Illinois Department of Transportation

Memorandum

To:	Studies and Plans Squads	PPM 50-10	
From:	James M. Sullivan	Revised by:	Scott Neihart
Subject:	Culvert Lengths and Design		
Date:	December 23, 1999	Revision Date:	April 1, 2016

PLAN PREPARATION MEMORANDUM 50-10

Culvert Material

Refer to Chapter 40-3.07 of the BDE Manual and ABD Memorandum 8.4 for allowable culvert materials based on location, traffic, and other factors.

Culvert Length

The end of the culvert is located at the point where the top of the culvert end section or headwall intercepts the embankment side slope. The embankment slope adjacent to the end section is steepened to match the slope of the end section wingwalls. This procedure is necessary to ensure that the culvert end section and the steeper slopes around the end section do not encroach into the road ditch cross section.

These procedures vary slightly, depending on the specific type of end section used. The procedures may be divided into four cases: precast concrete flared end sections, metal end sections, cast-in-place concrete end sections, and precast box culvert end sections. These cases are detailed for right angle culverts, in the attachments to this memo.

The details for the cases are shown for across road culverts, but the information can be used for entrance and sideroad culverts. Rural, 3R project normally require 2’ shoulders for field and private entrances, 3’ shoulders for commercial entrances and 4:1 sideslopes for all entrances. Rural expressways allow only field or private entrances, using 2’ shoulders and 6:1 sideslopes. Section 38 of the BDE Manual gives further recommendations for acceptable sideslopes. Mailbox turnouts adjacent to entrances pose problems on many projects. An acceptable sideslope must be maintained adjacent to the turnout, many times requiring the culvert to extend well beyond the entrance to the end of the turnout.

Pay lengths of precast culverts shall be from end to end of precast segments.

Culvert End Treatments – General

Unless they are adapted for the specific skew angle(s), precast end sections and metal end sections are not allowed on culvert with skews greater than 15 degrees. End sections with slopes steeper than 2:1 should not be used.

Precast end sections with the wingwalls parallel to the barrel walls will not be allowed without the approval of the Project Engineer or Bridge and Hydraulics Engineers

Culvert End Treatments – Precast Box Culverts

Cast-in-place end sections for precast culverts shall be designed in detail with complete and accurate drawings, bills of materials, and specifications for bidding by the studies and plans squads. The District Bridge and Hydraulics Engineer will review the end section details, and a structural engineer from the Bureau of Bridges and Structures will seal the details. The District Bridge and Hydraulics Engineer maintains an extensive database of end section designs and details. Designers should consult with the Bridge and Hydraulics Engineer prior to designing a cast-in-place end section. Payment for these end sections shall be per BOX CULVERT END SECTIONS of the culvert number specified.

Guardrail – General Considerations:

If guardrail is necessary, the designer should optimize the taper rate, and use a flared end section, if possible, to minimize the length of need and exposure of the guardrail.

Guardrail is a continuous maintenance problem for mowing, snow removal, and repair. Also, it is a significant roadside hazard, and a much larger target than the culvert itself. The embankment widening at the terminal sections may present unusual design problems for ditch alignment or even create right of way needs. As a general rule, guardrail is preferable to extending the culvert to the clear zone for larger height culverts/drop-offs.

Extension to Clear Zone – General Considerations:

Culvert extensions to the clear zone require careful design of the slopes to assure that the foreslope transitions do not create a “ramp” effect. These transitions should be at a minimum taper rate of 7.5 longitudinal to 1 lateral, and should not present a concave surface with respect to the approaching traffic. Also, extension of a hazard to a point at or just beyond the clear zone only reduces the likelihood that the hazard will be involved in a serious crash. The hazard remains as severe as ever to the vehicle and occupants who have the misfortune to confront it. As a general rule, extending a culvert beyond the clear zone is preferable for smaller drop-offs requiring action.

Culvert Inspection/Scoping

The preparation of studies and plans includes the field inspection of all drainage structures, investigation of high water reports, hydraulic review, and design of box culverts. The Squad Leader should inspect all single barrel or pipe culverts on each project as soon as possible to determine if the culverts should remain and whether they are suitable to extend if necessary. Where significant culvert work is needed, it should be diagrammed for inclusion in the study or project report, and reflected in the cost estimate.

Should the Squad Leader need help to determine a particular or unusual culvert condition, the District Bridge and Hydraulics Engineer will help as necessary. Should the Squad Leader become aware of a multiple box culvert that has not been addressed by the Bridge and Hydraulics Section in the Bridge Condition Report for the section, he/she should notify the Bridge and Hydraulics Engineer at once. If there is a survey for the project, the survey crew will *note (if requested by the Squad Leader)*, the culvert condition in the survey; however, it is the Squad Leader's responsibility to confirm the survey crew's findings.

Foundations for Precast Box Culverts

When precast concrete box culverts or cast-in-place box culverts with the option to use precast box culverts are called for on the plans, soil borings are required. The Standard Specifications allow the precast option unless the plans clearly state cast-in-place is the only option allowed. A request to the Geotechnical Engineer in Project Implementation for the borings and to check the soil condition at the location of culvert must be made by the designer. The request for soil borings should be in the form of a memo to the Geotechnical Engineer. The memo shall include a location map giving the site, stationing of the culvert, the proposed culvert's size and length, and the timeframe needed for the boring information. The borings must be made and included in the plans prior to submittal for letting.

The District Geotechnical Engineer will analyze the soil borings and give the designer any specific foundation requirements. Depending on soil conditions, and this analysis by the Geotechnical Engineer, something other than the 6 inch thickness of porous granular material under the culvert, and/or wingwalls may be required. If undercut is required with backfill of RR-1, use a modified version of the District Detail for Porous Granular Backfill to depict the undercutting work. If no undercut is required, use the Central Office specifications for this work.

Porous Granular Backfill and Porous Granular Embankment

Porous Granular Backfill should be considered when poor soil conditions dictate, or when it is critical to place the backfill very quickly. Placement of pipe culverts across existing roadways constructed under traffic will usually require Porous Granular Backfill: and placement of precast box culverts across existing roadways constructed under traffic will usually require Porous Granular Embankment. For roadway construction on new alignments closed to traffic

during construction, or for locations constructed using staged traffic control with signals, time constraints will not usually require the Porous Granular Backfill or Porous Granular Embankment. When Porous Granular Backfill or Porous Granular Embankment is used, the plans must clearly show the pay limits. If Porous Granular Backfill is required for a culvert, use District Special Provision "POROUS GRANULAR BACKFILL". If Porous Granular Embankment is required for a box culvert, use District Special Provision "POROUS GRANULAR EMBANKMENT".

Structural Design

Refer to Section 2.1.4 Structure Types and Section 2.3.1 Culvert and Three - Sided Precast Structure Selection Process of the Bridge Manual.

Traffic Control

There are two main types of traffic control for construction of across culverts, road closure at the construction site and stage construction. They have subtypes as follows:

Staging

- **Daytime Operations Only** – Suitable for small culverts with shallow cover. This method of traffic control will require an approval of an exception to Work Zone Safety and Mobility Supplemental Policy, Positive Protection of Workers, Drop-Offs, and Temporary Concrete Barrier: 4-15 from the Bureau of Safety Engineering.
- **24-Hour Flaggers** – May be feasible for operations up to 72 hours. This method of traffic control will require an approval of an exception to Work Zone Safety and Mobility Supplemental Policy, Positive Protection of Workers, Drop-Offs, and Temporary Concrete Barrier: 4-15 from the Bureau of Safety Engineering.
- **Traffic Signals with Temporary Concrete Barriers** – Feasible for most jobs. This does not apply for multi-lanes.

Road Closure

- **Runaround Detour** – Consider for major structures when economical.
- **Marked Route Detour** – Consider when time of closure is short and traffic light to moderate.
- **Median Crossover Detour** – Consider for major structures on multilane roads when economical.

The selection of the type of traffic control must consider the factors mentioned in Chapter 13 of the BDE Manual. In addition, for culvert construction, a few additional items must be considered:

Depth of cover – The deeper the cover over a culvert, the more difficult and expensive stage construction will be. Temporary sheet piling or Temporary Soil Retention System becomes necessary when exposed vertical surfaces are necessary at or near the stage construction line. Also, deeper excavations

affect the time required for construction. Deep excavations are not feasible for Daytime Operations Only. When the total time from start to finish would exceed 72 hours, the option of 24-Hour Flaggers should be avoided. Deep excavations also pose more risk to traffic and usually require Temporary Concrete Barriers to protect traffic.

Skew of crossing – The Designer must lay out the culvert joints along the stage construction line in evaluating stage construction of precast box culverts. As the skew, width, or diameter of precast culvert, and number of barrels increase, the skewed joint area becomes wider and stage construction becomes less feasible.

Temporary Sheet Piling and Temporary Soil Retention System – If required for Stage Construction, then traffic signals and Temporary Concrete Barrier should be used.

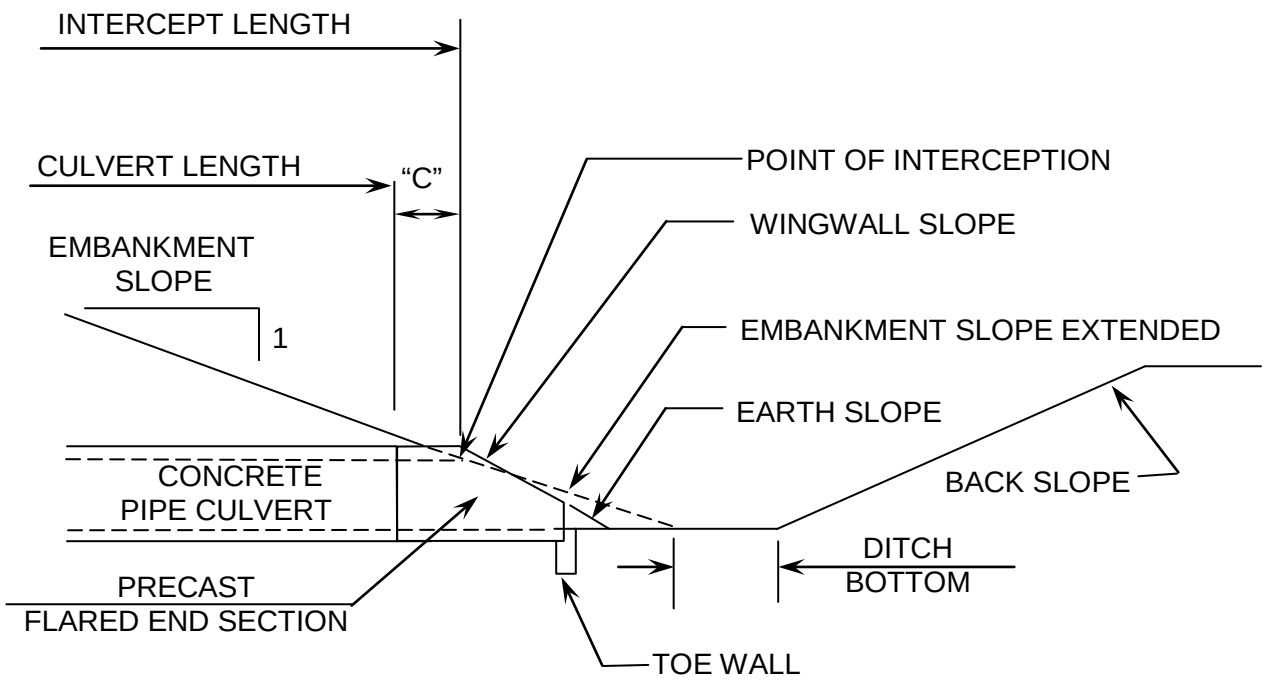
Time Required for Construction – Some culverts, especially precast, can be built very quickly with the road closed. The designer should consider all factors including type of culvert (precast vs. cast-in-place), time duration of construction, and cost of adverse travel. Usually only the barrel portion will have to be in place to reopen the road, with the end treatments being built after traffic restored.

Attach: Culvert Length Sketches; Cases I thru IV

CASE I

Pipe culverts with precast reinforced concrete flared end sections.

The Length to the interception of the embankment with the top, inside of the pipe is calculated. The value of "C" for the end section, from the appropriate highway standard, is deducted from the interception length. This resulting length is then used to determine culvert length.

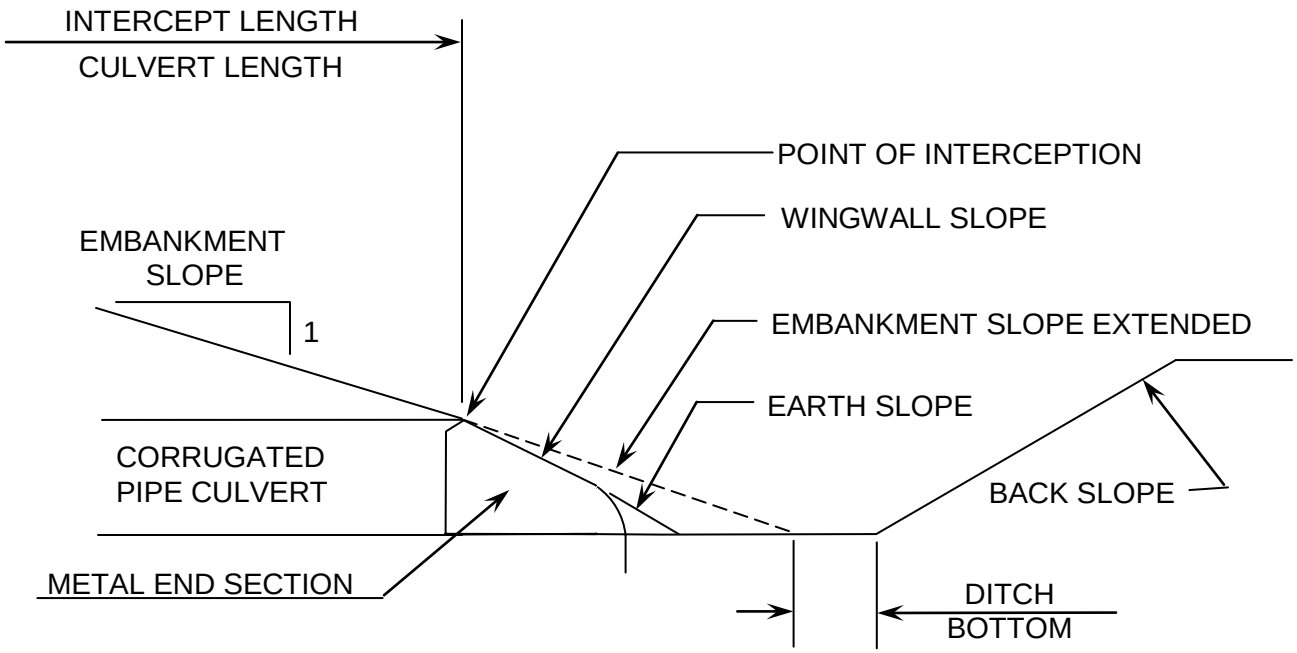


ELEVATION

CASE II

Pipe culverts with metal end sections.

The length of the interception on the embankment slope with the top of the pipe culvert is used to determine culvert length.

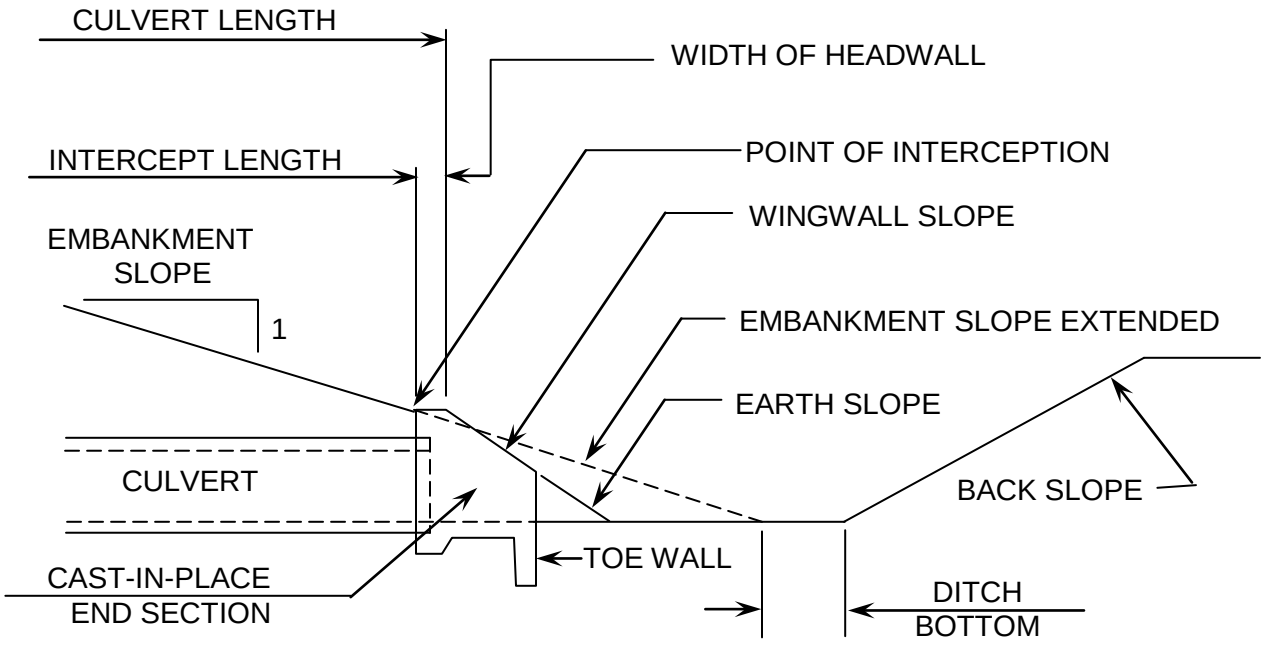


ELEVATION

CASE III

Culverts with cast-in-place end sections.

The length to the interception of the embankment slope with the top, back of the headwalls is calculated. The width of the embankment is added to the interception length.
This resulting length is then used to determine the culvert length.



ELEVATION

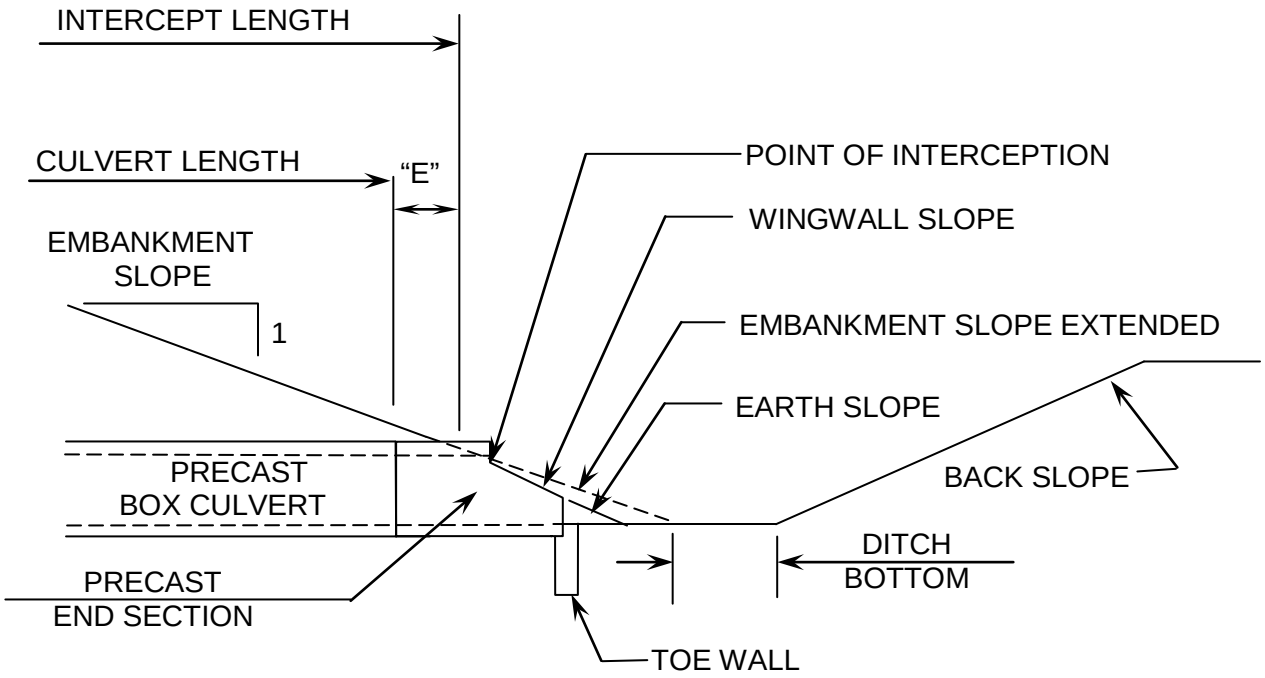
CASE IV

Precast box culverts with precast box culvert end sections (parallel wingwall).

Precast box culvert end sections are not desirable unless they include flared wingwalls that will prevent encroachment of the earth slopes into the culvert opening.

Precast end sections without flared wingwalls should definitely NOT be used if the span is less than twice the rise.

The length of the interception of the embankment slope with the top, inside of the box culvert is calculated. The value “E” from the precast end section detail is deducted from the interception length. This resulting length is then used to determine culvert length.



ELEVATION