11.80 REINFORCED CONCRETE CULVERTS

11.81 DESIGN CHANGES ON CULVERTS

No changes will be allowed for culverts designed by the Office of Bridges and Structures without first consulting the Office of Construction. These situations include projects which have a specific design number and those projects where the culvert is tabulated as "Drainage Structures By Culvert Contractor."

Article 1109.01B provides for exceptions/substitutions in the construction of reinforced concrete box culverts. As an option, a Contractor may construct a comparable size single or twin box culvert in English units using the RCB-G1-87 or TWRCB-G1-87 culvert standards in lieu of the metric culvert standards specified on the letting plans. A list of comparable English culvert opening sizes is provided in the above Supplemental Specifications.

Exceptions/substitutions on special designs that are not covered by the RCB-G1-87 or TWRCB-G1-87 standards will not be allowed. Some examples of special design conditions that are not covered by the referenced standards are:

- Design fill heights that are greater than standard design fill heights
- Drop inlets and tapered inlets
- Inlet end walls
- Flumes
- Scour floors

The above special design conditions do not have existing English culvert standards, therefore culverts with the above special designs will NOT be allowed to be substituted by English culvert standard designs listed in the Supplemental Specifications table.

For culverts other than those noted above, the project engineer needs to obtain concurrence from the District Construction Engineer for situations warranting significant change(s). Checking the suitability of design for these culverts is the responsibility of the project engineer.

11.82 INSTALLING REINFORCING STEEL, PLACING CONCRETE, AND FORM REMOVAL

Installing Reinforcing Steel

Reinforced culvert plans and culvert standards typically provide the following information regarding placement of reinforcing steel. The intent is for the reinforcing steel in each of the above cases be installed as specified. In application, it will be necessary to determine what is considered reasonably acceptable. For reinforcing steel placement in culverts, the following guidelines are recommended:

- Reinforcing bar spacing should be within 13 mm (½ inch) of the specified spacing to be considered reasonably acceptable.
- Reinforcing bar required splice lengths are typically represented as minimum splice lengths. Reasonably acceptable splice lengths shall never be less than the minimum specified.
- Reinforcing bar edge and end clearances are typically represented by the plan note, “Minimum clear distance from face of concrete to near reinforcing bar is to be 50 mm (2 inches) unless otherwise noted or shown.” Reasonably acceptable clearances for culvert structures shall be the clearance specified on the plans with a tolerance of minus zero and plus 13 mm (1/2 inch).
- *Specification 2404.03,E,2* requires that all vertical reinforcement shall be positioned using side-form spacers. Side-form spacers are chairing devices (similar to chairs

used for support of horizontal reinforcement) used to positively position vertical reinforcing steel at the required clearance from face of concrete (surface of form).

Field welding of deformed reinforcing steel is not permitted without approval of the Construction or Bridge Engineer as stated in *Materials I.M. 558, Field Welding Inspection Manual.*

Placing Concrete

Placing Concrete in Walls and Top Slab. *Specification 2415.03,B,2 Paragraph B* states that culverts, sidewalls, and top of slab may be constructed as:

- A monolith unit or,
- Concrete in sidewalls may be placed and allowed to harden before the top slab is placed.

If the contractor chooses to use the hardened concrete method, keyways will have to be installed to anchor the cover slab.

Article 2403.03,C, Placing Concrete, specifies that a tremie shall be used whenever the distance through which concrete must be dropped vertically exceeds 6 feet (2 m), except a 3 foot (1 m) drop shall not be exceeded for bridge floors and culvert slabs. For reinforced concrete box culverts, a tremie will be required if the concrete for the culvert floor and slab can not be placed within the allowable 3 foot (1 m) drop. For culvert walls, it is not possible to use a tremie for concrete placement due to the concentration of reinforcing in the walls and the lack of physical space to insert a tremie. This has been field evaluated and the determination has been made that the culvert wall thickness is sufficiently narrow that it functions like a tremie by confining the concrete when it is placed. To ensure satisfactory concrete placement in culvert walls, the following concrete placement procedure must be adhered to:

- Concrete must be discharged through a tapered neoprene boot under the hopper gate of the concrete bucket to control and confine the concrete placement.
- Concrete must be discharged as close to the culvert wall reinforcing as possible.
- Concrete is to be placed in layers for the full length of the wall placement and must not be allowed to be deposited in one location and caused to flow.
- Each layered placement of concrete is to be vibrated for consolidation and each subsequent layer vibrated extending into the preceding layer to consolidate the layer interface.

Following the above described concrete placement procedure for culvert walls has shown no segregation or cold joint problems.

Removal of Wall Forms

On large culvert jobs, it is a distinct advantage for the contractor to remove wall forms before the top slab has attained sufficient age to remove supporting forms. This will be permitted under the following conditions:

- Vertical forms may be removed as provided in *Specification 2403.03,M*.
- Slab forms must be supported independently of the wall forms.
- Vertical supports for the slab forms must be capped with timbers. Longitudinal spacing of supports with 100 x 150 mm (4 x 6 inch) caps on edge should not exceed 1.4 m (4 1/2 feet). With 100 x 200 mm (4 x 8 inch) caps, spacing should not exceed 1.8 m (6 feet). Rows of supports must not be over 1.2 m (4 feet) apart. There must be at least two rows of support, with the outside rows not more than 0.6 m (2 feet)

from walls. Variance from the above suggested spacing should be reviewed by the engineer.

- Vertical posts shall not be smaller than 100 x 100 mm (4 x 4 inch), but may be built up of two 50 x 100 mm (2 x 4 inch) pieces of lumber. Lateral bracing will be required. A vertical clearance of 6 mm (1/4 inch) must be provided between the wall form studs and the slab form joists.
  (NOTE: Lumber may be sized in metrics using "actual," not the conventional "nominal" sizes.)
- The slab form must remain in place as provided in *Specification 2403.03,M.*
- The interior walls of the culvert must be coated with white pigmented curing compound as provided in *Specification 2403.03,E*.

The wing walls and exterior surfaces of the barrel may be cured by any method specified in *Specification 2403.03,E.*

Removal of Slab Forms

Supporting forms for box culvert slabs may be removed when concrete has attained an age of 3 days and a modulus of rupture 24 MPa (350 psi) for spans up to and including 1.2 m (4 feet), 27.5 MPa (400 psi) for spans 1.2 m (4 feet) to and including 1.8 m (6 feet), and 31 MPa (450 psi) for spans exceeding 1.8 m (6 feet). When strength is not determined, forms for box culverts 1.2 m (4 feet) or less in width may be removed after the concrete has attained an age of 7 days, and forms for box culverts over 1.2 m (4 feet) in width may be removed in 14 days.

11.83 BOX CULVERT CURTAIN WALLS

Construction of curtain walls on culvert footings usually is quite a problem because of the difficulty in maintaining the excavation in proper condition while placing concrete.

If material to be excavated is of such nature that neat lines for the curtain wall cannot be maintained, the project engineer may allow forming and placing the curtain wall to the bottom of the footing. Mud must be prevented from working up into the concrete. If necessary, the footing for the curtain wall should be treated as provided by *Specification 2402.03, C*. As an option, and with the approval of the project engineer, steel sheet piling may be used instead of a poured curtain wall. This optional method of curtain wall construction is intended to address site conditions in which it is not reasonably practical for the contractor to dewater and excavate. Sheet pile curtain walls are not a substitute for cast-in-place curtain walls when they can be accomplished.

Sheet Pile Curtain Wall

Criteria for approving a sheet pile curtain wall alternate to the cast-in-place concrete curtain wall is as follows:

- Sheet pile for culvert curtain walls does not require certification of the sheet pile material, but must meet the following requirements.
- Sheet pile tops are to extend a minimum of 150 mm (6 inches) into the concrete culvert floor.
- Bottom of sheet piles are to extend into the ground to an elevation at least 1 m (3 feet) deeper than plan bottom elevation of the concrete curtain wall.
- Sheet piles shall be a minimum of 10 mm (3/8 inches) thick.
- Bottom mat of floor steel shall be continuous through holes cut in the sheet pile.

Reinforcement Placement

For culverts with parallel wings, "f-1" bars should be cut 305 mm (12 inches) from the bend and installed as shown on the plans. When the footing is placed, "f-1" bars must be installed using a 16 x 750 mm (5/8 inch diameter x 30 inch) bar as a lap splice.

NOTE: If metric bars are specified, this would be a 750 mm long, Number 15 bar.

For flared wing culverts, "t" and "u" bars must be installed when placing the curtain wall. Top of the curtain wall should be keyed or roughened, and flushed clean when the footing concrete is placed.

11.84 BOX CULVERT BELL JOINTS

Reinforced box culverts are designed with bell joints when the anticipated settlement exceeds 150 mm (6 inches) or where large fills will be placed over the culvert. The bell joints are designed to provide for movement at the joint without opening the joint to soil infiltration. Since movement resulting from settlement is expected to occur at the bell joint locations it is very important that the bell joints be constructed correctly to ensure that they do not crack under stresses developed during settlement.

The plan details for bell joint construction require that the bell joint be placed integrally with the culvert floor. Numerous requests have been received from contractors to permit a horizontal construction joint in the bell joint at the bottom of culvert floor. These requests have been made to simplify the bell joint and culvert floor construction sequence. It has been recognized that this would simplify the construction sequence. The constructability of culvert bell joints was field reviewed by the Office of Bridges & Structures and Office of Construction with a determination that permitting a staging construction joint in the bell joint would ensure improved construction quality.

Future culvert designs with bell joints will detail a permissible staging construction joint for culvert bell joints and will also require a keyway and installation of a “water stop” in the construction joint. For requests from contractors on current culvert projects to use a construction joint in culvert bell joints, contact the Office of Construction for a copy of the construction details.

11.85 GUIDELINES FOR INSPECTION OF PRECAST CONCRETE BOX CULVERTS

In order to ensure a quality installation of precast concrete box culverts, the following guidelines for inspection of the construction are recommended.

1. After excavation, but prior to the placement of granular bedding; the inspector is to ensure that all unsuitable material has been removed including any necessary core-outs and replacement with suitable materials.

2. During placement of granular bedding, but prior to placement of precast sections; the inspector is to ensure the limits and thickness of the granular bedding is according to the plan.

3. After placement of at least two precast sections, but prior to placement of six precast sections; the inspector is to ensure that the contractor is installing the precast box sections properly. This includes looking over the existing installation work and witnessing installation activity in progress. Be sure to observe the method of installation, proper gapping (between multiple culvert barrel lines), butyl rope gasket installation, culvert section alignment, proper tightening of culvert ties, placement of

engineering fabric on the sides and top of the culvert sections, etc.

4. After placement of all precast box and end sections, but prior to allowing backfilling to proceed; the inspector should look over the entire installation for the completion of all items noted in the above paragraph.

5. During backfilling operations; the inspector should observe the backfilling process and ensure the engineering fabric at the box section joints is correctly in place and is not moved out of position during backfilling.

6. At completion of the contractor's installation of the precast box culvert; the inspector should look over the completed installation for any deficiencies and have the contractor correct as needed.