paint, corrosion and rust. Surface to be repaired shall be blast-cleaned to SSPC-SP 10 (near white).

Where circumstances do not allow blast or power tool cleaning to be used, then hand tools may be used. Cleaning shall meet SSPC-SP 2, the removal of loose rust, mil scale or paint to the degree specified, by hand chipping, scrapping, sanding and wire-brushing. Surface preparation shall extend into the undamaged galvanized coating. Spray using a non-aerosol spray, or brush-apply the paint to the cleaned areas with 2 coats of organic zinc repair paint meeting Article 1080-9. Ensure that the total thickness of the 2 coats is not less than 3 dry mils. Allow adequate curing time before subjecting repaired items to service conditions in accordance with the manufacturer's printed instructions.

Application conditions shall be 40°F Air/Steel temperature and rising, steel temperature shall be 5°F above the dew point and relative humidity shall be 85% or less. Follow paint manufacturers recommendation if more restrictive than above requirements.

Follow paint manufacturers written instructions on storage temperatures, mixing application, continuous agitation and pot life. No thinners are to be used when applying organic zinc repair paint by brush or roller.

Instead of repairing by painting with organic zinc repair paint, other methods of repairing galvanized surfaces that are abraded or damaged are allowed provided the proposed method is acceptable to the Engineer.

Excessive damage to galvanized surfaces as determined by the Engineer is cause for rejection. Replace or re-galvanize rejected galvanized material.

SECTION 1077
PRECAST CONCRETE UNITS

1077-1 GENERAL

Use precast concrete units from sources participating in the Department's Precast Concrete QC/QA Program. A list of participating sources is available from the Materials and Tests Unit. The Department will remove a manufacturer of precast concrete units from this program if the monitoring efforts indicated that non-specification material is being provided or test procedures are not being followed.

This section covers the materials for and the production of precast reinforced concrete units produced in accordance with the contract. Where precast reinforced concrete circular manhole sections are used, they shall meet AASHTO M 199.

1077-2 PLAN REQUIREMENTS

The plans for precast units will be furnished by the Department in the *Roadway Standard Drawings* or details shown in the project plans.

When the Department does not make precast plans available and the Contractor chooses to precast, submit drawings to the Engineer for the items proposed to precast. Submit one complete set of drawings for review, at least 40 calendar days before beginning production. After acceptance, submit seven complete sets of drawings. Acceptance by the Engineer of contractor drawings will not be considered as relieving the Contractor of any responsibility for precast units. When precast units are load bearing and require structure design, have the plans prepared and certified by an engineer licensed by the State of North Carolina. Contractor furnished drawings shall show complete design, installation and construction information in such detail as to enable the Engineer to determine the adequacy of the proposed units for the intended use. Contractor drawings shall include details of steel reinforcement size and placement and a schedule that lists the size and type of precast units at each location where the precast units are to be used. Produce precast units in accordance with the approved drawings.

1077-3 MATERIALS

Refer to Division 10.

Item	Section
Air Entraining Agent	1024-3
Chemical Admixtures	1024-3
Coarse Aggregate	1014-2
Curing Agents	1026
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Miscellaneous Metals	1074
Portland Cement	1024-1
Reinforcing Steel	1070
Silica Fume	1024-7
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Water	1024-4

1077-4 INSPECTION

The Department reserves the right to place a duly authorized inspector in the plant at any time work related to the production of units for the Department is being performed. Notify the Engineer at least 7 days in advance when such work is scheduled to begin.

Provide an office area for the inspector of at least 50 sf with desk, chair, telephone, facilities for proper heating and cooling, adequate lightning and electrical outlets.

Acceptance of precast units will be on the basis of tests of materials, compression tests on concrete cylinders and inspection of the finished units, including amount and placement of steel reinforcement, to determine their conformance with the approved dimensions and design and their freedom from defect. The inspector will have the authority to reject any or all units not manufactured in accordance with these specifications. Any unit found to be defective in any manner at any time will be rejected and replaced by an acceptable unit or repaired in a manner approved by the Engineer.

(A) Storage

Store all Department units in a separate area on the yard. Store all units on a solid, unyielding foundation free of standing water or in a manner directed by the Engineer. Do not stack units before inspection.

(B) Transporting

Do not transport units away from the casting yard until the concrete has reached the minimum required 28 day compressive strength and a period of at least 5 days elapses after casting, unless otherwise permitted by the Engineer.

Do not transport any unit from the plant to the job site before the approval of that unit by the plant inspector. Such approval is stamped on the unit by the plant inspector.

1077-5 PORTLAND CEMENT CONCRETE

(A) Composition and Design

Portland cement concrete is composed of Portland cement, coarse aggregate (#67 or 78M), fine aggregate, water and unless otherwise permitted by the Engineer, an air entraining agent. If other cementitious materials and/or chemical admixtures are used, use these materials in the proper proportions to obtain the optimum effect. Do not use calcium chloride or other admixtures containing calcium chloride.

Supply concrete that develops a minimum compressive strength as shown in Table 1077-1 unless other strengths are designated on the approved drawings. When required, air entrain concrete to provide an air content of 4.5% ± 1.5%. Supply concrete with a maximum slump of 3.5 inches unless a high range water reducer (super plasticizer) is approved by the Engineer. Do not use concrete with a slump exceeding 6 inches. As an option, reduce the cement content of the mix design by up to 20% and replace with fly ash at a rate of 1.2 lbs. of fly ash for each pound of cement replaced or reduce the cement content up to 50% and replace with blast furnace slag on a pound for pound basis.

TABLE 1077-1 PRECAST CONCRETE STRENGTH REQUIREMENTS AT AN AGE OF 28 DAYS		
Precast Units	**Requirement**	**Specification Reference**
BARRIER:		
Portable	4,500 psi	Sect. 854, 1090 and 1170
Permanent	4,500 psi	Sect. 854, 857 and 1090
CULVERTS:		
Circular Pipe	4,000 psi	Sect. 310, 1032, 1034, 1520 and AASHTO M 170
Single Cell Box Sections	5,000 psi	Contract and AASHTO M 259
Pipe Tees	4,000 psi	Sect. 310, 1032 and AASHTO M 170
Pipe Elbows	4,000 psi	Sect. 310, 1032 and AASHTO M 170
Cross & Parallel Special End Sections	3,500 psi	Sect. 310 and 1032
DRAINAGE STRUCTURES:		
Boxes (Solid & Waffle)	4,000 psi	Sect. 840 and ASTM C913
CIRCULAR MANHOLES:		
Base	4,000 psi	Sect. 1525 and AASHTO M 199
Riser Section	4,000 psi	Sect. 1525 and AASHTO M 199
Top Section	4,000 psi	Sect. 1525 and AASHTO M 199
Grade Ring	4,000 psi	Sect. 858 and AASHTO M 199
WALLS AND PANELS:		
Wing, Head & End Walls	4,000 psi	AASHTO T 23
Precast Retaining Wall (PRW) Units	4,000 psi	Contract
Precast Retaining Wall Coping	3,000 psi	Contract
Retaining Wall Panels	4,000 psi	Contract
Sound Barrier Wall Panels	4,500 psi	Contract
INCIDENTAL PRECAST ITEMS:		
Concrete Pads For Outlet Pipe, Controller Base Cabinets	2,500 psi	Sect. 815, 816 and 825
Right-of-Way Markers	2,500 psi	Sect. 806 and 1054
Concrete Anchor For Cable Guardrail	3,000 psi	Sect. 1046
Picnic Tables	2,500 psi	Contract
Waste Containers	2,500 psi	Contract

Submit a proposed concrete mix design for the precast units. Determine quantities of fine and coarse aggregates necessary to provide concrete in accordance with this section by the method described in ACI 211 using the absolute volume method.

The Engineer will review the mix design only to ascertain general compliance with the *Standard Specifications*. Do not use a mix until notified that the mix is acceptable. Acceptance of the mix design does not relieve the Contractor of his responsibility to furnish an end product meeting the *Standard Specifications*. Upon request from the Contractor, a precast concrete unit mix design accepted and used satisfactorily on any Department project may be accepted for use on other projects.

(B) Testing

Make all representative concrete test cylinders and all testing required herein in the presence of the plant inspector for items with strength requirements greater than 2,500 psi in Table 1077-1, unless otherwise approved by the Engineer. For items with strength requirements of 2,500 psi, furnish a Type 3 material certification in accordance with Article 106-3 certifying that the item meets this Specification.

Before the first load is placed, determine the air content by a calibrated Chace indicator in accordance with AASHTO T 199. If the air content as determined by the Chace indicator fails to meet the *Standard Specifications*, perform 2 more tests with the Chace indicator on the same load and average all 3 tests. Acceptance or rejection of the load is based on the average of the 3 Chace indicator tests. As an alternate method determine the air content by AASHTO T 152, T196 or T121.

Perform temperature, air and slump tests whenever cylinders are cast.

Determine slump in accordance with AASHTO T 119 with no more than 3 1/2 inches allowed.

For the purpose of testing for the required 28 day compressive strength, furnish, at no cost to the Department, at least four concrete cylinders for each class of concrete, each structure and each day that precast units are produced for the Department. If the contractor anticipates an early break request, furnish the Department with two concrete cylinders for each early break request. These cylinders are in addition to the four concrete cylinders required for each day of production. Make and cure cylinders in accordance with AASHTO T 23 unless, by permission of the Engineer, the units are cured by one of the methods in Article 1077-9 for the full time required to meet the specified compressive strength requirements. In such case, cure the cylinders with the members and in the same manner as the members. Test cylinders in accordance with AASHTO T 22. If the average of two cylinders tested to determine compressive strength at the age of 28 days fails to indicate a compressive strength as shown in Table 1077-1, or such compressive strength as is required by the approved drawings, such failure is cause for the rejection of the members represented.

(C) Temperature Requirements

Maintain the concrete temperature at the time of placing in the forms not less than 50°F nor more than 95°F unless otherwise directed by the Engineer.

Place concrete in cold weather in accordance with Article 420-7.

(D) Use of Water Reducing Admixtures

Use water reducing admixtures in accordance with Subarticle 1000-4(G). Use high range water reducers (super plasticizers), if approved by the Engineer.

1077-6 FORMS

Use forms of sturdy construction and which are capable of consistently providing straight lines and uniform dimensions in the finished product. Use metal forms except where other materials are approved by the Engineer. Provide an identifying number on each form, and mark each precast unit with the same identifying number as the form used to cast unit. Forms not meeting these requirements are subject to rejection by the Engineer. Provide joints in forms that are smooth and tight enough to prevent leakage of mortar. Provide inside surfaces of forms that are accessible for cleaning. After each use, clean the forms thoroughly. Before casting, free the inside surfaces of the forms from rust, grease or other foreign matter. Do not allow coatings used for release of members to build up and in no case allow liquid or powder from coating materials to come in contact with the reinforcement steel.

1077-7 REINFORCEMENT

(A) Steel Reinforcement

Furnish steel reinforcement and place as shown in the plans and in accordance with Section 1070.

(B) Macro Synthetic Fiber Reinforcement

Substitute as an option, macro-synthetic fibers instead of 4 inches x 4 inches W1.4 x W1.4 welded wire reinforcement for selected precast concrete products in accordance with the following requirements.

(1) Materials

Refer to Division 10.

Item	Section
Portland Cement Concrete	1077-5

Substitute macro-synthetic fibers only for steel reinforcement with an area of steel of 0.12 sq.in./ft or less in the following items:

(a) Precast drainage structure units in accordance with *Roadway Standard Drawings* No. 840.45.

(b) Precast manhole 4.0 feet riser sections in accordance with *Roadway Standard Drawings* No. 840.52.

All other requirements, including reinforcement for these precast concrete items will remain the same.

(2) Submittal

Submit to the Department for approval by the precast producer and fiber manufacturer, independently performed test results certifying the macro-synthetic fibers and the precast concrete products meet the requirements listed herein.

(3) Macro-Synthetic Fibers

Manufacture from virgin polyolefins (polypropylene and polyethylene) and comply with ASTM D7508. Fibers manufactured from materials other than polyolefins. Submit test results certifying resistance to long-term deterioration when in contact with the moisture and alkalies present in cement paste and/or the substances present in air-entraining and chemical admixtures.

Fiber length shall be no less than 1.5 inches. Use macro-synthetic fibers with an aspect ratio (length divided by the equivalent diameter of the fiber) between 45 and 150, a minimum tensile strength of 40 ksi when tested in accordance with ASTM D3822 and a minimum modulus of elasticity of 400 ksi when tested in accordance with ASTM D3822.

(4) Fiber Reinforced Concrete

Approved structural fibers may be used as a replacement of steel reinforcement in allowable structures of *Roadway Standard Drawings* Nos. 840.45 and 840.52. The dosage rate, in pounds of fibers per cubic yard, shall be as recommended by the fiber manufacturer to provide a minimum average residual strength of concrete, tested in accordance with ASTM C1399, of no less than that of the concrete with the steel reinforcement that is being replaced and no less than 5 lb/cy. Submit the recommendations of the manufacturer that correlate the toughness of steel-reinforced concrete with that of the recommended dosage rate for the fiber-reinforced concrete.

Use fiber reinforced concrete with a 4.5% ± 1.5% air content and a compressive strength of at least 4,000 psi in 28 days.

Determine workability of the concrete mix in accordance with ASTM C995. The flow time shall at least 7 seconds and no greater than 25 seconds.

Assure the fibers are well dispersed and prevent fiber balling during production. After introduction of all other ingredients, add the plastic concrete and mix the plastic concrete for at least 4 minutes or for 50 revolutions at standard mixing speed.

1077-8 PLACING CONCRETE

Use the procedures and equipment for handling, placing and consolidating the concrete such that a uniformly dense and high grade concrete is obtained in all parts of the unit under all working and weather conditions. Do not mix, handle, deliver, place or finish concrete using devices made of aluminum or containing aluminum.

Internal, external or a combination of internal and external vibration is required as necessary to produce uniformly dense concrete without honeycomb.

1077-9 CURING CONCRETE

(A) General

Precast units are subjected to one of the methods of curing described below or to other methods or combinations of methods approved by the Engineer. Cure the precast units for a sufficient length of time so the concrete develops the specified compressive strength at 28 days or less. Do not strip forms until at least 24 hours after the concrete attains initial set. For this purpose, initial set is defined as at least 500 psi resistance to a standard penetrometer. The option to strip forms earlier is available provided concrete cylinders indicate a strength of at least 75% of the 28 day compressive strength is attained before release for each day's production. Do not deface or injure the units.

(B) Curing at Elevated Temperatures

Cure at elevated temperatures in accordance with Subarticle 1078-10(B).

(C) Water Curing

Water curing of precast units is allowed as described in Subarticle 420-15(B), by covering with water saturated material, or by a system of perforated pipes, mechanical sprinklers, porous hoses or by any other method that keeps the units moist during the specified curing period. Do not use methods that deface or injure the precast units.

(D) Curing Compound

Application of a curing compound is allowed provided it is left intact until the specified compressive strength is met. Keep all surfaces moist before the application of the compound and damp when the compound is applied. Seal the surface with a single uniform coating at the rate of coverage recommended by the curing compound manufacturer, or as directed by the Engineer, but not less than 1 gal per 150 sf of area.

1077-10 LIFT HOLES, HANDLING

Do not cast or drill more than 4 holes in each unit for the purpose of handling or placing unless otherwise approved by the Engineer. Locate all lift holes and handling devices in accordance with plan and design requirements. Units damaged while being handled or transported are rejected or require repair in a manner approved by the Engineer.

1077-11 FINAL FINISH

Unless otherwise required by the contract, finish all concrete in accordance with Subarticle 420-17(B).

Do not repair units with honeycomb, cracks, or spalls until inspected by the Engineer. Use repair methods that are approved by the Engineer before their use. Any appreciable impairment of structural adequacy is cause for rejection.

1077-12 EXPOSED AGGREGATE FINISH FOR PRECAST CONCRETE PANELS

When required, provide an exposed aggregate finish for front faces of panels with a depth of exposure ranging from 0 to 1/4 inch. Before beginning production, furnish three 12 inch x 12 inch sample panels to establish acceptable variations in color, texture and uniformity of the finish. After the sample panels are accepted and within 30 days of beginning production, produce a reinforced test panel of the largest size that will be used for the project with the accepted exposed aggregate finish. Acceptance of the appearance of panels during production will be based on the test panel and accepted sample panels.

Use aggregate and cement from the same source as was used for the test panel and accepted sample panels to produce panels with an exposed aggregate finish. Provide access to visually inspect the entire finish of each completed panel and compare it to the test panel appearance before stacking panels. Replace the test panel with a new test panel every three months during production or when fly ash or cement source changes.

1077-13 STEPS FOR PRECAST DRAINAGE STRUCTURES

Supply steps meeting AASHTO M 199 for design, materials and dimensions. Incorporate steps in all drainage structures over 3.5 feet in height. Do not detail the lowest step more than 16 inches from the bottom.

1077-14 MARKING

Clearly show the following information on each precast member:

(A) Date of manufacture,

(B) Name of the manufacturer,

(C) Piece mark designations where such designations are shown in the plans, and

(D) For precast culverts, match mark each precast member by a method approved by the Engineer, before shipment.

Indent marking into the concrete or paint on with waterproof paint.

1077-15 DIMENSIONS

Ensure that all dimensions allow assembly of the units in place without objectionable deviation from the lines shown in the plans. If requested by the Engineer, assemble the precast members to ensure a quality fit before shipment of the precast members.

1077-16 INCIDENTAL PRECAST ITEMS

Furnish a Type 3 materials certification in accordance with Article 106-3 for incidental precast items in Table 1077-1. Signal Cabinet Foundations shall meet the requirements herein and in Section 1098.