Section 4145. Concrete Culvert Pipe

4145.01 GENERAL REQUIREMENTS.

These specifications cover reinforced and nonreinforced concrete pipe intended for construction of culverts, sanitary sewers, and storm sewers. Furnish pipe manufactured according to the contract documents and produced by a plant for which the method of manufacture and the quality of product have been approved by the Engineer.

4145.02 CLASSIFICATION.

A. Furnish concrete pipe according to strength (class). These will be designated as 1500D (Class II), 2000D (Class III), 3000D (Class IV), and 3750D (Class V) (75D, 100D, 150D, and 175D) pipe. These designations indicate the D load (test load in pounds per linear foot of length per foot of inside diameter or Newtons per meter of length per millimeter of inside diameter) to produce the ultimate load specified. Table 4145.02-1 shows the D load and the corresponding class.

Table 4145.02-1: D Load and Corresponding Class

D load-ultimate	Class
1500D (75D)	Class II
2000D (100D)	Class III
3000D (150D)	Class IV
3750D (175D)	Class V

B. Ensure the class, design, date of manufacture, and trademark are plainly marked or stenciled on the inside of the pipe near the tongues no later than 24 hours after fabrication. If a manufacturer operates two or more plants, ensure the markings they use include a separate distinctive designation for each plant. Renew all markings made using paint before the original markings become unreadable. When the strength of pipe is related to its orientation because of design or reinforcement, permanently mark each piece, at least once inside and once outside on opposite walls, to indicate the top.

4145.03 MATERIALS.

~~Comply with the applicable requirements of Division 41~~ Apply Section 2419.

4145.04 DESIGN.

A. For circular pipe, comply with the following for details of the shell, design, and distribution of reinforcement:

- Diameter less than 12 inches (300 mm): AASHTO M 86/M 86M.
- Diameter 12 inches (300 mm) or larger: AASHTO M 170/M 170M.

B. Apply AASHTO M 198 or AASHTO M 315 when circular pipe with gaskets is specified.

C. Apply AASHTO M 206/M 206M when reinforced concrete arch pipe is specified.

D. Apply AASHTO M 207/M 207M when reinforced concrete elliptical pipe is specified.

E. If furnishing AASHTO design pipe, ensure it complies with the following:

- Minimum thickness of any part of the joint no less than 30% of the computed wall thickness
- Length of any part of the joint no less than shown in Table 4145.04-1.

Table 4145.04-1: Minimum Joint Length

Computed Wall Thickness	Minimum Length of Joint
3" (75 mm) or Less	87% of computed wall thickness
3" to 6" (75.1 mm to 150 mm)	75% of computed wall thickness but not less than 2 3/4" (70 mm)
6" to 9" (150.1 mm to 225 mm)	61% of computed wall thickness but not less than 4 1/2" (115 mm)

F. Compute wall thickness based on the following: No more than 1 inch per foot (25 mm per 300 mm) of pipe diameter or equivalent diameter, plus 1 inch (25 mm).

4145.05 STRENGTH.

A. Furnish pipe that has the strength specified for the design used, including both ultimate load and load to produce a 0.01 inch (0.3 mm) crack.

B. Meet the requirements of AASHTO M 170/M 170M for pipe, except the load to produce a 0.01 inch (0.3 mm) crack will not be measured for nonreinforced pipe.

C. All strength tests will be conducted according to AASHTO T 280.

D. The barrel section of aprons shall be 1500D (75D) (Class II) or better for 1500D (75D) (Class II) pipe installations and 2000D (100D) (Class III) or better for 2000D (100D) (Class III) and greater pipe installations.

4145.06 MANUFACTURE.

The term "cast pipe" refers to pipe manufactured by placing concrete of plastic consistency between forms and consolidating it by vibration.

A. General Requirements.

1. Comply with the following:

- Store cement, measure materials, and mix concrete according to the applicable requirements of Article 2301.02, C, 2, 3, and 4.
- Follow the requirements of Article 2301.02, C, 4 for use of ready mixed concrete.
- Obtain the Engineer's approval for use of admixtures.

- Store and handle aggregate to avoid contamination and frequent variations of specified gravity, gradation, and moisture content.
- When cages are to be made by resistance welding, house the reinforcement in a weatherproof building and ensure it is not in contact with the ground. Apply Article 2404.03, A, to reinforcement.

2. The Engineer may also approve procedures for concrete placement at low temperatures based on applicable requirements of Article 2403.03, F, and facilities to be used.

B. Casting Base.
Ensure cast pipe forms rest on a clean, smooth, and level concrete base when the concrete is placed.

C. Construction of Reinforcement Cages.

1. Form welded wire fabric reinforcement cages using a machine designed for this purpose. Construct and operate the machine to produce cages accurately formed to the required shape and dimensions. Either discard reinforcement fabric that has been kinked from tight winding or other causes, or straighten it to the extent that a true shaped cage can be formed from it. Ensure the lengths of all laps of circumferential reinforcement are no less than 40 diameters of the wire. No lap will be required for groove hoop wires in single line pipe.

2. Weld the circumferential wires to hold cages in the desired shape. Circumferential wires may be welded to transverse wires with resistance welds, or circumferential wires may be welded together within the laps by arc welds. If resistance welds are used, construct no less than one weld on each circumferential wire. Distribute these welds alternately between the two transverse wires in the lap, except when normal spacing is such that two transverse wires will not fall within the lap. Ensure these welds do not reduce strength of the wire below 70,000 psi (480 MPa).

3. Ensure arc welds are long enough to hold the wires firmly together and to withstand handling and placing. Reweld all broken welds in cages prior to placing the outside form. Position the weld near the center of the lap. Ensure the strength of the two wires welded together is no less than 70,000 psi (480 MPa), based on the cross sectional area of one wire in square inches (square millimeters). Place a minimum of 1 arc weld per foot (0.3 meter) of length of cage, plus one weld.

4. For 3000D (150D) (Class IV) pipe 54 inches (1350 mm) in diameter and larger, tie inner and outer cages together using clips or other approved methods. If using clips, place in no less than one circumferential row per foot (300 mm) of length of cage plus one. Space each row no more than 8 inches (200 mm) along the outer cage within 45 degrees of the top and bottom of the pipe. Use clips fabricated from no smaller than No. 6 (4.877 mm diameter) wire.

D. Forms.
Use forms that are smooth and true to shape and dimensions and are maintained in good condition.

E. Placing Concrete.
If the concrete is not consolidated during placement using a machine designed for that purpose, then consolidate it by vibration. Apply external vibrators to the forms to prevent denting and deforming the forms.

F. Lift Holes.

1. Pipe may be furnished with lift holes. No more than two lift holes will be allowed. Limit the lift holes to no larger than 2 1/2 inches (65 mm) in diameter. Cast (or form) them in a manner so that there are no breaks of the circumferential reinforcing of single cage reinforced pipe or of the inner cage of double cage reinforced pipe. When practical, bend circumferential wires slightly to provide for the lift holes.

2. Cutting of circumferential wire in lift hole locations will be permitted if the pipe satisfies the 0.01 inch (0.3 mm) crack test requirements of AASHTO M 170/M 170M for the specified strength (class) of pipe.

G. Curing.
Cure pipe using one of the wet methods specified in AASHTO M 170/M 170M or by some other method approved by the Engineer which will:
- Give uniform and consistent curing, and
- Will produce pipe which will meet the strength requirements.

H. Yarding.
Place lines of pipe in storage yards at least 2 feet (0.6 m) apart with both ends of each pipe readily accessible to facilitate inspection.

I. Tongue and Groove.
Ensure the tongue and groove are compatible so that when the pipe is laid, it will be possible for the contractors to comply with Article 2416.03, D, 5.

J. Pipe Connectors.
When pipe connectors are required, use connectors of the design shown in the contract documents or an approved alternate.

K. Special Shapes.
The contract documents may require pieces of special design. If not specified, the strength (class) specified will indicate reinforcement requirements.

4145.07 REJECTION.
In addition to causes for rejection as listed in AASHTO M 170/M 170M or AASHTO M 86/M 86M, failure to meet the requirements specified above is sufficient cause for withdrawing approval of a manufacturer. Withdrawal or approval of a manufacturer may apply to certain specific sizes or to all sizes of pipe.