

**SECTION M.08
DRAINAGE**

M.08.01--Pipe: The pipe for this work shall conform to the following requirements:

1--Cast Iron Pipe: This pipe shall conform to the requirements of AASHTO M 64 for Extra-Heavy Cast Iron Culvert Pipe.

2--Coated Corrugated Metal Pipe and Coated Corrugated Metal Pipe Elbows: This pipe shall conform to the requirements of AASHTO M36, Type 1, Type IR or AASHTO M245, Type 1. For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07. AASHTO M36, Type 1 & IR includes pipe fabricated from zinc-coated steel sheet coated with bituminous material and aluminum-coated (Type 2) steel sheet. AASHTO M245, Type 1 is for pipe fabricated from metallic-coated and polymer-precoated steel sheet.

The corrugation size and sheet thickness shall conform to the following:

<u>Nominal Inside Diameter (mm)</u>		<u>Specified Sheet Thickness (mm)</u>
150	38 X 6.5 mm Corrugations	1.32
200		1.63
250		<u>1.63, 2.01</u>
300		1.63, 2.01
375		1.63, 2.01, 2.77
450		1.63, 2.01, 2.77
525	68 X 13 mm Corrugations	1.63, 2.01, 2.77
600		2.01, 2.77, 3.51
750		2.01, 2.77, 3.51, 4.27
900		2.01, 2.77, 3.51, 4.27
1050		2.77, 3.51, 4.27
1200		<u>2.77, 3.51, 4.27</u>
1350		
1500	75 X 25 mm or	2.01, 2.77, 3.51
1800		2.01, 2.77, 3.51
2100	125 X 25 mm Corrugations	2.77, 3.51, 4.27
2250		2.77, 3.51, 4.27
2400		2.77, 3.51, 4.27

<u>Nominal Inside Diameter (mm)</u>		<u>Specified Sheet Thickness (mm)</u>	
		<u>Steel</u>	<u>Aluminum</u>
450		1.63, 2.01	1.52, 1.91
600		1.63, 2.01	1.52, 1.91
750		1.63, 2.01	1.52, 1.91
900		1.63, 2.01	1.91, 2.67
1050		2.01, 2.77	2.67, 3.43
1200	Helical Rib 19 X 19 X 190 mm	2.01, 2.77	2.67, 3.43
1350		2.01, 2.77	2.67, 3.43
1500		2.77	3.43
1650		2.77	3.43
1800		2.77	3.43
1950		2.77	3.43
2100		2.77	3.43

Aluminum pipe sheet thickness shall be 100 µm less than specified above for 38 x 6.5 mm, 68 x 13 mm, and 75 x 25 mm corrugations. Helical Rib shall be as specified above.

Unless otherwise specified, the lightest sheet thickness listed for a specified diameter may be furnished.

The pipe and pipe elbows conforming to the requirements of AASHTO M36 shall be coated with bituminous material as specified in AASHTO M190 Type C. Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material or paved invert.

The pipe and pipe elbows conforming to the requirements of AASHTO M245 shall be coated as specified in AASHTO M246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Coupling bands shall conform to the requirements of AASHTO M36 or M245, whichever is applicable. All coupling bands shall be coated with material conforming with AASHTO M190 or in conformance with M246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) pipe do not require a coating of bituminous material.

Only one type of coating will be allowed for any continuously connected run of pipe.

If elongation of the pipe is required, it shall be done by one of the following methods:

Shop Strutting: The pipe shall be elongated by the manufacturer, after fabrication, by reducing the horizontal diameter three percent and increasing the vertical diameter three percent, and held in the elongated shape by means of rod, all in accordance with this specification.

The rods shall be 16 mm diameter, threaded 180 mm at both ends with washers and nuts. The length of the rods shall be the diameter of the pipe plus 203 mm. The rods shall be placed on the horizontal axis of the pipe on 610 mm spacing and located at the halfway point between the circumferential riveting.

A soft wood block 50 mm X 100 mm and 300 mm long shall be placed over the rods at each end to provide contact against the outside of the pipe. The long dimension of the blocks shall be parallel with the horizontal axis of the pipe in order to prevent distortion of the pipe when the nuts are tightened.

The three percent elongation shall be obtained by tightening on rods uniformly from end-to-end of the pipe, obtaining approximately one-quarter of the required elongation each time through the length of the pipe.

The strutting rods shall be left in the pipe until the fill is completed and well compacted, unless for some unusual condition their removal is ordered by the Engineer.

The rods shall be removed by the Contractor by cutting them from the inside of the pipe flush with the sidewalls, and a coating of bituminous material shall be applied to protect the metal of the pipe where it has been exposed.

A tolerance of 1 percent of the pipe diameter in the elongation will be permitted.

(b) Mechanical Elongation: The manufacturer shall elongate the pipe by increasing the diameter along the vertical axis by approximately 5 percent with a corresponding decrease along the horizontal axis by mechanical means in which sufficient pressure is applied to the sides of the pipe after fabrication to produce the specified distortion. The elongation shall be maintained by drilling holes in the ends of sections and placing horizontal wires. The wires shall be removed after the pipe sections have been placed, coupling bands installed and backfill placed.

3--Perforated or Plain Coated Metal Pipe for Underdrains or Outlets: This pipe shall conform to the requirements of AASHTO M36, Type III or AASHTO M245, Type III. The specifications are further supplemented by the following: For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07.

(a) Perforations: The minimum diameter of 6.5 mm for the perforations shall apply after asphalt coating. Pipe to be used for outlets shall not be perforated.

(b) Coating: The pipe conforming to the requirements of AASHTO M36 shall be coated to the requirements of AASHTO M190, Type A, except the thickness shall be 0.75 mm instead of 1.25 mm. Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material.

The pipe conforming to the requirements of AASHTO M245 shall be coated as specified in AASHTO M 246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Coupling bands shall conform to the requirements of AASHTO M36 or M245, whichever is applicable.

All steel coupling bands shall be coated with material conforming with AASHTO M190 or in conformance with M246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) do not require a coating of bituminous material.

Only one type of coating will be allowed for any continuously connected run of pipe.

Sheet thickness shall conform to Subarticle M.08.01-2

4--Coated Corrugated Metal Pipe-Arches: These pipe-arches shall conform to the requirements of AASHTO M36, Type II, Type IIR or AASHTO M245, Type II. The corrugation size and sheet thickness shall conform to the following: For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07.

<u>Pipe-Arch Size (mm)</u>	<u>Equivalent Diameter (mm)</u>		<u>Pipe-Arch Specified Sheet Thickness (mm)</u>
430 X 330	375		1.63
530 X 380	450		1.63
610 X 460	525		1.63
710 X 510	600		2.01
885 X 610	750		2.01
1060 X 740	900	68 X 13 mm	2.77
1240 X 840	1050	Corrugations	2.77
1440 X 970	1200		2.77
1620 X 1100	1350		3.51
1800 X 1200	1500		3.51
1800 X 1200	1500		4.27
1670 X 1300	1500	75 X 25 mm	2.01
1850 X 1400	1650	or	2.01
2050 X 1500	1800	125 X 25 mm	2.77
2200 X 1620	1950	Corrugations	2.77
2400 X 1720	2100		2.77
2600 X 1820	2250		2.77
2840 X 1920	2400		2.77
500 X 410	450		1.63
580 X 490	525		1.63
680 X 540	600		1.63
830 X 670	750	19 X 19 X 190 mm	2.01
1010 X 790	900	Helical Rib	2.01
1160 X 920	1050		2.77
1340 X 1050	1200		2.77
1520 X 1170	1350		2.77
1670 X 1300	1500		2.77

Unless otherwise specified, the lightest sheet thickness listed for a specified diameter may be furnished.

Pipe-arches conforming to the requirements of AASHTO M36 shall be coated with bituminous material as specified in AASHTO M190, Type C. Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material or paved invert.

Pipe-arches conforming to the requirements of AASHTO M245 shall be coated as specified in AASHTO M246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Only one type of coating will be allowed for any continuously connected run of pipe arch.

Coupling bands shall conform to the requirements of AASHTO M36 or M245, whichever is applicable. All coupling bands shall be coated with material conforming with AASHTO M190 or in conformance with M246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) pipe arches do not require a coating of bituminous material.

5--Corrugated Structural Plates and Bolts: These plates and bolts are for use in the construction of metal pipe of the large diameter and for metal plate arches or pipe arches to be assembled in the field, and they shall conform to the requirements of AASHTO M 167 for corrugated metal pipe. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07. The plates shall have not less than the minimum gage shown on plans, which shall provide with the corrugations a section modulus not less than that specified.

The dimensions of plates and details of fabrication shall conform to the requirements of the manufacturer. Where the plans call for a heavier gage for the bottom of the pipe than for the remainder of the pipe circumference, the lower fourth of the circumference shall be the minimum width of the heavier gage material.

The coating shall conform to the requirements of AASHTO M243.

6--Reinforced Concrete Pipe: Unless otherwise specified, this pipe shall conform to the requirements of AASHTO M170, Class IV, as supplemented and modified by the following:

(a) **Reinforcement:** In circular pipe, only circular reinforcement will be allowed.

(b) **Laps and Welds:** The reinforcement shall be lapped not less than 51 mm and welded with an electric welding machine.

(c) **Quality Assurance Testing:** Circular and elliptical reinforced concrete pipe shall be tested by the three-edge bearing method prescribed in AASHTO T 280, except as follows:

- 1) Modified or special design pipe shall be tested to the 0.3-mm load and the ultimate load requirements as per AASHTO M 170 and M 207.
- 2) At the discretion of the Engineer, pipe of standard design, as specified in AASHTO M 170 and M 207, may be tested to the 0.3-mm requirement plus ten percent additional load in lieu of ultimate load testing. Test pipe attaining an 0.3-mm crack will not be acceptable for use on CDOT projects.
- 3) Cores for absorption and determination of steel reinforcement shall be taken on a random basis as determined by the Engineer. The cores shall be at least 150 mm in diameter.

(d) **Inspection:** The pipe plant, materials, processes of manufacture and the finished pipe shall be subject to inspection and approval by the Department. The pipe manufacturer's records related to component materials, production and shipment of pipe for Department use shall be made available to the Department on request. The equipment and labor necessary for inspection, sampling and testing as required by the Department shall be furnished by the pipe

manufacturer. Test equipment shall be calibrated at least once each 12 months, or as directed by the Engineer. The plant cement and aggregate scales shall be inspected and sealed by the approved agency at least once every twelve months.

(e) Preliminary Tests and Tests for Extended Deliveries: As directed by the Engineer, the Department shall select for test from the stock of any manufacturer proposing to supply pipe to the Department two (2) of each size pipe up through 750 mm diameter and one (1) of each size greater than 750 mm diameter. These sample pipes shall be tested under Department supervision by the three-edge bearing method. Absorption tests shall be made on each size, wall thickness, and class of pipe meeting the three-edge bearing load requirements.

Frequency for extended deliveries shall be one three-edge bearing test for each 500 pipe shipped to Department projects.

For pipe that fails, it shall be necessary for the manufacturer to either physically isolate the rejected pipe at his plant or to provide some means to clearly indicate the unacceptability of the pipe. Either method shall be performed to the satisfaction of the Engineer. When production is resumed on any size, wall thickness or class previously rejected, preliminary tests shall be required. Moreover, the frequency of tests for extended deliveries shall be one three-edge bearing test for each 200 pipe shipped to Department projects.

If 95 percent of all pipe tested at a particular plant from the first of the calendar year to September 30 meet specifications, including both preliminary and extended tests, it will not be necessary to perform the Fall three-edge bearing tests at this plant.

Use of compression tests on representative cylinders or cores to determine the compressive strength of the concrete incorporated into the pipe products will be at the discretion of the Engineer.

(f) Shipping: Pipe shall not be shipped until it is at least 7 days old unless earlier shipment is authorized by the Engineer on the basis of tests.

(g) Certification: Pipe will be accepted by the Department on the basis of manufacturer's certification. The manufacturer shall certify each shipment of pipe on Department Form MATP.C.-1, "Certification of Precast Concrete Products." Two (2) copies of this certification shall be furnished with the shipment to the Engineer at the project site.

7--Plain and Perforated Concrete Drain Pipe: The materials entering into the construction of this pipe shall be the same as described hereinbefore under Reinforced Concrete Pipe, except that the pipe shall not be reinforced.

Workmanship, variations in dimensions, marking, curing, shipping, test specimens, and inspection shall be the same as that specified for reinforced concrete pipe described above.

(a) Wall Thickness: The wall thickness of concrete drain pipe shall not be less than 19 mm.

(b) Perforations: The perforations shall be 6.5 mm clear opening. The number and location of longitudinal rows of perforations shall be as shown on the plans. Unless otherwise specified, the pipe shall be 152 mm minimum inside diameter.

(c) Absorption Tests: Absorption testing shall be performed in accordance with the requirements of AASHTO T 280 and M 170.

8--Plain and Perforated Vitrified Clay Pipe: This pipe shall conform to the requirements of AASHTO M 65 for pipe of full circular cross-section as supplemented by the following requirements:

Pipe for use under pavements and shoulders shall be extra-strength pipe. Outside of these areas, standard-strength pipe may be used.

Unless otherwise specified, the pipe shall be 152 mm minimum in diameter.

9--Reinforced Concrete Elliptical Pipe: This pipe shall conform to the requirements of AASHTO M 207, Class HE IV and supplemented as follows:

(a) Manufacturing and testing shall conform to Articles M.08.01-6.

10--Slotted Reinforced Concrete Pipe for Underdrain and Outlets: This pipe shall conform to the requirements of Article M.08.01-6 and shall be slotted in accordance with AASHTO M175, Type 2 or as shown on the plans.

The pipe for outlets shall not be slotted.

11--Slotted Drain Pipe: The pipe shall be asphalt coated and conform to Subarticle M.08.01-2. Concrete shall conform to Article M.03.01, Class "A" or pavement type. Concrete shall be cured in conformance with M.03.01. The inlet aperture shall be longitudinal on top of the pipe and may be continuous or intermittent. The opening in the pipe wall may be fabricated in the form of continuous bar risers and spacers or of intermittent cut-out segments with structural members supporting a continuous grating as indicated in the plans. End caps shall be as provided by the manufacturer.

Elastomeric polymer sealer shall meet the physical requirements of either FS SS-S-195B or ASTM D3406 and be accepted on manufacturer's certification.

The pipe shall be helically corrugated with a continuous welded or lock seam. Pipe ends shall have two (2) rolled annular corrugations on each end for jointing.

Bar Riser and Spacer Type: Riser assemblies shall be fabricated from structural steel, in accordance with the dimensions on the plans. The riser assemblies shall be hot dipped galvanized according to ASTM A-123. The assemblies shall be welded to the corrugated pipe on each side of the riser at the location of the solid web spacers. The riser shall terminate 25 mm from the ends of each pipe length to allow clearance for single bolt coupling bands. The ends of the riser shall be closed with a suitable welded plate where solid web spacers do not come to the ends of the riser.

The maximum deviation from straight in both the vertical and horizontal plane of the riser assembly shall not exceed 19 mm in a 6 m length.

Continuous Grating Type: The cut-out pipe segments shall provide a 50 mm wide slot of maximum length between the lock seams. The slot shall be left intact 25 mm on each side of the lock seam and this material shall be utilized to fasten the reinforcing bar in place.

A bent epoxy coated reinforcing bar shall cross the slotted opening on 150 mm centers. The reinforcing bar shall be an ASTM A615, No. 13 deformed bar epoxy coated with 7 mils of fusion bonded epoxy powder conforming to AASHTO M284.

Grating shall be furnished unless noted in the contract documents. Grating and all bearing bars, cross bars, and bent connecting bars shall be welding quality, mild carbon steel conforming to ASTM A569 and to the dimensions shown on the plans.

Tie down bolts shall be J-Type bolts, plated, ASTM A307 steel supplied with self-locking nuts.

Concrete forms shall be of cellular foam plastic base, fabricated as an integral part of the pipe and reinforcing bar assembly. The form shall be capped with a thick wood or plastic cap resting on top of the foam plastic and reinforcing bar.

The maximum deviation from straight in both the vertical and horizontal plane of the completed assembly shall not exceed 19 mm in 6 m length. All grating and hardware shall be galvanized in conformance with Article M.06.03. Expansion joint filler shall conform to M.03.01-5(B).

12--Vacant

13--Porous Concrete Pipe for Underdrains and Outlets: This pipe shall conform to the requirements of AASHTO M176, except that the minimum laying length shall be 610 mm.

14--Corrugated Aluminum Pipe: This pipe shall conform to the requirements of AASHTO M196 Type I or Type IR. Sheet thickness shall conform to the requirements of M.08.01-2. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07.

15--Corrugated Aluminum Pipe for Underdrains and Outlets: This pipe shall conform to the requirements of AASHTO M196 Type III or Type IIIR. Sheet thickness shall conform to the requirements of M.08.01-2.

Pipe for outlets shall not be perforated.

16--Corrugated Aluminum Pipe Arches: These pipe arches shall conform to the requirements of AASHTO M196 Type II or Type IIR. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07.

Sheet thickness shall conform to the requirements of M.08.01-4.

17--Vacant

18--Cold-Applied Bituminous Sealer: This material, for use in sealing of joints in concrete and vitrified clay pipes, shall be free of asbestos and shall meet the following requirements:

	Min.	Max.
Penetration, 25°C, 150 gm., 5 sec., with cone, dmm (FS SS-R-406, Method 223.12)	175	300
Loss on Heating, 163°C, 5 hrs., 50 gm. (AASHTO T47)	—	10
Total Bitumen, Benzene (AASHTO T44), %	40	—
Inorganic Content (Ash) (AASHTO T111), %	15	50

It shall be of such consistency that it may be spread on the joints with a trowel when the temperature of the air is between -7° C and 38° C. The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal, and shall not flow, crack or become brittle when exposed to the atmosphere.

Unless otherwise specified, sampling shall be done in accordance with AASHTO T 40.

The bituminous sealer shall be delivered to the project in suitable containers for handling, and shall be sealed or otherwise protected from contamination. The container shall show the brand name, net mass or volume, and the requirements for application.

19--Preformed Plastic Gaskets: This material for use in sealing of joints in concrete and vitrified clay pipe shall conform to the requirements of FS SSSS00210 (G.S.A.--F.S.S.)

20--Flexible, Watertight, Rubber-Type Gaskets: This material for use in sealing concrete pipe joints shall conform to the requirements of AASHTO M 198.

21--Bedding Material: This material shall be sand or sandy soil, all of which passes a 9.5 mm sieve, and not more than 10 percent passes a 75 µm sieve.

When ground water is encountered the Engineer may allow No. 6 stone conforming to Article M.01.01 to be used instead of sand or sandy soil.

22--Reinforced Concrete Culvert End: The barrel shall conform to the requirements of AASHTO M 170, Class II, except that the three-edge bearing tests will not be required. The flare shall be of the same thickness and materials as the barrel, and shall have steel reinforcement equaling or exceeding the amount shown on the table for the pertinent size.

Tongues and grooves shall be compatible with tongues and grooves of pipe meeting AASHTO M 170, Class IV.

Air entrainment shall be added to these units so as to maintain 5 to 8 percent entrained air.

23--Metal Culvert End: The materials used in this work shall meet the pertinent requirements of Articles M.08.01-2 and M.08.01-4.

Bolts and fittings shall conform to the requirements of ASTM A 307 and shall be galvanized to conform to the requirements of ASTM A 153.

The units shall be coated as specified in Articles M.08.012, M.08.01-4 or M.08.01-5.

Fabrication: These units shall be formed from a rectangular sheet of metal by cutting and bending to form the desired shape. Two or more sheets may be fastened together by riveting or bolting so as to form a rectangular sheet of the required width. Skirt extensions and a top plate, as needed to complete the unit, shall be separately formed. Skirt extensions shall be riveted or bolted to the skirt.

All edges which will be exposed above the surface of the ground shall be reinforced before forming the unit by either of the following means:

(1)--The edge shall be bent to form a semicircular roll with an exterior diameter of 25 mm, as shown in the detail drawing on the plans.

(2)--A split tube of 25 mm outside diameter and not lighter than 14 gage, shall be slipped over a row of rivets spaced not more than 152 mm apart, as shown in the detail drawing on the plans.

One corrugation, matching the corrugations of the pipe or pipe-arch to which the unit is to be attached, shall be formed in the unit to insure secure and accurate alignment.

Attachment: The unit may be shop-riveted to a length of the appropriate pipe or pipe-arch, or may be field attached to the pipe or pipe arch by either of the other attachment systems shown on the plans, or by other means acceptable to the Engineer. If the unit is shop-riveted to a length of pipe or pipe-arch, this length shall be sufficient to permit proper use of standard coupling bands.

24--Vacant

25--Corrugated Polyethylene Pipe: Corrugated Polyethylene Pipe, either corrugated interior surface (Type C) or smooth interior surface (Type S) without perforations or with perforations (Type CP or SP), shall conform to AASHTO M252 or M294. Type D pipe shall have a smooth interior surface braced circumferentially or spirally with projections or ribs joined to a smooth outer wall. Both surfaces shall be fused to, or be continuous with, the internal supports. Type D shall conform to AASHTO M 294.

26--Geotextile: The geotextile shall be nonrotting, acid and alkali resistant and have sufficient strength and permeability for the purpose intended, including handling and backfilling operations. Fibers shall be low water absorbent. The fiber network must be dimensionally stable and resistant to delamination. The geotextile shall be free of any chemical treatment or coating that will reduce its permeability. The geotextile shall also be free of any flaws or defects which will alter its physical properties. Torn or punctured geotextiles shall not be used. For each specific use, only geotextiles which are already on the Connecticut Department of Transportation's Geotextile Approved list for the geotextile type will be used. The Engineer reserves the right to reject any geotextile which he deems unsatisfactory for a specific use. The brand name shall be labeled on the geotextile or the geotextile container. Geotextiles which are

susceptible to damage from sunlight or heat shall be so identified by suitable warning information on the packaging material.

Geotextiles susceptible to sunlight damage shall not be used in any installations where exposure to light will exceed 30 days, unless specifically authorized in writing by the Engineer.

27--Polyvinyl Chloride Plastic Pipe: The pipe shall conform to the requirements of ASTM D 1785. Couplings and elbows shall conform to the requirements of ASTM D 2466 or D 2467.

28--Polyvinyl Chloride Gravity Pipe: This pipe shall conform to one of the following specifications: ASTM F789, ASTM F679 or ASTM F794.

This pipe shall require a certificate of compliance and a materials certificate in conformance with Article 1.06.07.

M.08.02--Catch Basins, Manholes and Drop Inlets: The materials to be used in the construction shall be those indicated on the plans or ordered by the Engineer, and they shall conform to the requirements of these specifications.

1--Brick for Catch Basins, Manholes or Drop Inlets: Brick for catch basins, manholes or drop inlets shall conform to the requirements of AASHTO M 91, Grade SM, except that the depth shall be 57 mm, the width 92 mm and the length 203 mm, and except that the maximum water-absorption by 5-hour boiling shall not exceed the following limits:

Average of 5 bricks	15 percent
Individual brick	18 percent

2--Concrete Building Brick for Catch Basins, Manholes or Drop Inlets: Concrete building brick for catch basins, manholes or drop inlets shall conform to the requirements of ASTM C 55, Grade S II.

3--Masonry Concrete Units for Catch Basins, Manholes or Drop Inlets: Masonry concrete units for catch basins, manholes or drop inlets shall conform to the requirements of ASTM C 139.

4--Precast Units for Drainage Structures: Precast units for drainage structures may be used except where particular conditions require building or casting in place. Precast manholes shall conform to the requirements of AASHTO M199 (ASTM C478).

Precast catch basins and drop inlets shall conform to the requirements of AASHTO M 199 (ASTM C478), except as modified by the following:

- a. All materials used for concrete shall conform to the requirements of Section M.03.
- b. The 28-day compressive strength of the concrete shall be a minimum of 21 MPa.

Type I or II, or IS or III cement with air-entraining additives, or Type IA or IIA or IS-A or IIIA cement may be used.

The concrete shall contain not less than four nor more than seven percent entrained air. Water-absorption of individual cores taken from precast units shall be not more than seven percent.

Reinforcement shall conform to the requirements of Article M.06.01.

The manufacturing plant, the quality of materials, the process of manufacture and the finished precast unit shall be subject to inspection and approval by the Department.

The units shall be cast in substantial permanent steel forms so constructed that no overall dimension of a casting shall vary more than 6.4 mm over and under the specified dimension, and so that the frame for the inlet grate is in the desired position in the completed unit.

Suitable provision shall be made in precasting the units for convenient handling of the completed casting, and additional reinforcement steel shall be provided to allow for such handling in the casting yard and during transportation and placing. Each completed unit shall be identified with the name of manufacturer and date of the concrete pour from which it was cast, either by casting this information into an exposed face of the unit or by suitable stencil. Forms shall not be removed until 24 hours after placing of concrete. The precast units shall be cured in accordance with AASHTO M 170, except that liquid membrane-forming compounds for curing concrete shall not be used in curing the precast tops of catch basins or drop inlets. Upon completion of the curing, all surfaces of the top units of catch basins and drop inlets shall be given an application of protective compound material, conforming to Article M.03.01-11, at the rate of 0.2 L/m².

For each day's production of precast units, the manufacturer shall mold, cure and test one set of four standard cylinders, or cylinders compacted in a similar manner to the parent precast units, for the purpose of determining the compressive strength of the concrete incorporated into the precast units. Concrete used in molding the cylinders shall be representative of the concrete incorporated into the precast units during the production period. Cylinders shall be molded in accordance with AASHTO T 23, cured by the same method as the units they represent, and tested as prescribed in AASHTO T 22. A compression test will be performed on two (2) cylinders seven (7) days after casting. If the average compressive strength is not less than that required and no individual cylinder is less than 90 percent of the required compressive strength, the precast units represented by these cylinders will be acceptable for use at 7 days of age.

If the strength requirement is not met in the first test, a second test will be performed on one cylinder at 14 days; and provided the minimum strength is achieved, the units will be acceptable for use as of that date. Should the second test fail, a third compression test will be performed on the fourth cylinder at 28 days after casting; and the units will be acceptable for use at that time if the minimum strength requirement is met. If the strength requirements are not met in the 28-day test, all precast units of the production period will be rejected.

In lieu of cylinders, the manufacturer may, with the permission of the Department, perform compression tests on 100 mm cores drilled from the walls of appropriate precast units to determine the compressive strength of the concrete. Cores shall be obtained and tested in accordance with AASHTO T 24.

The manufacturer shall determine the air content of the concrete used in the day's production of precast units by performing tests as prescribed in AASHTO T 152 on representative samples.

The equipment and personnel necessary to perform the required testing shall be furnished by the manufacturer and approved by the Department. All testing equipment shall be calibrated at least once each twelve (12) months or as directed by the Engineer. The manufacturer shall maintain records relative to the production, testing and shipment of precast units supplied to the Department. Said records shall be available to a representative of the Department upon his request.

The Department shall accept precast concrete units on the basis of manufacturer's certification. The manufacturer shall certify each shipment of precast concrete units on Department Form MAT PC-1, "Certification of Precast Concrete Products." Two (2) copies of this certification shall be furnished with the shipment to the Engineer at the project site.

Precast units that are cracked, show evidence of honeycomb, or have over ten (10) percent of their surface area patched, shall be subject to rejection, even though meeting other requirements.

At such time as may be requested, the manufacturer shall furnish and deliver to the Laboratory, free of any charge, a complete unit for coring and absorption test purposes. A maximum of two such units per year will be requested except that for each failure in the test, an additional unit shall be furnished.

5--Metal for Drainage Structures: Metal for catch basin, drop inlet and manhole frames, extensions, covers and gratings shall be cast iron, cast steel, structural steel or malleable iron conforming to the requirements of the plans. Covers and gratings shall bear uniformly on their supports.

Extensions shall be designed so that the existing manhole cover or catch basin grate, when set in place, will have substantially the same bearing, fit and load carrying capacity as in the existing frame. The extension shall be designed to fit into the original frame, resting specifically on the flange and rim area. The extension shall accept the existing cover or grate so that the cover or grate is seated firmly without movement.

Ladder rungs for manholes shall conform to AASHTO M199 (ASTM C478). Those portions of aluminum ladder rungs embedded in concrete shall be given one coat of zinc chromate paint conforming to FS TT-P645 or equivalent.

Cast iron shall conform to the requirements of AASHTO M 105, Class 25 for the frames and Class 30 for grates.

Cast steel shall conform to the requirements of ASTM A 27, Grade optional, and shall be thoroughly annealed.

Structural Steel shall conform to the requirements of ASTM A 36, or A 283, Grade B or better, as to quality and details of fabrication, except that in the chemical composition of the steel, the two-tenths of one percent of copper may be omitted.

Malleable iron shall conform to the requirements of the specifications of ASTM A 47, Grade 22010.

The materials and method of manufacture for drop inlets shall conform to the requirements as stated on the plans or as ordered.

M.08.03--Aggregates for Underdrains: Materials for filling the trench shall consist of well-graded, clean, non-plastic sands or well-graded, clean, durable broken stone or screened gravel. The type of material to be used shall be sand, unless otherwise called for by the contract documents or ordered by the Engineer.

1--Broken Stone or Screened Gravel: This material shall conform to the gradation requirements for Size No. 8 under Article M.01.01.

2--Sand: This material shall be a commercial product and shall meet the requirements of Article M.03.01.-2.