

8.4 Design Features

8.4.1 Culvert Sizes and Shape

The culvert size and shape selected shall be based on engineering and economic criteria related to site conditions.

The following minimum sizes shall be used to avoid maintenance problems and clogging:

- 600 mm (24 in) for Interstate Systems, or equivalent for non-circular shapes
- 450 mm (18 in) for other systems, or equivalent for non-circular shapes
- Use arch or oval shapes only if required by hydraulic limitations, site characteristics, structural criteria, or environmental criteria
- Where practical, the minimum height of box culverts should be 1.52 m (5 ft) for inspectability

8.4.2 Multiple Barrels

Multiple barrel culverts shall fit within the natural dominant channel with minor widening of the channel so as to avoid conveyance loss through sediment deposition in some of the barrels. They are to be avoided where:

- the approach flow is high velocity, particularly if supercritical, (These sites require either a single barrel or special inlet treatment to avoid adverse hydraulic jump effects.)
- fish passage is required unless special treatment is provided to insure adequate low flows (commonly one barrel is lowered) See Section 8.5.5.
- a high potential exists for debris problems (clogging of culvert inlet)
- a meander bend is present immediately upstream

8.4.3 Material Selection

The material selection shall consider replacement cost and difficulty of construction as well as traffic delay.

- The material selected shall be based on a comparison of the total cost of alternate materials over the design life of the structure which is dependent upon the following:
 - durability (service life)
 - structural strength
 - hydraulic roughness
 - bedding conditions
 - abrasion and corrosion resistance
 - water tightness requirements
- The selection shall not be made using first cost as the only criteria.
- See Chapter 4, Culvert Repair, Materials, and Structural Design, for discussion of various pipe types and service life.

8.4.4 Culvert Skew

The culvert skew shall not exceed 45° as measured from a line perpendicular to the roadway centerline without the approval of the Hydraulics and Drainage Section. Consider structural impacts of skew. Flexible culverts may need balanced fill.

8.4.5 End Treatment (Inlet or Outlet)

The culvert inlet type shall be selected from the following list based on the considerations given and the inlet coefficient, K_E . (A table of recommended values of K_E is included in Appendix B.) Consideration shall also be given to safety since some end treatments can be hazardous to errant vehicles.

Projecting Inlets or Outlets

- extend beyond the roadway embankment and are susceptible to damage during roadway maintenance and from errant vehicles
- have low construction cost
- have poor hydraulic efficiency for thin materials
- shall include anchoring the inlet to concrete slope paving and toe wall to strengthen the weak leading edge
- are used predominantly with metal pipe

Concrete Headwalls with Bevels

- increase the efficiency of metal pipe
- provide embankment stability and embankment erosion protection
- provide protection from buoyancy
- shorten the required structure length

Improved Inlets

- shall be considered for culverts which will operate in inlet control
- can increase the hydraulic performance of the culvert, but may also add to the total culvert cost, therefore, they should only be used if practicable
- slope-taper shall not be considered where fish passage is required
- could increase downstream flows and velocities

Commercial End Sections

- are available for corrugated metal, high density polyethylene pipe and concrete pipe
- retard embankment erosion and incur less damage from maintenance
- may improve projecting metal pipe entrances by increasing hydraulic efficiency and improving their appearance
- are hydraulically equal to a headwall

Wingwalls

- are used to retain the roadway embankment to avoid a projecting culvert barrel
- are used where the side slopes of the channel are unstable
- are used where the culvert is skewed to the normal channel flow
- provide the best hydraulic efficiency if the flare angle is between 30° and 60°

Aprons

- are used to reduce scour from high headwater depths or from approach velocity in the channel
- shall extend at least two pipe diameters upstream
- shall not protrude above the normal streambed elevation

Mitered Inlets

- are hydraulically more efficient than thin edge projecting
- shall be mitered to match the fill slope
- shall include anchoring the inlet to strengthen the weak leading edge for culverts 1200 mm (48 in) in diameter and larger

Cut-off-Walls

- are generally used as primary protection against piping at culvert inlets and as secondary protection against erosion at culvert outlets (primary outlet protection is designed by the hydraulic engineer)
- shall be used at endwalls and slope paved inlets and outlets as detailed on the Standard Drawings
- shall have embedment depths which comply with the following:
 - 1) for culverts included on Standard Drawings, use dimension shown
 - 2) for culverts not included on Standard Drawings, embed cutoff walls a minimum of 1.2m (4 ft) below the streambed and 0.6m (2 ft) below the bottom of the culvert
 - 3) where riprap is required, the embedment depth should not be less than the thickness of riprap/bedding material

Weep Holes

- may be required to relieve uplift pressure and reduce hydrostatic pressure behind headwalls