additional reinforcing steel at openings in the top slab or side walls to meet or exceed the reinforcement shown on SCDOT Standard Drawing No. 722-105-02.

Detail all box culverts, whether cast-in-place or precast, with cast-in-place wing walls, head walls, aprons, and cut-off walls on both the inlet and outlet ends. Do not use precast wing walls, head walls, aprons, cut-off walls, and footings.

In situations where guardrail is required and installation of the posts conflicts with the top slab of the culvert, provide a moment slab supported concrete barrier. Design and detail the moment slab to eliminate transfer of moment to the culvert barrel. If the moment slab is attached to the culvert barrel for resistance to sliding forces, design and detail the connection to resist horizontal sliding forces only.

3.2 Wing Walls

Wing walls are typically flared out approximately 30 degrees in relation to the centerline of the culvert, but the angle may vary based on site conditions. Detail the wing walls so that the top of the wing wall is at least 12 inches above the finished ground line. Design and detail the wing wall height so that, at the junction of the wing wall and culvert barrel, the top of the wing wall is the same elevation as the top of the top slab of the culvert barrel. Extend the wing wall at least to a point where the soil can wrap around the exposed face of the wing wall, using a slope of 2H:1V or flatter, without encroaching on the projected barrel opening.

Support wing walls by footings or aprons, but assume no support from the culvert barrel(s).

Detail the thickness of wing walls equal to or greater than the exterior wall thickness of the culvert. If the maximum wing wall height is greater than 6 feet and the wing wall has a layer of reinforcing in each face, provide a minimum of 5 inches of clearance between the mats of reinforcing steel.

3.3 Aprons

For box culverts, detail aprons as continuously cast-in-place concrete placed from end to end of the wing walls. Aprons may cover the entire area between the wing walls and the ends of the culvert barrel(s) or may follow the edges of the wing wall/culvert barrel(s). Detail the thickness of the aprons equal to or greater than the thickness of the bottom slab unless the bottom slab thickness exceeds 12 inches. If the bottom slab thickness exceeds 12 inches, detail the apron thickness as 12 inches unless a thicker apron is required by design.

3.4 Cut-off Walls

Detail cut-off walls with a minimum thickness of 10 inches. Detail cut-off walls to extend a minimum of 2 feet below the bottom of the bottom slab or apron. Detail cut-off walls to extend to a depth 2 feet below the scour depth or into rock not-susceptible to scour. If cut-off walls are used as structural elements, design and detail appropriate reinforcement.

3.5 Head Walls

Detail head walls with a minimum height of 12 inches above the finished ground line and a minimum thickness of 12 inches. Detail head walls to extend the full width of the culvert barrel(s).

Anchor the head walls to the top slabs of culverts with reinforcing steel that has been designed and detailed to resist overturning and sliding. Detail each face of the head wall with a minimum of 0.2 square inches of reinforcing steel per foot in each direction.

3.6 Concrete Cover

For cast-in-place box culverts, provide concrete cover to reinforcing in accordance with the AASHTO LRFD Bridge Design Specifications. For W/C ratios that are less than or equal to 0.4, use a concrete cover modification factor of 1.0.

For precast box culverts, detail the clear cover as shown in ASTM C 1433 and ASTM C 1577.

3.7 Existing Culverts and Extensions

Where a change in fill height greater than 2-feet is proposed for culverts remaining in place or being extended, evaluate the existing culvert to determine if it is structurally adequate to handle the revised loading conditions or if it will require total replacement. Review and document the existing condition of the culvert. Use the existing culvert plans, if available, to determine structural capacity in accordance with either the original design specifications used for the structure, or the AASHTO Standard Specifications for Highway Bridges, 17th Edition. If existing culvert plans are not available, use destructive and/or non-destructive testing to determine dimensions and reinforcing amounts to be used in the analysis. Prepare a report documenting the evaluation, sign and seal the report, and submit to SCDOT.

Construct all box culvert extensions of existing cast-in-place culverts using cast-in-place concrete. Construct extensions of existing precast culverts using either precast sections or cast-in-place concrete. If precast sections are used, design and detail the extensions with a cast-in-place concrete transition between the end of the existing barrel and the first new section of precast barrel.

For extensions of existing culverts, detail adhesive anchors, #6 (#19) or greater in size, at a maximum spacing of 18 inches in the exposed ends of the existing barrel. Match the interior barrel shape of the new culvert to that of the existing culvert (i.e. chamfers, ledges, etc.) except as noted in the section titled “Walls” in this document.

3.8 Cast-in-Place Concrete Box Culverts

3.8.1 General

For culverts with skews greater than 25 degrees, design and detail the transverse reinforcing steel perpendicular to the longitudinal reinforcing steel. For lesser skew angles, design and detail the transverse reinforcing steel either perpendicular or parallel to the skew.

At the discontinuous edges of culvert barrel sections, design edge beams for the top and bottom slabs.

3.8.2 Slabs

Use a minimum thickness of 10 inches for cast-in-place box culvert top and bottom slabs.

3.8.3 Walls

Detail cast-in-place box culvert walls vertical and detail a minimum thickness of 8 inches. If the vertical opening dimension of the culvert is greater than 6 feet, provide a minimum of 5 inches of clearance between mats of reinforcing in the walls.

For extensions of existing multi-barrel culverts having interior wall thicknesses less than the new wall thicknesses, detail a minimum 6:1 transition at the junction of the new and existing interior walls.

3.8.4 Construction Joints

Limit the maximum pouring length of cast-in-place culvert barrel sections to 70 feet. Detail keyed transverse construction joints in the barrel(s) as required to meet this limit. Detail the longitudinal reinforcing steel continuous across the joints.

If the volume of cast-in-place concrete exceeds 225 CY in any pour, provide a pouring sequence on the plans. Complete all concrete pours in less than 5 hours. Provide the minimum pouring rate on the plans.

Detail a keyed construction joint in the walls, 6 inches minimum above the top of the bottom slab. When the height of the wall, measured from the top of the bottom slab, is 8 feet or greater, also detail a keyed construction joint between the walls and top slab.

For construction joints located between elevations of extreme low tide and extreme high tide, provide second-method waterproofing on both sides of the joint in accordance with Section 814 of the SCDOT Standard Specifications.

3.9 Precast Concrete Box Culverts

3.9.1 General

Do not use precast box culvert sections if any of the following conditions exist:

- the design earth cover exceeds the maximum height specified in the ASTM design tables.,
- the design earth cover is less than 2 feet,
- the culvert is an extension of an existing cast-in-place culvert, or
- the culvert will be used for pedestrian traffic.

Use monolithically cast box culvert sections. Do not use precast concrete split box culvert sections.

3.9.2 Design Requirements

Design precast box culvert sections for new culverts in accordance with ASTM C 1577. For precast culverts having design fill heights greater than 5 feet, round the design fill height up to the next higher 5 foot increment when using the tabulated design information from ASTM C 1577.

3.9.3 Detailing Requirements

Detail precast box culverts in accordance with SCDOT Standard Drawing No. 722-305-00 and Section 722 of the SCDOT Standard Specifications for Highway Construction. Require on the plans that the Contractor place all precast box culverts on a prepared bed of aggregate (Coarse Aggregate No. 5, No. 56, or No. 57) having a minimum thickness of 6 inches. Extend the aggregate bed the entire width and length of the culvert plus 12 inches beyond the outer walls of the barrel(s).

On the plans for precast box culverts, include details for cast-in-place wing walls, head walls, aprons, cut-off walls, and footings. Detail these cast-in-place elements in accordance with the requirements of Section 2.3.3. Attach these elements to the precast culvert barrel(s) using #6 (#19) adhesive anchors detailed at a maximum spacing of 18 inches in the exposed ends of the barrel(s). Design these elements as self-supporting.

Where multiple precast box culvert barrels are placed side by side, the plans shall require a 4 inch minimum and 6 inch maximum space between adjacent barrel sections. The plans shall require this space to be filled with flowable fill or cast-in-place concrete. If the space is filled with flowable fill, the plans shall require that, at both the upstream and downstream ends, the last 6 inches of space between the barrels (measured along the longitudinal direction of the barrels) be filled with a cast-in-place concrete cap for the full height of the culvert.

3.10 **Plan Preparation**

Comply with the Roadway Structure Plan Preparation Requirements for development of culvert plans.