DIVISION 10
MATERIALS

SECTION 1000
PORTLAND CEMENT CONCRETE PRODUCTION AND DELIVERY

1000-1 DESCRIPTION

This section addresses Portland cement concrete to be used for pavement, structures and precast and incidental construction. Produce Portland cement concrete composed of Portland cement, fine and coarse aggregates, and water. Include supplementary cementitious material (SCM) and chemical admixtures as required or needed. SCMs consist of ground granulated blast furnace slag, fly ash or silica fume and may be substituted for a portion of the Portland cement. Type (Portland-Limestone Cement) IL, (Portland-Pozzolan Cement) IP, (Portland-Slag Cement) IS or (Ternary Blended Cement) IT blended cement may be used instead of Portland cement (see Section 1024 for details). Cement, fine and coarse aggregate, and SCMs shall be approved by the Department prior to use. Only use admixtures that are currently on the NCDOT APL.

All Portland cement concrete mixtures shall be designed by a NCDOT Certified Concrete Mix Design Technician or an engineer licensed by the State of North Carolina.

For approved mixture designs requiring a major change, submit a new mix design accompanied by the applicable test results indicating the mix conforms to the design requirements for the indicated class of concrete. Define a major change as:

(A) A source change in coarse aggregate or fine aggregate.

(B) A change in cement type (e.g. from Type I/II to Type IL).

(C) A change in SCM class or type change (e.g. Class F fly ash to Class C fly ash)

(D) A quantitative change in coarse aggregate, fine aggregate, or pozzolan greater than 5% (by weight).

(E) A quantitative change in water (applies to increase only) or cement (applies to decrease only).

For approved mix designs requiring a minor change, submit a Materials and Tests Form 312M. Define a minor change as:

(A) A change in source of the same type of cement or SCM.

(B) A change in source or brand of admixtures.

When concrete for any one pour is furnished by multiple concrete plants, use the same mix design for all concrete, including sources and quantities of ingredients.

Use materials which do not produce a mottled appearance through rusting or other staining of the finished concrete surface.

1000-2 MATERIALS

Refer to Division 10.

Item	Section
Air Entraining Agent	1024-3
Calcium Nitrite Corrosion Inhibitor	1024-3
Chemical Admixtures	1024-3
Coarse Aggregate	1014-2
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Portland Cement	1024-1
Silica Fume	1024-7
Type IL Blended Cement	1024-1
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Type IT Blended Cement	1024-1
Water	1024-4

1000-3 PORTLAND CEMENT CONCRETE FOR STRUCTURES AND INCIDENTAL CONSTRUCTION

(A) Composition and Design

Provide the class of concrete required by the contract. Higher strength classes of concrete may be permissible as approved by the Engineer.

Submit proposed concrete mix designs for each class of concrete to be used in the work. Mix proportions shall meet the design requirements provided in Table 1000-1 and the applicable portions of this section. Laboratory trial batches shall be created to confirm the proposed mix design meets the requirements of the plastic and hardened concrete.

Submit mix designs in terms of saturated surface dry weights on *Materials and Tests Form 312U* at least 35 days before proposed use. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated surface dry mix proportions will not be permitted unless revised mix designs have been submitted to the Engineer and approved.

Accompany *Materials and Tests Form 312U* with a listing of laboratory test results of aggregate gradation, air content, slump and compressive strength from a certified laboratory. List the compressive strength of at least three 6 inch x 12 inch or 4 inch x 8 inch cylinders at the age of 7 and 28 days.

Perform laboratory tests in accordance with the following test procedures:

Property	Test Method
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump	AASHTO T 119
Compressive Strength	AASHTO T 22 and R100

The Engineer will review the mix design for compliance with the specifications and notify the Contractor as to its acceptability. Do not use a mix until written notice has been received. Acceptance of the mix design does not relieve the Contractor of his responsibility to furnish a product that meets the contract.

(B) Air Entrainment

Entrain air in the concrete unless otherwise indicated in the plans or in the Specifications. Add an air entraining agent at the time of mixing to produce an air content in the freshly mixed concrete of 6.0% ± 1.5% when tested at the job site. Determine the air content in accordance with AASHTO T 121, T152 or T196. Measurement of air content may also be performed by the Chace Indicator, in which case sufficient tests will be made in accordance with AASHTO T 121, T152 or T196 to establish correlation with the Chace Indicator. Concrete for structures will not be rejected based on tests made with the Chace Indicator. Concrete for incidental construction may be rejected based on an average of 3 or more tests made with the Chace Indicator.

Air entraining agent may be added at the job site when permitted by the Engineer.

(C) Strength of Concrete

The compressive strength of the concrete will be considered the average compressive strength test results of two 6 inch x 12 inch cylinders, or two 4 inch x 8 inch cylinders if the aggregate size is not larger than size 57 or 57M. Make cylinders in accordance with AASHTO R 100 from the concrete delivered to the work. Make cylinders at such frequencies as the Engineer may determine and cure them in accordance with AASHTO R 100 as modified by the Department. Copies of these modified test procedures are available upon request from the Materials and Tests Unit.

When the average compressive strength of the concrete test cylinders is less than the minimum strength specified for the class of concrete and the Engineer determines it is within reasonably close conformity with strength requirements, concrete strength will be considered acceptable. When the Engineer determines average cylinder strength is below the specification, the in-place concrete will be investigated. Based on these investigation results, the concrete will be accepted with no reduction in payment, accepted at a reduced unit price or rejected as set forth in Article 105-3.

(D) Temperature Requirements

The concrete temperature at the time of placement shall be not less than 50°F and no more than 95°F except where other temperatures are required by Articles 420-4, 420-7, 420-14 and 420-15.

Do not place concrete without permission when the air temperature measured at the location of the concrete operation in the shade away from artificial heat is below 35°F.

When such permission is granted, uniformly heat the aggregates and/or water to a temperature not higher than 150°F. Heated concrete shall be between 55°F and 80°F at the time of placement.

TABLE 1000-1
DESIGN REQUIREMENTS FOR CONCRETE

Class of Concrete	Min. Compressive Strength at 28 days	Maximum Water-Cementitious Ratio	Maximum Slump		Min. Cementitious Content	Coarse Aggregate Sizes
			Vibrated	Non-Vibrated		
Units	*psi*		*inch*	*inch*	*lb/cy*	
AA	4500	0.426	1.5 slip form 3.5 [A]	---	639	57, 67, or 78M
Drilled Pier [B]	4500	0.450	---	5 – 7 dry 7 - 9 wet	640	78M
Sand Light-weight	4500	0.420	4.0 [A]	---	715	Lightweight (see Table 1014-1)
A [B,C]	3000	0.532	3.5 [A]	4.0	564	57, 67, or 78M
B[B]	2500	0.567	1.5 machine placed 2.5 [A] hand placed	4.0	508	57, 67, or 78M

A. A slump of 6 inches is allowed only by use of an approved admixture meeting Article 1024-3. In no case shall the water-cement ratio on the approved design be exceeded.

B. Drilled Pier mixes are non-air entrained. Class A and Class B mixes may be non-air entrained if specified by the contract or special provision.

C. Per Article 450-2, Class A concrete used for drilled-in piles shall have a slump of 6-8 inches and is achieved using an approved water reducer. Do not exceed the water-cement ratio on the approved design.

(E) Elapsed Time for Placing Concrete

Regulate the delivery so the maximum interval between the placing of batches at the work site does not exceed 20 minutes. Place concrete before exceeding the times in Table 1000-2. Measure the elapsed time as the time between adding the mixing water to the mix and placing the concrete.

TABLE 1000-2 ELAPSED TIME FOR PLACING CONCRETE		
Air or Concrete Temperature Whichever is Higher	Maximum Elapsed Time	
	No Retarding Admixture Used	Retarding Admixture Used
90°F or above	30 minutes	1 hr. 15 minutes
80°F through 89°F	45 minutes	1 hr. 30 minutes
79°F or below[A]	60 minutes	1 hr. 45 minutes
70°F through 79°F[B]	60 minutes	1 hr. 45 minutes
69°F or below[B]	1 hr. 30 minutes	2 hr. 15 minutes

A. Applicable to Class AA, A and Drilled Pier concrete.
B. Applicable to Class B concrete.

(F) Use of Set Retarding Admixtures

Use an approved set retarding admixture in all concrete placed in the superstructure of bridges such that the concrete will remain workable until the entire operation of placing and finishing, including corrective measures, if necessary, has been completed. The Engineer may waive the use of set retarding admixture when conditions clearly indicate that it is not needed.

Other structural concrete may contain an approved set retarding admixture when permitted by the Engineer.

Use a set retarding admixture on the NCDOT APL following the manufacturer's recommended dosage rate.

(G) Use of Water Reducing Admixtures

By permission of the Engineer, the Contractor may use an approved water reducing admixture to facilitate placing and finishing.

Use a water reducing admixture on the NCDOT APL following the manufacturer's recommended dosage rate. Concrete containing water reducing admixtures that exhibits segregation and/or excessive bleeding will be rejected. Utilizing an admixture to modify slump does not relinquish the contractor's responsibility to ensure the final product quality and overall configuration meets design specifications. Caution should be taken when placing these mixes on steep grades to prevent unintended changes to the set slope.

(H) Use of Calcium Chloride

Calcium chloride may be used as a set accelerating agent where permitted by the Engineer. Use one lb. of calcium chloride per 100 lbs. of cement except where lesser amounts are directed by the Engineer. Do not use calcium chloride where steel reinforcement, metal conduit or other metals will be in contact with the concrete. Do not use calcium chloride in concrete that has a temperature higher than 70°F, or when the air temperature is greater than 70°F. Provide cold weather protection for concrete containing calcium chloride in the same manner as is provided for concrete without calcium chloride.

Use calcium chloride in liquid form. Dissolve solid calcium chloride using one lb. or less of calcium chloride per one quart of water and mix well to form a liquid solution. To avoid incompatibility with other additives, add the calcium chloride to the batch after all other ingredients have been put into the mixer.

(I) Use of Supplementary Cementitious Materials (SCMs)

SCMs may be substituted for cement in the mix design at a rate of 1.0 lb. of SCM to each pound of cement replaced, up to the maximum amount shown in Table 1024-1. Concrete mixes using SCMs shall not exceed the maximum allowable water/cementitious material

ratio for the designated concrete class. Use Table 1000-1 to determine the maximum allowable water-cementitious material ratio for the classes of concrete listed.

(J) Use of Calcium Nitrite Corrosion Inhibitor

Units with calcium nitrite in a quantity less than specified are subject to rejection. Furnish concrete powder drilled from representative cylinders to the Engineer, in a quantity to be specified, to verify the concentrations of calcium nitrite in hardened concrete. Concrete that fails to contain calcium nitrite at the required concentrations as tested is subject to rejection. Use air-entraining, water-reducing and/or set-controlling admixtures compatible with calcium nitrite solutions. Strictly adhere to the manufacturer's written recommendations regarding the use of admixtures, including storage, transportation and method of mixing. If preferred, use calcium nitrite, which acts as an accelerator, in conjunction with a retarder to control the set of concrete, as per the manufacturer's recommendation. Add an approved calcium nitrite corrosion inhibitor (30% solids) to the concrete mix at the batch plant for the bridge elements identified by the plan notes. Use the inhibitor at a minimum rate of 3.0 gal/cy. Ensure that the hardened concrete contains at least 5.8 lbs/cy nitrite (NO_2) when tested in accordance with Materials and Tests Method Chem. C-20.0. The preceding paragraph does not apply to concrete used in prestressed concrete members. Concrete used in prestressed concrete members shall be tested in accordance with Subarticle 1078-4(G).

1000-4 PORTLAND CEMENT CONCRETE FOR PAVEMENT

(A) Composition and Design

Submit a concrete paving mix design in terms of saturated surface dry weights on *Materials and Tests Form 312U* to the Engineer for approval at least 35 days before proposed use. Mix proportions shall meet the design requirements provided in Table 1000-3 and the applicable portions of this section.

TABLE 1000-3
DESIGN REQUIREMENTS FOR CONCRETE PAVEMENT

Class of Concrete	Min. Compressive Strength at 28 days	Min. Flexural Strength at 28 days	Maximum Water/ Cementitious Ratio	Max. Slump	Min. Cementitious Content	Air Content	Coarse Aggregate Sizes
Units	*psi*	*psi*	*lb/lb*	*inch*	*lb/cy*	%	
Pavement	4500	650	0.559	1.5 slip form 3.0 hand placed	526	5.0% ± 1.5%	57, 67, or 78M
Very High Early Strength for Pavement Repair	4500	650 400 at 4 hours[A]	0.500	1.5 slip form 3.0 hand placed	600	5.0% ± 1.5%	57, 67, or 78M

A. Use of a high alkali cement or reactive aggregate is prohibited unless the supplier can achieve the required flexural strength in 4 hours while substituting the minimum supplementary cementitious material (SCM) amount specified in Section 1024-1 for mitigating ASR.

Include in the mix design the source of aggregates, cement, SCM, water and admixtures; the gradation and specific gravity of the aggregates; the fineness modulus of the fine aggregate; and the dry rodded unit weight and size of the coarse aggregate. Submit test

results showing that the mix design conforms to the criteria, including the 1, 3, 7, 14 and 28-day strengths of the average of two 6 inch x 6 inch x 20 inch beams and the average of two 6 inch x 12 inch cylinders for each age made and tested in accordance with AASHTO R 39, T22 and T97 from a certified laboratory. Design the mix to produce an average strength sufficient to indicate that a minimum strength of 650 psi in flexure and 4,500 psi in compression will be achieved in the field within 28 days.

Where concrete with a higher slump for hand methods of placing and finishing is necessary, submit an adjusted mix design for approval to provide a maximum slump of 3 inches and to maintain the water/cementitious material ratio established by the original mix design. The water/cementitious ratio refers to the ratio of the weight of water (lb) in concrete to the combined weight of cement and SCMs in the concrete. For mixes that use only cement (e.g. no SCMs), the water/cementitious ratio refers to the ratio of the weight of water (lb) to the weight of cement (lb) in the concrete.

(B) Air Entrainment

Entrain air in the concrete by the use of an approved air entraining agent dispensed with the mixing water, unless prohibited.

Provide an air content of 5.0% ± 1.5% in the freshly mixed concrete. The air content will be determined in accordance with AASHTO T 121, T152 or T196. At the option of the Engineer, the air content may be measured by the Chace Indicator, in which case sufficient tests will be made to establish correlation with the test methods of AASHTO T 121, T152 or T196. Concrete will not be rejected based on tests from the Chace Indicator.

(C) Slump

Provide concrete with a maximum slump of 1.5 inches where placed by a fully mechanized paving train and no more than 3 inches where placed by hand methods.

The sample taken for determination of slump will be obtained immediately after the concrete has been discharged onto the road.

(D) Set Retarding Admixture and Water Reducing Admixture

With permission, the Contractor may use an approved set retarding admixture, an approved water reducing admixture or both to facilitate placing and finishing. Use a quantity of set retarding admixture or water reducing admixture within the range shown on the current list of approved admixtures maintained by the Materials and Tests Unit.

(E) Use of Supplementary Cementitious Materials (SCMs)

SCMs may be substituted for cement in the mix design at a rate of 1.0 lb. of SCM to each pound of cement replaced, up to the maximum amount shown in Table 1024-1. Concrete mixes using SCMs shall not exceed the maximum allowable water-cementitious material ratio for the designated concrete class. Use Table 1000-3 to determine the maximum allowable water-cementitious material ratio for the classes of concrete listed.

(F) Contractor's Responsibility for Process Control

Before or at the preconstruction conference, submit a plan detailing the process control and the type and frequency of testing and inspection necessary to produce concrete that meets the specifications. During all batching and delivery operations assign a Certified Concrete Batch Technician on site whose sole duty is to supervise the production and control of the concrete. This duty includes the following:

(1) Tests and inspections necessary to maintain the stockpiles of aggregates in an unsegregated and uncontaminated condition.

(2) Calibration of admixture dispensing systems, weighing systems and water gauges.

(3) Tests and adjustments of mix proportions for moisture content of aggregates.

(4) Mixer performance tests before reducing mixing time of central mix plant to less than 90 seconds and at other times when deemed necessary by the Engineer.

(5) Verifying the actual mixing time of the concrete after all materials are introduced into the mixer at the beginning of paving operations and at least once each month.

(6) Testing all vibrators.

(7) Tests necessary to document the slump and air content of the mix produced. Determine air content at least twice each day.

(8) Tests for depth of the pavement in the plastic state.

(9) Furnishing data to verify that the approved theoretical cement content has been met at intervals not to exceed 50,000 sy of pavement.

(10) Signing all plant reports, batch tickets and delivery tickets.

The Department certifies technicians who satisfactorily complete examinations prepared and administered by the Department.

Perform all test procedures in compliance with the appropriate articles of Section 1000.

Tests may be witnessed by the Engineer. Document the results of all tests and inspections and make a copy available to the Engineer upon request. Take prompt action to correct conditions that have resulted in or could result in the submission of materials, products, or completed construction that do not conform to the specifications.

(G) Contractor Not Relieved of Responsibility for End Result

The Contractor will not be relieved of his obligation to produce a uniform pavement meeting specifications by reason of:

(1) The acceptance or approval by the Engineer of the concrete mix design or any adjustments;

(2) Compliance with the concrete mix design and compliance with the testing requirements and other process control requirements by the Contractor; or

(3) The failure of the Engineer to perform any tests in the process control, nor the performance of any tests in the process control that indicate compliance with the specifications.

1000-5 VERY HIGH EARLY STRENGTH CONCRETE FOR CONCRETE PAVEMENT REPAIR

Mix proportions shall meet the design requirements provided in Table 1000-3 and the applicable portions of this section. Use cement, fine aggregate, coarse aggregate, admixtures and SCMs that have been approved by the Department. SCMs shall be used according to Section 1024.

Accompany *Materials and Tests Form 312U* with 4 hour flexural strength results of at least 6 beams made and tested in accordance with AASHTO R 39 and T97. In addition, submit 4 hour compressive strength results of at least six 4 inch by 8 inch or 6 inch by 12 inch cylinders and maturity test results of the mix. With permission of the Engineer, compressive strength testing and maturity testing may be used in lieu of or concurrent with flexural strength testing to determine the acceptability of the concrete in the field.

1000-6 HIGH EARLY STRENGTH PORTLAND CEMENT CONCRETE

Use high early strength Portland cement concrete when required by contract. When not required, it may be used at the Contractor’s option with approval of the Engineer.

For all classes of concrete, high early strength concrete may be produced by using Type III Portland cement. To produce high early strength concrete with regular cement, use a higher class of concrete as follows:

For Class A and Class B, use Class AA with a cement content of at least 677 lbs/cy. Other classes that lend themselves to high early strength with regular cement will be reviewed by the Engineer on a case-by-case basis.

1000-7 FLOWABLE FILL

Flowable fill consists of Portland cement, water, supplementary cementitious materials and/or fine aggregate and, optionally, concrete admixtures.

Submit the proposed mix design on *Materials and Tests Form 312U* at least 35 days before use.

State on *Materials and Tests Form 312U* the intended use of the material (excavatable or non-excavatable). Excavatable flowable fill shall have a maximum strength of 150 psi at 56 days of age. Non-excavatable flowable fill shall have a minimum strength of 125 psi at 28 days of age. Accompany *Materials and Tests Form 312U* with a listing of compressive strength of at least three 4 inch x 8 inch cylinders at the age of 28 or 56 days, depending on whether the mix is to be excavated or not. Air cure the cylinders during the entire period before testing. The Engineer will advise the Contractor in writing of the acceptability of the mix design.

1000-8 LATEX MODIFIED CONCRETE (LMC)

(A) Materials

Refer to Division 10.

Item	Section
Coarse Aggregate, standard size No. 78M	1014-2
Fine Aggregate	1014-1
Portland Cement	1024-1
Type IL Blended Cement	1024-1
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Type IT Blended Cement	1024-1
Water	1024-4

Use a formulated latex admixture that is a non-hazardous, film forming and polymeric emulsion in water and is homogeneous and uniform in composition. Add all stabilizers at the point of manufacture. The use of Type III high early strength cement in LMC is only permitted as allowed by the contract.

Use a latex modifier conforming to Table 1000-4.

TABLE 1000-4 PROPERTIES OF LATEX MODIFIER FOR CONCRETE	
Property	**Requirement**
Polymer Type	Styrene Butadiene: 68 ± 4% Styrene 32 ± 4% Butadiene
Average Polymer Particle Size	1500 to 2500 Angstroms
Emulsion Stabilizers	Anionic and non-ionic surfactants
Percent Solids	46.5% to 49.0%
Weight per gallon at 75°F	8.40 to 8.60 lb
pH	9.5 to 11.0
Shelf Life	2 Years
Color	White

Provide a Type 5 material certification for each load of latex emulsion admixture in accordance with Article 106-3. Test admixture samples to verify compliance with the requirements before use. Allow 7 days for sampling and testing after delivery to the project.

Do not allow the temperature of latex emulsion admixture to fall below 35°F at any time or exceed 85°F after delivery to the project.

For latex emulsion that has been in storage, use a transfer pump and lines to recirculate it before using and sampling.

For LMC, use a workable mixture that meets Table 1000-5.

Measure the slump 4 to 5 minutes after discharge from the mixer.

Submit the LMC mix design, including laboratory compressive strength data for a minimum of six (6) 4-inch by 8-inch cylinders at seven (7) days for normal setting concrete to the Engineer for review. Include test results for the slump and air content of the laboratory mix. Perform tests in accordance with AASHTO T 22, T119 and T152.

TABLE 1000-5 PROPERTIES OF LATEX MODIFIED CONCRETE	
Property	**Requirement**
Cement Content, lb/cy	658 min.
Latex Emulsion Admixture, gal/cy	24.5 min.
Air Content of Plastic Mix, %	3.5 - 6.5
Slump, inches	3 - 6
% Fine Aggregate as percent of total aggregate by weight	50 - 55
7 day Compressive Strength, psi	3,000 min.
Water-Cement Ratio by weight	0.40 max.

(B) Equipment

Before beginning any work, obtain approval for all equipment to be used for deck preparation, mixing, placing, finishing and curing the latex modified concrete.

Use sandblasting equipment capable of removing all clay, salt deposits, oil and grease deposits and all other foreign matter. Provide traps or separators to remove oil and water from the compressed air. Use traps or separators of adequate size and drain them periodically during operations. For proportioning and mixing, use self-contained, mobile and continuously mixing equipment that meets the following requirements:

(1) Use a self-propelled mixer that is capable of carrying sufficient unmixed dry, bulk cement, sand, coarse aggregate, latex modifier and water to produce at least 6 cy of concrete on site.

(2) Use a mixer that is capable of positive measurement of cement introduced into the mix. Use a recording meter that is visible at all times and equipped with a ticket printout to indicate the quantity of cement.

(3) Calibrate the mixers to accurately proportion the specified mix. Before placing latex modified concrete, perform calibration and yield tests under the Engineer's supervision in accordance with the Department's written instructions. Copies of these written instructions are available from the Materials and Tests Unit. Perform the calibration and yield tests using the material to be used on the project. Recalibrate the mixer after any major maintenance operation on the mixer, anytime the source of materials changes or as directed by the Engineer. Furnish all materials and equipment necessary to perform the calibrations and yield tests.

(4) Use a mixer that controls the flow of water and latex emulsion into the mix. Measure the flow rate of water and the latex emulsion with a calibrated flowmeter coordinated with both the cement and aggregate feeding mechanisms and the mixer. Adjust the flow rate, as necessary, to control the slump and ensure that the water-cement ratios are met. In addition to flowmeters, use mixers with accumulative water and latex meters capable of indicating the number of gallons, to the nearest 0.1 gallon, introduced into the mixer. Filter water and latex with a suitable mesh filter before it flows through the accumulative water and latex meters.

(5) Calibrate the mixer to automatically proportion and blend all components of the indicated composition on a continuous or intermittent basis as the finishing operation requires. Provide a mixer that discharges mixed material through a conventional chute and is capable of spraying water over the placement width as it moves ahead to ensure that the surface to be overlaid is wet before receiving the modified material.

(6) Mount a tachometer on the unit to indicate the drive shaft speed.

(7) Use adequate hand tools for placing and leveling concrete down to approximately the correct level for striking off with the screed.

(8) Use a finishing machine that meets the approval of the Engineer and the requirements of the contract. Use a self-propelled finishing machine capable of forward and reverse movement under positive control. Use a machine with at least 2 finishing devices, one that is a vibrating screed and the other either a vibrating screed, oscillating screed, or one or more rotating cylindrical drums 48 inches long or less and operating between 1,500 and 2,500 vpm. Make certain the finishing machine can finish the surface to within 1 foot of the edges of the area being placed. Raise all screeds when the finishing machine is moving backwards over the screeded surface.

(9) Use screeds with a vibration frequency that is variable between 3,000 and 6,000 vpm with positive controls. Use screeds with a metal covered bottom face not less than 4 inches wide. Provide screeds with positive control of the vertical position.

(10) Use supporting rails for travelling of the finishing machine rigid enough to eliminate deflection from the weight of the machine.

(C) Proportioning and Mixing of Modified Compositions

Use mobile continuous mixers that accurately proportion all materials for the specified mixture. Operate the proportioning equipment at the manufacturer's recommended speed verified with the tachometer during calibration and normal operations.

Yield checks and other checks are permitted.

(D) Contractor's Responsibility for Process Control

Before or at the preconstruction conference, submit a plan detailing the process control and the type and frequency of testing and inspection necessary to produce concrete that meets the specifications. During all batching and delivery operations assign a Certified Concrete

Batch Technician on site whose sole duty is to supervise the production and control of the concrete. This duty includes the following:

(1) Tests and inspections necessary to maintain the stockpiles of aggregates in an unsegregated and uncontaminated condition.

(2) Calibration of admixture dispensing systems, weighing systems and water gauges.

(3) Tests and adjustments of mix proportions for moisture content of aggregates.

(4) Mixer performance tests before reducing mixing time of central mix plant to less than 90 seconds and at other times when deemed necessary by the Engineer.

(5) Verifying the actual mixing time of the concrete after all materials are introduced into the mixer at the beginning of paving operations and at least once each month.

(6) Testing all vibrators.

(7) Tests necessary to document the slump and air content of the mix produced. Determine air content at least twice each day.

(8) Tests for depth of the pavement in the plastic state.

(9) Furnishing data to verify that the approved theoretical cement content has been met at intervals not to exceed 50,000 sy of pavement.

(10) Signing all plant reports, batch tickets and delivery tickets.

The Department certifies technicians who satisfactorily complete examinations prepared and administered by the Division of Highways.

Perform all test procedures in compliance with the appropriate articles of Section 1000.

Tests may be witnessed by the Engineer. Document the results of all tests and inspections and make a copy available to the Engineer upon request. Take prompt action to correct conditions that have resulted in or could result in the submission of materials, products, or completed construction that do not conform to these specifications.

1000-9 MEASURING MATERIALS

(A) Weighing Cement

Measure cement by weight on scales separate from those used for other materials and in a hopper that is entirely free and independent of the hoppers used for weighing the aggregates. When the quantity of cement in a batch exceeds 30% of the full capacity of the scale, ensure the quantity of cement as indicated by the scale is within ± 1% of the required weight. For smaller batches, ensure the quantity of cement as indicated by the scale be not less than the required amount or more than 4% in excess. Equip all beam type scales with a tare beam.

(B) Weighing Aggregates

Measure aggregates by weight. Base batch weights on saturated surface dry materials which is the required weight plus the total weight of surface moisture contained in the aggregate. Ensure the individual aggregates, as weighed, are within ± 2% of the required weights.

(C) Water

Measure water by volume or by weight. Ensure the quantity of water measured is within ± 1% of the required amount.

(D) Admixture Dispensing Systems

Provide a separate dispensing system with separate fill and discharge lines for each type of admixture to be used, except that admixtures may be measured and introduced into the mix

manually if approval has been obtained. Ensure each system is capable of measuring, displaying and discharging the required amount of admixture into the mix. Keep dispensing systems clean and in good operating condition. Use a dispensing system that is either:

(1) Manually operated, self-contained; or

(2) Semi-automatic or automatic, self-contained; or

(3) Interfaced to operate automatically with the concrete batching control panel.

Have the admixture dispenser dispense the required quantity of admixture for each concrete batch within an accuracy of ± 3%. Check the accuracy of the dispenser as provided below. Check the accuracy at the point of discharge, or through a bypass valve suitable for obtaining a calibrated sample of admixture and at the volumes normally used for one half mixer capacity and for full mixer capacity. Determine the accuracy at the time of installation and check daily during the early part of each day's operation.

Include in each system a graduated measuring unit into which the admixture is batched to permit a quick visual check of accuracy before its discharge. Ensure the measuring unit is clearly graduated and be of sufficient size to hold the maximum anticipated dose for one batch. Clearly mark the measuring unit for the type of admixture to be used.

Control the discharge sequence so an admixture will not be brought into contact with raw cement or another admixture before being diluted through contact with the mixing water in the mixer. Where 2 types of admixtures are being used, do not discharge them into the mix simultaneously. Add the air entraining agent with the first addition of water and add any other chemical admixture with the final addition of water, unless otherwise permitted.

Construct the discharge lines to completely empty after each cycle. Locate the admixture dispensing systems so the batching plant operator will have a visual verification of the actual quantity of admixture batched.

Use air entraining admixtures in accordance with the manufacturer's recommendations and in such quantity to provide the specified air content in freshly mixed concrete. Use a quantity of set retarding admixture and of water reducing admixture per 100 lbs. of cement that is within the range recommended on the current list of approved admixtures issued by the Materials and Tests Unit.

1000-10 BATCHING PLANT

(A) General

Plants located on the Department rights of way shall conform to Article 107-3.

Have ready mixed concrete plants inspected and approved by the Department before they are used to produce concrete, either paving, structural or incidental, for the project. Plants shall meet all the applicable requirements of these *Standard Specifications*, and in addition, ensure each ready mix plant provides at least three acceptable truck mixers or truck agitators available for use. Use trucks that have an identifying number. Plants approved by the Department will be placed on a list of approved plants available to the Contractor. All plants will be subject to reinspection at intervals selected by the Engineer. Reapproval after each inspection will be contingent on continuing compliance with the *Standard Specifications*.

(B) Bins and Hoppers

Provide bins with separate compartments for fine aggregates and for each required size of coarse aggregate in the batching plant. Design each compartment to discharge efficiently and freely into the weighing hopper. Provide control so, as the quantity desired is being approached, the material may be added slowly and shut off with precision. Construct weighing hoppers to eliminate accumulation of tare materials and to discharge fully unless

otherwise permitted. Provide a port or other opening for removing an overload of any one of the several materials from the hopper.

(C) Scales

Use either the beam type, load cell type or the springless dial type scales for weighing aggregates and cement. Ensure the minimum graduation on beam or dial is not more than 0.1% of the total capacity of the scale. Methods of weighing, other than beam or springless dial scales, may be approved by the Engineer provided they meet the required weighing tolerances. Ensure the scales are accurate within 0.5% under operating conditions. Make available ten 50 lb. test weights at the plant for checking accuracy. Use test weights which meet the U.S. Bureau of Standards requirements for calibrating and testing equipment. Keep all exposed fulcrums, clevises and similar working parts of scales clean. When beam type scales are used, make provisions for indicating to the operator that the required load in the weighing hopper is being approached. Ensure the device indicates at least the last 50 lbs. of load and design it to give a positive indication of overload of the scales. During charging of the hopper, have all indicating devices in full view of the operator and provide convenient access to all controls. Ensure the indicating devices are in the immediate vicinity of the operator and easily readable by the operator.

(D) Water Measuring Devices

Use devices for measurement of the water which are readily adjustable and are capable of being set to deliver the required amount and cut off the flow automatically when this amount has been discharged. Under all operating conditions the device shall have accuracy within 1% of the quantity of water required for the batch. Arrange the device so variable pressures in the water supply line will not affect the measurements. Use measuring tanks of adequate capacity to furnish the maximum mixing water required and equip them with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amounts in the tank.

1000-11 MIXERS AND AGITATORS

(A) General

Mixers are defined as equipment to mix concrete and may be stationary or truck mounted. Agitators are defined as equipment used to haul central mixed concrete and may be truck mixers or truck agitators. Provide a metal plate or plates attached to each mixer and agitator in a prominent place on which the manufacturer has plainly marked the mixing speed of the drum or paddles and the maximum capacity of the drum or container in terms of volume of mixed concrete. On truck mixers and agitators, show the manufacturer's recommended agitating and mixing speed of rotation of the mixing drum or blades. Equip stationary mixers with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Equip truck mixers with counters to verify the number of revolutions of the drum or blades. Actuate the counters at the initial time the drums have reached mixing speed.

Examine mixers and agitators periodically for changes in condition due to accumulation of hard concrete or mortar, wear of blades or any other condition which decreases mixing efficiency. Mixers are unacceptable when the radial height or other dimension of the blade has worn below 90% of the original dimension. This radial height excludes any lips on the blade and is the height of the blade running perpendicular to the shell of the drum. Where such conditions are found, do not use the units until they are corrected.

Also examine mixers and agitators periodically for general mechanical condition, including water measuring and discharge apparatus, identifying number on trucks, condition of the blades, speed of rotation of the drum and condition of the drum.

(B) Mixer Capacity

Do not load truck mixers with concrete with more than 63% of the gross volume of the drum. Use mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity. Use stationary mixers, when loaded at the manufacturers guaranteed mixing capacity and the concrete mixed for the prescribed mixing time, capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and discharging the concrete with satisfactory uniformity.

Use at least 20% of the rated mixing capacity as the minimum quantity of concrete permitted to be mixed or agitated in any mixer.

(C) Agitator Capacity

Load the agitator to not exceed 80% of the gross drum volume and have it be capable of maintaining the concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

(D) Consistency Tests

The Engineer may, from time to time, make slump tests to measure consistency of the concrete. Take individual samples at approximately the 1/5th point, the midpoint and the 4/5th point of the load, using AASHTO T 119. Such tests will be made within 20 minutes of discharge of that portion of the load. If the results vary by more than 1 inch in slump, do not use the mixer or agitator unless the condition is corrected.

1000-12 MIXING AND DELIVERY

(A) General

Mix and deliver concrete to the site of the work by one of the following methods, except where other methods are approved by the Engineer. Maintain responsibility for controlling the materials and operations as to produce uniform concrete meeting specifications requirements.

When concrete is being produced for structures and incidental construction in accordance with Article 1000-3, have present during all batching operations a Certified Concrete Batch Technician employed by the Contractor or concrete supplier. During batching and delivery, the sole duty of this employee is to supervise the production and control of the concrete. Perform moisture tests, adjust mix proportions of aggregates for free moisture, complete and sign Batch Tickets (*Materials and Tests Form 903*) or approved delivery tickets and assure quality control of the batching. Delivery tickets will be permitted instead of batch tickets (*Materials and Tests Form 903*) provided they have been reviewed and approved by the Materials and Tests Unit. The Department certifies technicians who satisfactorily complete examinations prepared and administered by the Department.

(1) Central Mixed Concrete

Concrete that is mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in a truck agitator or in a truck mixer operating at agitating speed or in non-agitating equipment approved by the Engineer. Perform mixing within the capacity and at the mixing speeds recommended by the manufacturer.

(2) Transit Mixed Concrete

Concrete that is mixed completely in a truck mixer while at the batching plant, in transit, or at the work site.

(3) Shrink Mixed Concrete

Concrete that is mixed partially in a stationary mixer at a central mixing plant and completed as transit mixed concrete. Place all ingredients for a batch in the stationary mixer, partially mix before any concrete is discharged to the truck mixer and do not exceed the rated capacity of the equipment for the batch size. The mixing time at the stationary mixer may be reduced to the minimum necessary to intermingle the ingredients, and the mixing may be completed in the truck mixer. Use the number of mixing revolutions in the truck mixer as specified for transit mixed concrete or reduce as indicated by mixer performance tests.

(B) Mixing Time for Central Mixed Concrete

Mixing time begins when all solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. In charging the mixer, water will enter in advance of cement and aggregate. Ensure all the water is substantially in the drum before 1/3 of the specified mixing time has elapsed. Count transfer time in multiple drum mixers as part of the mixing time.

Where mixer performance tests are not made, use a minimum mixing time of 90 seconds, providing that blending of materials during charging is achieved to the satisfaction of the Engineer. The minimum mixing time for an individual mixer is that which, as shown by mixer performance tests, will produce concrete in accordance with Table 1000-6, except that the mixing time shall not be less than 50 seconds under any circumstances. Maximum mixing time excluding discharge time is 150 seconds.

Sampling and testing for mixer performance tests will be done as provided below. Charge the mixer to its rated capacity with the materials and proportions to be used in the work and mixed at the recommended mixing speed to the target time. Stop mixing and begin discharging. Two samples of sufficient size to make the required tests will be taken after discharge of approximately 15% and 85% of the load.

TABLE 1000-6
REQUIREMENTS FOR UNIFORMITY OF CONCRETE

Property	Requirement	Test Method
Difference in Test Samples Air Content, percent by volume of concrete	1.0%	AASHTO T 152
Slump	1.0"	AASHTO T 119
Coarse aggregate content, portion by weight of each sample retained on the No. 4 sieve	6.0%	AASHTO M 157
Weight	1.0 lb	AASHTO T 121
Average Compressive Strength at 7 days, percent of average	10.0%[A]	AASHTO T 22 AASHTO R 100

A. Tentative approval may be granted pending 7 day compressive strength tests.

Each of the two samples of concrete will be separately tested for the properties listed in Table 1000-6. Tests will be conducted in accordance with the test procedures specified in Table 1000-6 or procedures established by the Materials and Tests Unit.

The mixer performance test described above will be performed on at least two batches of concrete. For the performance test to be acceptable, have all tests in each batch tested meet the requirements listed above.

The Engineer may recheck mixer performance at any time when, in his opinion, satisfactory mixing is not being accomplished.

Where satisfactory mixing cannot be accomplished in 90 seconds, the Engineer may increase the mixing time or require that the mixer be repaired or replaced before any further mixing can be done.

(C) Truck Mixers and Truck Agitators

When a truck mixer is used for complete mixing, mix each batch of concrete for at least 70 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as mixing speed, unless otherwise directed by the Engineer. Unless the mixer is equipped with a counter which will distinguish between mixing and agitating speeds, perform the minimum required number of revolutions of the drum at mixing speed as directed by the Engineer, either at the batching plant before the mixer leaves for the work site and/or at the work site before the concrete is discharged. Perform any additional mixing at the speed designated by the manufacturer of the equipment as agitating speed. Put all materials including mixing water in the drum before actuating the revolution counter for determining the number of revolutions of the drum.

When a truck mixer or truck agitator is used to transport concrete that has been completely mixed in a stationary mixer, perform mixing during transport at agitating speed.

Provide concrete, when discharged from truck mixers or truck agitators, of the consistency and workability required for the work. Control the rate of discharge of the plastic concrete from the mixer drum by the speed or rotation of the drum in the discharge direction with the discharge gate fully open. If additional mixing water is necessary to produce the slump necessary for proper placement, add it only with permission and rotate the truck mixer drum at least 25 revolutions at mixing speed before discharge of any concrete. Additional mixing water will be allowed only if the maximum specified water content per cubic yard is not exceeded.

(D) Delivery

Use a ticket system for recording the transportation of batches from the proportioning plant to the site of the work. Use tickets furnished by the Engineer and fill it out in accordance with instructions issued by the Engineer. Issue the tickets to the truck operator at the proportioning plant for each load and have them signed by the plant inspector, which will signify that the concrete in the truck has been inspected before departure. Ensure each ticket shows the time batching was completed and if transit mixed, the number of revolutions at mixing speed, if any, at the plant. Deliver the tickets to the inspector at the site of the work. Do not use loads which do not carry such tickets and loads which do not arrive in satisfactory condition within the time limits specified in the work.

1000-13 VOLUMETRIC MIXED CONCRETE

Upon written request by the contractor, the Department may approve the use of concrete proportioned by volume. The volumetric producer must submit and have approved a process control plan and product quality control plan by the Materials and Tests Unit. If concrete is proportioned by volume, the other requirements of these specifications with the following modifications will apply. Unless otherwise approved by the Department, use of concrete proportioned by volume shall be limited to Class B concrete and no more than 30 cy per unit per day.

(A) Materials

Use materials that meet the requirements for the respective items except that they will be measured by a calibrated volume-weight relationship.

Storage facilities for all material shall be designed to permit the Department to make necessary inspections before the batching operations. The facilities shall permit identification of approved material at all times and shall be designed to avoid mixing with, or contaminating by, unapproved material. Coarse and fine aggregate shall be furnished and handled so variations in the moisture content affecting the uniform consistency of the concrete is avoided.

Moisture content of the coarse and fine aggregate will be made available onsite for the Engineer's review for each load. The frequency of moisture testing will be dependent on

certain variables such as weather, season and source; however, moisture tests should be performed at least once at the beginning of the work day for each source material. Additional daily moisture tests for the coarse and fine aggregate shall be performed if requested by the Engineer.

Unused materials should be emptied from hopper daily. Concrete should not be mixed with materials left in the hopper overnight.

(B) Equipment

Provide volumetric mixers with rating plates indicating that the performance of the mixer is in accordance with the Volumetric Mixer Manufacturer Bureau or equivalent. Mixers must comply with ASTM C685. Unless otherwise specified, all mixing operations must be in strict accordance with the manufacturer's recommended procedures. Such procedures shall be provided to the Department for review upon request.

The volumetric mixer shall be capable of carrying sufficient unmixed dry bulk cement, supplementary cementitious material (if required), fine aggregate, coarse aggregate, admixtures and water, in separate compartments and accurately proportioning the specified mix. Each batching or mixing unit (or both) shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed and the weight-calibrated constant of the machine in terms of a revolution counter or other output indicator.

The concrete mixing device shall be an auger-type continuous mixer used in conjunction with volumetric proportioning. The mixer shall produce concrete, uniform in color and appearance, with homogeneous distribution of the material throughout the mixture. Mixing time necessary to produce uniform concrete shall be established by the contractor and shall comply with other requirements of these specifications. Only equipment found acceptable in every respect and capable of producing uniform results will be permitted.

Each volumetric mixer shall be equipped with an onboard ticketing system that will electronically produce a record of all material used and their respective weights and the total volume of concrete placed. Alternate methods of recordation may be used if approved by the Engineer. Tickets shall identify at least the following information:

(1) Contractor Name
(2) Contractor Phone Number
(3) NCDOT Project No. and TIP No.
(4) Date
(5) Truck No.
(6) Ticket No.
(7) Time Start/End of Pour
(8) Mix ID and Description (Strength)
(9) Aggregate Moisture Before Mixing

(C) Proportioning Devices

Volume proportioning devices, such as counters, calibrated gate openings or flow meters, shall be easily accessible for controlling and determining the quantities of the ingredients discharged. All indicating devices that affect the accuracy of proportioning and mixing of concrete shall be in full view of and near enough to be read by the operator and Engineer while concrete is being produced. In operation, the entire measuring and dispensing mechanism shall produce the specified proportions of each ingredient.

Provide positive control of the flow of water and admixtures into the mixing chamber with a volumetric mixer. Indicate water flow by a flow meter and be readily adjustable to provide for slump control and/or minor variations in aggregate moisture. Provide a mixer capable of continuously circulating or mechanically agitating the admixtures.

Dispense liquid admixtures through a controlled, calibrated flow meter. A positive means to observe the continuous flow of material shall be provided. If an admixture requires diluting, the admixture shall be diluted and thoroughly mixed before introducing the admixture into the dispenser. When admixtures are diluted, the ratio of dilution and the mixing shall be approved by and performed in the presence of the Department.

The volumetric mixer shall be capable of measurement of cement, supplementary cementitious material (if required), liquids and aggregate being introduced into the mix.

(D) Calibration

Volume-weight relationships will be based on calibration. The proportioning devices shall be calibrated by the contractor before the start of each NCDOT job and subsequently at intervals recommended by the equipment manufacturer. Calibrations will be performed in the presence of the Department and subject to approval from the Department. Calibration of the cement and aggregate proportioning devices shall be accomplished by weighing (determining the mass of) each component. Calibration of the admixture and water proportioning devices shall be accomplished by weight (mass) or volume. Tolerances in proportioning the individual components will be as follows:

TABLE 1000-7
VOLUMETRIC MIXED CONCRETE CALIBRATION TOLERANCES

Item	Tolerance
Cement, Weight (Mass) percent	0 to +4
Fine Aggregate, Weight (Mass) percent	± 2
Coarse Aggregate, Weight (Mass) percent	± 2
Admixtures, Weight (Mass) or Volume percent	± 3
Water, Weight (Mass) or Volume percent	± 1

Each volumetric mixer must be accompanied at all times by completed calibration worksheets and they shall be made available to the Department upon request.

(E) Verification of Yield

Verification of the proportioning devices may be required at any time by the Department. Verification shall be accomplished by proportioning the rock and sand based on the cement meter count for each concrete mobile mixer. Once the count (revolutions) for 94 lbs. of cement has been determined then delivery of the correct amount of rock and sand can be verified.

(F) Uniformity

When concrete is produced, have present during all batching operations a Certified Concrete Batch Technician. During batching and placement, the sole duty of this employee is to supervise the production and control of the concrete, perform moisture tests, adjust mix proportions of aggregates for free moisture, complete and sign approved delivery tickets and assure quality control of the batching.

Two samples of sufficient size to make the required tests will be taken after discharge of approximately 15% and 85% of the load. Each of the two samples of concrete will be separately tested for the properties listed in Table 1000-7. Tests will be conducted in accordance with the test procedures specified in Table 1000-7 or procedures established by the Materials and Tests Unit. The Engineer may recheck mixer performance at any time when, in his opinion, satisfactory mixing is not being accomplished.

SECTION 1002
SHOTCRETE PRODUCTION AND DELIVERY

1002-1 DESCRIPTION

This section addresses shotcrete to be used for temporary support of excavations and other applications in accordance with the contract. Produce shotcrete by either the dry-mix or wet-mix process composed of Portland cement, fine and/or coarse aggregates, water and at the Contractor's option, SCMs. Include chemical admixtures as required or needed for shotcrete produced by the wet-mix process. SCMs may be substituted for a portion of the Portland cement. Type IL, IS, IP or IT blended cement may be used instead of Portland cement.

Mixes for all shotcrete shall be designed by a Certified Concrete Mix Design Technician or an engineer licensed by the State of North Carolina. Dry-mix shotcrete shall be on the NCDOT APL. Shotcrete shall be applied by a nozzelman certified as an ACI Shotcrete Nozzelman in accordance with *ACI Certification Publication CP-60*. Nozzlemen shall be certified in either dry-mix or wet-mix shotcrete based on the process to be used for the work.

1002-2 MATERIALS

Refer to Division 10.

Item	Section
Chemical Admixtures	1024-3
Coarse Aggregate	1014-2
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Portland Cement	1024-1
Silica Fume	1024-7
Type IL Blended Cement	1024-1
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Type IT Blended Cement	1024-1
Water	1024-4

1002-3 SHOTCRETE FOR TEMPORARY SUPPORT OF EXCAVATIONS

(A) Composition and Design

Submit proposed shotcrete mix designs for each shotcrete mix to be used in the work. Mix proportions shall be determined by a testing laboratory approved by the Department. Submit shotcrete mix designs in terms of saturated surface dry weights on *Materials and Tests Form 312U* at least 35 days before proposed use. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated surface dry mix proportions will not be permitted unless revised shotcrete mix designs have been submitted to the Engineer and approved.

The Engineer will review the shotcrete mix design for compliance with the contract and notify the Contractor as to its acceptability contingent upon compressive strength test results for cores from preconstruction test panels. Do not use a shotcrete mix until written notice has been received. Acceptance of the shotcrete mix design does not relieve the Contractor of his responsibility to furnish a product that meets this contract.

(B) Chemical Admixtures

Use a quantity of chemical admixture within the range shown on the current list of approved admixtures issued by the Materials and Tests Unit.

(C) Strength of Shotcrete

Provide shotcrete with a compressive strength at 3 and 28 days of at least 2,000 psi and 4,000 psi, respectively. The compressive strength of the shotcrete will be considered the average compressive strength test results of 3 cores from the same test panel at each age.

(D) Preconstruction Test Panels

Before beginning construction, provide one preconstruction test panel for each shotcrete mix design and nozzlemen using the same equipment that will be used for the work. Use 3 feet x 3 feet forms at least 3.5 inches thick for preconstruction test panels.

Batch, deliver, mix and apply shotcrete in accordance with Subarticles 1002-3(E) and 1002-3(F) and the contract. Make preconstruction test panels in the presence of the Engineer with forms in a vertical position and from the same shooting position anticipated for construction. Do not disturb test panels for the first 24 hours after shotcreting.

(E) Mixing and Delivery

Produce shotcrete of required strength, consistency, quality and uniformity with minimum rebound. Do not use rebound or previously expanded material in the shotcrete mix. Thoroughly mix materials in sufficient quantity to place shotcrete continuously. Regulate the delivery so the maximum interval between the shooting of batches at the work site does not exceed 20 minutes. Comply with Articles 1000-10 through 1000-13 to the extent applicable for shotcrete instead of concrete.

(F) Shooting Requirements

Use equipment capable of handling and shooting shotcrete at a steady uninterrupted flow. Use air supply systems that supply clean, dry air free of contamination and capable of maintaining sufficient nozzle velocity at all times. Apply shotcrete with the same equipment and methods as used for the preconstruction test panels.

The shotcrete temperature at the time of shooting shall be not less than 50°F or no more than 90°F. Do not apply shotcrete during heavy rains or runoff or high winds so the nozzle stream separates during shooting. Do not apply shotcrete if surface to receive shotcrete is frozen or the air temperature measured at the location of the shotcreting operation in the shade away from artificial heat is below 40°F. Apply shotcrete before the time between adding the mixing water to the shotcrete mix and shooting the shotcrete exceeds 60 minutes.

(G) Production Test Panels

Provide one production test panel for every 33 cy of shotcrete with at least one test panel for each day shotcreting occurs. Use 18 inch x 18 inch forms at least 3.5 inches thick for production test panels. Make production test panels with forms in a vertical position from the same shooting position and at the same time as shotcreting is done. Do not disturb test panels for the first 24 hours after shotcreting.

(H) Handling and Storing Test Panels

Notify the Area Materials Engineer when preconstruction or production test panels are made within 24 hours of shooting the panels. Field cure and protect test panels from damage in accordance with ASTM C1140. The Contractor shall core the panels in the presence of the Engineer. The Department will transport the cores to a Materials and Tests Regional Laboratory for testing.

SECTION 1003
GROUT PRODUCTION AND DELIVERY

1003-1 DESCRIPTION

This section addresses cement grout to be used for structures, foundations, retaining walls, concrete barriers, embankments, pavements and other applications in accordance with the contract. Produce non-metallic grout composed of Portland cement and water and at the Contractor's option or as required, aggregate and supplementary cementitious materials. Include chemical admixtures as required or needed. Provide sand cement or neat cement grout as required. Define "neat cement grout" as grout without aggregate.

The types of grout with their typical uses are as shown below:

Type 1 – A cement grout with only a 3 day strength requirement and a fluid consistency that is typically used for filling subsurface voids.

Type 2 – A nonshrink grout with strength, height change and flow conforming to ASTM C1107 that is typically used for foundations and rock anchors.

Type 3 – A nonshrink grout with high early strength and freeze-thaw durability requirements that is typically used in pile blockouts, grout pockets, shear keys, dowel holes and recesses for concrete barriers and structures.

Type 4 – A neat cement grout with low strength, a fluid consistency and high fly ash content that is typically used for slab jacking.

Type 5 – A neat cement grout that is typically used for soil nails and ground anchors.

Type 6 – A low slump, low mobility cement grout with minimal strength that is typically used for compaction grouting.

1003-2 MATERIALS

Refer to Division 10.

Item	Section
Chemical Admixtures	1024-3
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Portland Cement	1024-1
Silica Fume	1024-7
Water	1024-4

Do not use grout that contains soluble chlorides or more than 1% soluble sulfate.

At the Contractor's option, use an approved packaged grout instead of the materials above except for water. Use packaged grouts that are on the NCDOT APL.

Use admixtures for grout that are on the NCDOT APL or other admixtures in accordance with Subarticle 1024-3(E) except do not use concrete additives or unclassified or other admixtures in Type 4 or 6 grout. Use Class F fly ash for Type 4 grout and Type II Portland cement for Type 6 grout.

Use well graded rounded aggregate with a gradation, liquid limit (LL) and plasticity index (PI) that meet Table 1003-1 for Type 6 grout. Fly ash may be substituted for a portion of the fines in the aggregate. Do not use any other supplementary cementitious materials in Type 6 grout.

TABLE 1003-1 AGGREGATE REQUIREMENTS FOR TYPE 6 GROUT			
Gradation		Maximum Liquid Limit	Maximum Plasticity Index
Sieve Designation per AASHTO M 92	Percentage Passing (% by weight)		
3/8"	100	N/A	N/A
No. 4	70 – 95		
No. 8	50 – 90		
No. 16	30 – 80		
No. 30	25 – 70		
No. 50	20 – 50		
No. 100	15 – 40		
No. 200	10 – 30	25	10

1003-3 COMPOSITION AND DESIGN

When using approved packaged grout, a grout mix design submittal is not required. Otherwise, submit proposed grout mix designs for each grout mix to be used in the work, except for Type 5 grout, which has a prescribed mix design specified in Article 1003-4. Mixes for all grout shall be designed by a Certified Concrete Mix Design Technician or an engineer licensed by the State of North Carolina. Mix proportions shall be determined by a testing laboratory approved by the Department. Base grout mix designs on laboratory trial batches that meet Table 1003-2 and this section. With permission, the Contractor may use a quantity of chemical admixture within the range shown on the current list of approved admixtures maintained by the Materials and Tests Unit.

Submit grout mix designs in terms of saturated surface dry weights on *Materials and Tests Form 312U* at least 35 days before proposed use. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated surface dry mix proportions will not be permitted unless revised grout mix designs have been submitted to the Engineer and approved.

Accompany *Materials and Tests Form 312U* with a listing of laboratory test results of compressive strength, density and flow or slump and if applicable, aggregate gradation, height change and durability from a certified laboratory. List the compressive strength of at least three 2 inch cubes at the age of 3 and 14 or 28 days per Table 1003-2 for Type 1 through 4 grouts. List the compressive strength of at least three 6 inch x 12 inch cylinders at the age of 3 and 28 days for Type 6 grout.

The Engineer will review the grout mix design for compliance with the contract and notify the Contractor as to its acceptability. Do not use a grout mix until written notice has been received. Acceptance of the grout mix design or use of approved packaged grouts does not relieve the Contractor of his responsibility to furnish a product that meets the contract.

Perform laboratory tests in accordance with the following test procedures:

Property	Test Method
Aggregate Gradation[A]	AASHTO T 27
Compressive Strength	AASHTO T 106
Density (Unit Weight)	AASHTO T 121, AASHTO T 133[B], ANSI/API RP[C] 13B-1[B] (Section 4, Mud Balance)
Durability	AASHTO T 161[D]
Flow	ASTM C939 (Flow Cone)
Height Change	ASTM C1090[E]
Slump	AASHTO T 119 (Except do not rod grout)

A. Applicable to grout with aggregate.
B. Applicable to Neat Cement Grout.
C. American National Standards Institute/American Petroleum Institute Recommended Practice.
D. Procedure A (Rapid Freezing and Thawing in Water) required
E. Moist room storage required.

1003-4 GROUT REQUIREMENTS

Provide grout types in accordance with the contract. Use grouts with properties that meet Table 1003-2. For Type 1 through 5 grouts, the compressive strength of the grout will be considered the average compressive strength test results of three 2 inch cubes at the oldest age per Table 1003-2. Make cubes that meet AASHTO T 106 from the grout delivered for the work or mixed on-site. Make cubes at such frequencies as the Engineer may determine and cure them in accordance with AASHTO T 106.

For Type 5 grout, use neat cement grout that only contains cement and water with a water cement ratio of 0.4 to 0.5, which is approximately 5.5 gallons of water per 94 lbs. of Portland cement.

For Type 6 grout, the compressive strength of the grout will be considered the average compressive strength test results of three 6 inch x 12 inch cylinders at the age of 28 days. Make cylinders in accordance with AASHTO R 100 except do not rod grout. Make cylinders at such frequencies as the Engineer may determine and cure them in accordance with AASHTO R 100.

TABLE 1003-2
GROUT REQUIREMENTS

Type of Grout	Minimum Compressive Strength at			Height Change at 28 days	Flow[A]/Slump[B]	Minimum Durability Factor
	3 days	14 days[C]	28 days			
1	3,000 psi	-	-	-	10 – 30 sec	-
2	Table 1[D]				Fluid Consistency[D]	-
3	5,000 psi[E]	5,000 psi	-	0 – 0.2%	Per Accepted Grout Mix Design or Approved Packaged Grout[F]	80
4[G]	600 psi	-	1,500 psi	-	10 – 26 sec	-
5	1,500 psi	-	4,000 psi	-	Per Standard Mix Design specified in Article 1003-4	-
6	100 psi	-	250 psi	-	< 2"	-

A. Applicable to Type 1 through 4 grouts.
B. Applicable to Type 6 grout.
C. Not applicable to Type 2 grout
D. ASTM C1107.
E. Minimum compressive strength at 3 days is only required to approve Type 3 grout mix designs or evaluate Type 3 packaged grouts for the NCDOT APL.
F. Add mixing water to Type 3 packaged grout at the manufacturer's recommended rate to produce grout with the designed consistency and required 3 day strength.
G. Use Type 4 grout with proportions by volume of 1 part cement and 3 parts fly ash.

1003-5 TEMPERATURE REQUIREMENTS

When using an approved packaged grout, follow the manufacturer's instructions for grout and air temperature at the time of placement. Otherwise, the grout temperature at the time of placement shall be not less than 50°F nor more than 90°F. Do not place grout when the air temperature measured at the location of the grouting operation in the shade away from artificial heat is below 40°F.

1003-6 ELAPSED TIME FOR PLACING GROUT

Agitate grout continuously before placement. Regulate the delivery so the maximum interval between the placing of batches at the work site does not exceed 20 minutes. Place grout before exceeding the times in Table 1003-3. Measure the elapsed time as the time between adding the mixing water to the grout mix and placing the grout.

TABLE 1003-3
ELAPSED TIME FOR PLACING GROUT
(with continuous agitation)

Air or Grout Temperature, Whichever is Higher	Maximum Elapsed Time	
	No Retarding Admixture Used	Retarding Admixture Used
90°F or above	30 minutes	1 hr. 15 minutes
80°F through 89°F	45 minutes	1 hr. 30 minutes
79°F or below	60 minutes	1 hr. 45 minutes

1003-7 MIXING AND DELIVERY

Use grout free of any lumps and undispersed cement. When using an approved packaged grout, mix grout in accordance with the manufacturer's instructions. Otherwise, comply with Articles 1000-9 through 1000-13 to the extent applicable for grout instead of concrete.

SECTION 1005
GENERAL REQUIREMENTS FOR AGGREGATE

1005-1 GENERAL

Obtain aggregates from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006. Obtain aggregates from pre-approved sources, or have the source approved through the Department's Aggregate QC/QA Program before use. Approval of such sources is based not only on the quality of the aggregate, but also on satisfactory production facilities and procedures. A list of approved aggregate sources participating in the Department's Aggregate QC/QA Program in North Carolina and adjoining states is available from the Materials and Tests Unit. Use of aggregates is allowed in the work provided they have been properly stockpiled in units of not less than 300 tons, tests of representative samples of these aggregates indicate satisfactory compliance with the specifications and the source meets all the requirements of the Aggregate QC/QA Program.

Separate aggregate containing rock of more than one identifiable rock type or particles of visibly different degrees of weathering in amounts of 10% or more into each individual type. Aggregate is acceptable only if each type does not exceed the percentage of wear specified for a particular use.

Blended aggregates from different sources are allowed if all aggregates meet the Specifications for soundness or resistance to abrasion.

1005-2 HANDLING AND STORING AGGREGATES

Handle and stockpile aggregates in such a manner to minimize segregation.

Provide sites for aggregate stockpiles that are cleared, grubbed and cleaned with a firm, smooth and well drained ground surface. Maintain a cover of at least 3 inches of aggregate over the ground surface to avoid the inclusion of soil or foreign material. Operate trucks or other equipment on a stockpile in an acceptable manner.

Space, or separate with suitable walls or partitions, stockpiles of different types or sizes of aggregates to prevent the mixing of the aggregates. Do not allow the stockpile to become contaminated with foreign matter or degrade excessively. Failure of aggregate samples to meet all gradation requirements due to excessive degradation will be determined by sieve tests of samples taken from any portion of the stockpile and is cause for discontinuance of such stockpiling procedure.

Stockpiled aggregates should be essentially free of clay or shale particles, and should contain dust that is primarily rock dust produced through normal handling of the aggregate.

Sampling stockpiles for conformance shall be conducted as described in the Aggregate QC/QA Program manual.

1005-3 GRADATION

Grade all standard sizes of aggregate to meet Tables 1005-1 or 1005-2.

1005-4 TESTING

Aggregates will be tested in accordance with the test methods below except where other test procedures are required by other articles covering a particular application.

Property	Test Method
Gradation	AASHTO T 27 and T11, AASHTO T 88 as Modified for Base Course and Stabilizer
Liquid Limit	AASHTO T 89 as Modified
Plasticity Index	AASHTO T 90
Resistance to Abrasion (Percentage of Wear)	AASHTO T 96
Soundness	AASHTO T 104 Using Sodium Sulfate

1 Copies of modified test procedures are available from the Materials and Tests Unit.

TABLE 1005-1
AGGREGATE GRADATION - COARSE AGGREGATE

Percentage of Total by Weight Passing													
Std. Size #	**2"**	**1 1/2"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#8**	**#10**	**#16**	**#40**	**#200**	**Remarks**
4	100	90-100	20-55	0-15	-	0-5	-	-	-	-	-	A	Asphalt Plant Mix
467M	100	95-100	-	35-70	-	0-30	0-5	-	-	-	-	A	Asphalt Plant Mix
5	-	100	90-100	20-55	0-10	0-5	-	-	-	-	-	A	AST, Sediment Control Stone
57	-	100	95-100	-	25-60	-	0-10	0-5	-	-	-	A	AST, Str. Conc., Shoulder Drain, Sediment Control Stone
57M	-	100	95-100	-	25-45	-	0-10	0-5	-	-	-	A	AST, Concrete Pavement
6M	-	-	100	90-100	20-55	0-20	0-8	-	-	-	-	A	AST
67	-	-	100	90-100	-	20-55	0-10	0-5	-	-	-	A	AST, Str. Concrete, Asphalt Plant Mix
78M	-	-	-	100	98-100	75-100	20-45	0-15	-	-	-	A	AST, Str. Conc., Weep Hole Drains, , Asphalt Plant Mix
14M	-	-	-	-	100	98-100	35-70	5-20	-	0-8	-	A	Asphalt Plant Mix, AST, Weep Hole Drains, Str. Concrete
9M	-	-	-	-	100	98-100	85-100	10-40	-	0-10	-	A	AST
ABC	-	100	75-97	-	55-80	-	35-55	-	25-45	-	14-30	4-12[B]	Aggregate Base Course, Aggregate Stabilization
ABC(M)	-	100	75-100	-	45-79	-	20-40	-	0-25		-	0-12[B]	Maintenance Stabilization
Light-weight[C]	-	-	-	-	100	80-100	5-40	0-20	-	0-10	-	0-2.5	AST

A. See Subarticle 1005-4(A). **B.** See Subarticle 1005-4(B). **C.** For Lightweight Aggregate used in Structural Concrete, see Subarticle 1014-2(E)(6)

(A) When aggregates are used for Portland cement concrete, asphalt treatment and asphalt plant mix, the requirements pertaining to material passing the No. 200 sieve are as follows:

(1) When tested in a stockpile at the quarry site, the amount of material passing the No. 200 sieve shall be no greater than 1.0%.

(2) When tested at the job site before use, the amount of material passing the No. 200 sieve shall:

(a) Be no greater than 1.5% for aggregate used in Portland cement concrete or asphalt surface treatment.

(b) Be no greater than 2.0% for aggregate used in asphalt plant mix.

(3) If a stockpile at the job site is found to contain in excess of the specified amount of material passing the No. 200 sieve before use, the Engineer may approve its use provided:

(a) For aggregate used in Portland cement concrete, the total percentage by weight passing the No. 200 sieve in the combined coarse and fine aggregate in the mix does not exceed 3.5%, and provided no increase in water-cement ratio is required by the use of this aggregate.

(b) For aggregate used in asphalt plant mix, the total percentage by weight of minus No. 200 material in the plant mix being produced, as determined by the extraction test, can be maintained within the limits allowed by the job mix formula.

(B) For ABC and ABC(M), in addition to the gradation requirements, the material passing the No. 40 sieve shall not have a LL in excess of 30 nor a PI in excess of 4. If PI exceeds 4 and is no more than 6, soil mortar limits apply. If PI exceeds 6, material shall be rejected. The gradation requirements for material passing the No. 10 sieve (soil mortar) will be as required in Section 1010.

TABLE 1005-2
AGGREGATE GRADATION FINE AGGREGATE

Std. Size #	Percentage of Total by Weight Passing								Remarks
	3/8"	#4	#8	#16	#30	#50	#100	#200	
1S	100	90-100		40-85		0-20		0-3	Blotting Sand, Asphalt Retreatment
2S	100	95-100	80-100	45-95	25-75	5-30	0-10	0-3	Concrete, Shotcrete, Grout, Subsurface Drainage, Blotting Sand
2MS		95-100	80-100	45-95	25-75	5-35	0-20	0-8[A]	Concrete, Shotcrete, Grout, Subsurface Drainage
4S		100	95-100			15-45	0-10	0-5	Mortar

A. When tested at the job site before use, the amount of material passing the No. 200 sieve shall not be greater than 10%.

SECTION 1006
AGGREGATE QUALITY CONTROL/QUALITY ASSURANCE

The Aggregate QC/QA Program is designed to allow aggregate producers the responsibility for controlling the quality of material they produce and to utilize the quality control information they provide in the acceptance process by the Department. It requires aggregate producers to perform quality control sampling, testing and record keeping on aggregates they ship for use by the Department. It requires the Department to perform quality assurance sampling, testing and record keeping confirming the performance of the producers' control plan. The program and participation requirements are described in the *Aggregate QC/QA Program Manual*.

Participation in this program does not relieve the producer of the responsibility of complying with all requirements of the *Standard Specifications*.

SECTION 1008
AGGREGATE FOR STABILIZATION

1008-1 AGGREGATE STABILIZATION

(A) General

Aggregates consist of crushed stone, crushed gravel, uncrushed gravel or other similar material having hard, strong, durable particles free of adherent coatings.

Supply aggregates from approved sources participating in the Department's Aggregate QC/QA Program in accordance with Sections 1005 and 1006. Sources will not be approved unless the material has satisfactory soundness and satisfactory resistance to abrasion. Satisfactory soundness will be a loss in weight of not greater than 15% when subject to 5 alternations of the soundness test. Satisfactory resistance to abrasion will be a percentage of wear of not greater than 55%.

(B) Sampling and Acceptance

Sampling and acceptance for the determination of gradation, LL and PI will be performed as described in the *Aggregate QC/QA Program Manual* and the *Aggregate Sampling Manual* using the versions in effect at the time material is shipped.

SECTION 1010
AGGREGATE FOR NON-ASPHALT TYPE BASES

1010-1 AGGREGATE BASE COURSE

(A) General Requirements

Aggregate base course material consists of crushed stone, crushed gravel, uncrushed gravel or other similar material having hard, strong, durable particles free of adherent coatings.

Provide aggregates from approved sources participating in the Department's Aggregate QC/QA Program in accordance with Sections 1005 and 1006. Sources will not be approved unless the material has satisfactory soundness and resistance to abrasion. Satisfactory soundness will be a weighted average loss of not greater than 15% when subjected to five alternations of the soundness test. Satisfactory resistance to abrasion will be a percentage of wear of not greater than 55%.

(B) Sampling and Acceptance

Sampling and acceptance for the determination of gradation, LL and PI will be performed as described in the *Aggregate QC/QA Program Manual* and the *Aggregate Sampling Manual* using the versions in effect at the time material is shipped.

1010-2 AGGREGATE FOR PLANT MIXED CEMENT TREATED BASE COURSE

Provide aggregate meeting Article 1010-1, except as modified herein. Sources of aggregate will not be approved unless the material has a percentage of wear of not greater than 65%.

SECTION 1012
AGGREGATE FOR ASPHALT PAVEMENTS AND SURFACE TREATMENTS

1012-1 AGGREGATE FOR ASPHALT PLANT MIXES

(A) General

Design the asphalt plant mix with coarse and fine aggregate that meet Section 1005, except as noted herein. Size, uniformly grade and combine the aggregate fractions in such proportions that the resulting mixture meets the grading and physical requirements of these specifications for the specified mix type. Materials that will not produce a mixture within the design criteria required by these specifications will be rejected, unless otherwise approved by the Engineer.

The consensus property criteria in Table 1012-1 apply to the design aggregate blend. Source property criteria apply to individual aggregate sources.

For all dense-graded surface course mixes, that are the top or final layer, limit the amount of coarse aggregate or fine aggregate produced from crystalline limestone, crystalline-dolomitic limestone or marble to no more than 50% of the total amount of coarse aggregate or fine aggregate in the asphalt mixture. For open-graded asphalt friction course and ultra-thin bonded wearing course, do not use aggregates produced from crystalline limestone, crystalline-dolomitic limestone or marble.

(B) Coarse Aggregate

(1) General

Use coarse aggregate consisting of crushed stone, crushed gravel, a mixture of uncrushed gravel with either crushed stone or crushed gravel or other inert material having similar characteristics. Provide coarse aggregate composed of clean, tough, durable fragments free from an excess of flat or elongated pieces and free of organic matter and deleterious substances.

Use coarse aggregate from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006. A list of sources participating in the Department's Aggregate QC/QA Program in North Carolina and adjoining states is available from the Materials and Tests Unit in Raleigh.

(2) Gradation

Use standard size coarse aggregate meeting Table 1005-1 and these *Standard Specifications* unless otherwise approved by the Engineer.

(3) Coarse Aggregate Angularity (Fractured Faces)

Use coarse aggregate meeting Table 1012-1 for coarse aggregate angularity (fractured faces) when tested in accordance with ASTM D5821.

(4) Flat and Elongated Pieces

Use coarse aggregate meeting Table 1012-1 for flat and elongated pieces when tested in accordance with ASTM D4791 on the No. 4 sieve and larger with a 5:1 aspect ratio (maximum to minimum) for all pavement types, except there is no requirement for Types S4.75A and S9.5B.

(5) Soundness

The maximum weighted average soundness loss of individual coarse aggregate sources when subjected to 5 cycles using sodium sulfate when tested in accordance with AASHTO T 104 is 15%.

TABLE 1012-1
AGGREGATE CONSENSUS PROPERTIES[A]

Mix Type	Coarse Aggregate Angularity[B]	Fine Aggregate Angularity % Minimum	Sand Equivalent % Minimum	Flat and Elongated 5 : 1 Ratio % Maximum
Test Method	*ASTM D5821*	*AASHTO T 304*	*AASHTO T 176*	*ASTM D4791*
S4.75A; S9.5B	75 / -	40	40	-
S9.5C; I19.0C; B25.0C	95 / 90	45	45	10
S9.5D	100 / 100	45	50	10
OGFC	100 / 100	45	45	10
UBWC	100 / 85	45	45	10

A. Requirements apply to the design aggregate blend.
B. 95/90 denotes that 95% of the coarse aggregate has one fractured face and 90% has 2 or more fractured faces.

(6) Toughness (Resistance to Abrasion)

The maximum allowable percentage of loss of each individual coarse aggregate source for all plant mix types except open-graded asphalt friction course, shall be 55% when tested in accordance with AASHTO T 96. The maximum percentage loss for aggregate used in OGFC shall be 45%. The percentage loss for aggregate used in UBWC shall be no more than 35%.

(7) Deleterious Materials

The maximum allowable percentage by weight of clay lumps and friable particles in individual aggregate sources shall be 1% when tested in accordance with AASHTO T 112.

(8) Durability (Micro-Deval test)

The maximum allowable abrasion loss for aggregate used in UBWC shall be 18% when tested in accordance with AASHTO T 327.

(C) Fine Aggregate

(1) General

Use fine aggregate that is consistently graded from coarse to fine and consists of natural sand, stone screenings, or a blend of natural sand and stone screenings. Use aggregate composed of rough surfaced and angular grains of quartz or other hard durable rock.

Use fine aggregate from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006. A list of sources participating in the Department's QC/QA Program in North Carolina and adjoining states is available from the Department's Materials and Tests Unit in Raleigh. If a natural sand source is owned by the same owner as the asphalt plant where the material is used, participation in the Aggregate QC/QA Program is not required.

Furnish sand from approved sources. Do not use sources contaminated by industrial waste. A sufficient number of samples of fine aggregate, but in no case less than three, will be taken to indicate any variation within any stockpile or source of supply.

Do not use fine aggregate containing sticks, roots, trash, visible lumps of clay, or other unsatisfactory material unless all undesirable material is removed to the satisfaction of the Engineer before the aggregate is used in the asphalt mixture.

Use natural sand that is non-plastic when tested in accordance with AASHTO T 90.

Produce stone screenings from stone that has a maximum percentage of wear of 55% when tested in accordance with AASHTO T 96 using test grading A.

(2) Gradation

Use stone screenings that are consistently graded with not more than 20% by weight passing the No. 200 sieve when tested by dry sieving in accordance with AASHTO T 27. Use natural sand that is consistently graded.

(3) Clay Content (Sand Equivalent)

Use a fine aggregate blend that has a minimum sand equivalent percentage as indicated in Table 1012-1 when tested in accordance with AASHTO T 176.

(4) Soundness

The maximum weighted average soundness loss of individual fine aggregate sources when subjected to 5 cycles using sodium sulfate shall be 15% when tested in accordance with AASHTO T 104.

Natural sand that contains grains of questionable hardness will be subjected to 5 cycles of the soundness test. The weighted average loss shall be not more than 15%. The soundness test will be performed before establishing the mix design.

(5) Deleterious Materials

The maximum percentage by weight of clay lumps and friable particles in individual fine aggregate sources shall be 1% when tested in accordance with AASHTO T 112.

(6) Fine Aggregate Angularity

Use a fine aggregate blend that has a minimum fine aggregate angularity as indicated in Table 1012-1 when tested in accordance with AASHTO T 304, Method A.

(D) Mineral Filler

Use mineral filler consisting of limestone dust, dolomite dust, Portland cement, or other inert mineral matter that conforms to AASHTO M 17.

(E) Reclaimed Asphalt Shingles (RAS)

For use in asphalt mix, Reclaimed Asphalt Shingles (RAS) can be either manufacturer-waste shingles or post-consumer shingles that have been processed into a product that meets the requirements of this section.

Manufacturer-waste RAS (MRAS) are processed shingle materials discarded from the manufacturing of new asphalt shingles. It may include asphalt shingles or shingle tabs that have been rejected by the shingle manufacturer.

Post-consumer RAS (PRAS) are processed shingle materials recovered from mixed roofing material scrap removed from existing structures. Tear-off shingle scrap must be sorted and other roofing debris, including nails, plastic, metal, wood, coal tar epoxy, rubber materials, or other undesirable components, shall be removed. This sorting of the scrap must be done prior to grinding of the PRAS for use in asphalt production.

Sample and test PRAS for asbestos and provide results demonstrating that the bulk samples contain less than one percent of asbestos containing material in accordance with Federal, State of North Carolina, and Local regulations. Use NC-accredited Asbestos Inspectors or Roofing Supervisors to sample the PRAS to meet the above criteria. Maintain records on-site indicating shingle source(s), asbestos operation plan approved by Division of Public Health's Health Hazards Control Unit, and all asbestos analytical reports. All documentation will be subject to review by the Department.

Process RAS by ambient grinding or granulating methods such that 100% of the particles will pass the 9.50 mm (3/8 inch) sieve when tested in accordance with AASHTO T27. Perform sieve analysis on processed asphalt shingles prior to ignition or solvent extraction testing.

RAS shall contain no more than 0.5% by total cumulative weight of deleterious materials. These materials include, but are not limited to, excessive dirt, debris, concrete, metals, glass, paper, rubber, wood, plastic, soil, brick, tars, or other contaminating substances.

Blend RAS with fine aggregate, meeting the requirements of this Section, if needed to keep the processed material workable. Any stockpile containing RAS will be considered a RAS stockpile and will be limited in mixtures as prescribed in Article 610-3.

MRAS and PRAS shall not be blended together for the production of hot mix asphalt.

(1) Mix Design RAS

Incorporate RAS from stockpiles that have been tested for uniformity of gradation and binder content prior to use in an asphalt mix design.

(2) Mix Production RAS

New Source RAS is defined as acceptable material which was not included in the stockpile when samples were taken for mix design purposes. Process new source RAS so that all materials will meet the gradation requirements prior to introduction into the plant mixer unit.

After a stockpile of processed RAS has been sampled and mix designs made from these samples, do not add new source RAS to the original stockpile without prior field testing to ensure gradation and binder uniformity. Sample and test new source RAS before blending with the existing stockpile.

Store new source RAS in a separate stockpile until the material can be sampled and tested for comparison with the original recycled mix design data. New source RAS may also be placed against the existing stockpile in a linear manner provided it is sampled for mix design conformity prior to its use in the recycled mix. Store RAS materials in such a manner as to prevent contamination.

Field approval of new source RAS will be based on Table 1012-2 and volumetric mix properties on the mix with the new source RAS included. Provided these tolerances are met, volumetric properties of the new mix will then be performed. If all volumetric mix properties meet the mix design criteria for that mix type, the new source RAS may continue to be used.

If the gradation, binder content, or any of the volumetric mix properties are not within the allowable tolerances of Table 1012-2, do not use the new source RAS unless approved by the Engineer. The Contractor may elect to either not use the stockpile, to request an adjustment to the JMF, or to redesign the mix.

TABLE 1012-2 NEW SOURCE RAS BINDER AND GRADATION TOLERANCES (Apply Tolerances to Mix Design Data)	
P_b %	**± 2.5**
Sieve Size, mm	*Tolerance*
4.75	± 5
2.36	± 4
1.18	± 4
0.300	± 4
0.150	± 4
0.075	± 2.0

(F) Reclaimed Asphalt Pavement (RAP)

(1) RAP Classifications

During production incorporate RAP from stockpiles or other sources tested for uniformity of gradation and binder content before use in an asphalt mix. Ensure that no deleterious material is allowed in any stockpile. When multiple stockpiles of recycled material are used during production, erect and maintain signs satisfactory to the Engineer properly identifying each stockpile. Use RAP that meets all requirements specified for the following classifications.

(a) Millings

Existing RAP that is removed from its original location by a milling process as specified in Section 607. Millings shall have a uniform gradation and binder content and all materials must pass a 1 1/2 inch sieve before introduction into the plant mixer unit.

(b) Processed RAP

RAP that is processed by crushing, screening and/or blending to produce a uniform gradation and binder content. Processed RAP shall have a uniform gradation and binder content and will pass a 1 inch sieve before introduction into the plant mixer unit.

(c) Fractionated RAP

RAP that is processed by crushing, screening and/or blending into one or two stockpiles. When only one fractionated RAP stockpile is used, the stockpile shall only contain material passing the 5/8 inch sieve. If a second coarse fraction is used, the coarse stockpile shall only contain material passing the 1 inch sieve and retained on the 5/8 inch sieve. The Engineer may allow the Contractor to use an alternate screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse, fine, or the combination of both. Use a separate cold feed bin for each stockpile of fractionated RAP introduced into the plant mixer unit.

Perform gradation and asphalt content tests at a rate of one per 1,000 tons of RAP, with at least five tests per stockpile to determine the asphalt content and gradation. Assure that no deleterious material is allowed to contaminate any stockpile. The Engineer may reject by visual inspection any stockpiles that are not kept clean, separated and free of foreign materials.

For the Fractionated RAP to be considered for approval, the gradation and asphalt content shall be uniform. Individual test results, when compared to the target, will be accepted if within the tolerances listed in Table 1012-3.

TABLE 1012-3 FRACTIONATED RAP GRADATION AND BINDER TOLERANCES[A] (Apply Tolerances to Mix Design Data)	
P_b %	**± 0.3%**
Sieve Size, mm	*Tolerance*
25.0	± 5%
19.0	± 5%
12.5	± 5%
9.50	± 5%
4.75	± 5%
2.36	± 4%
1.18	± 4%
0.300	± 4%
0.150	± 4%
0.075	± 1.5%

A. If more than 20% of the individual sieves are out of the gradation tolerances, or if more than 20% of the asphalt binder content test results fall outside the appropriate tolerances, the RAP shall not be used in asphalt mix unless the RAP representing the failing tests is removed from the stockpile.

Do not add additional material to any fractionated RAP stockpile, unless otherwise approved by the Engineer.

Maintain a record system for all fractionated RAP stockpiles at the plant site. Include at a minimum the following: Stockpile identification and a sketch of all stockpile areas at the plant site; all RAP test results (including asphalt content, gradation and asphalt binder characteristics).

(2) RAP Management During Production

New source RAP is any acceptable material that was not included in the stockpile or other source when samples were taken for mix design purposes.

After a stockpile of millings, processed RAP or fractionated RAP has been sampled and mix designs made from these samples, do not add new source RAP to the original stockpile without prior field testing to insure gradation and binder uniformity. Sample and test new source RAP to ensure it meets one of the RAP Classifications in Subarticle 1012-1(F)(1) before blending with the existing stockpile.

Store new source RAP in a separate stockpile until the material can be sampled and tested for comparison with the original recycled mix design data. New source RAP may also be placed against the existing stockpile in a linear manner provided it is sampled for mix design conformity before its use in the recycled mix.

Unprocessed RAP is asphalt material that was not milled and/or has not been processed to obtain a uniform gradation and binder content and is not representative of the RAP used during the applicable mix design. Unprocessed RAP shall not be incorporated into any JMFs before processing. Different sources of unprocessed RAP may be stockpiled together provided it is generally free of contamination and will be processed before use in a recycled mix. RAP contamination in the form of excessive dirt, debris, clean stone, concrete, etc. will not be allowed. Incidental amounts of dirt, concrete and clean stone may be acceptable. Unprocessed RAP may be processed and then classified as a new source RAP as described above.

Field approval of new source RAP will be based on Table 1012-4 and volumetric mix properties in the mix with the new source RAP included. Provided the Table 1012-3 tolerances are met, volumetric properties of the new mix will then be performed. If all volumetric mix properties meet the mix design criteria for that mix type, the new source RAP may continue to be used.

If the gradation, binder content, or any of the volumetric mix properties are not within the allowable tolerances of Table 1012-4, do not use the new source RAP unless approved by the Engineer. The Contractor may elect to either not use the stockpile, to request an adjustment to the JMF, or to redesign the mix.

TABLE 1012-4
NEW SOURCE RAP GRADATION AND BINDER TOLERANCES
(Apply Tolerances To Mix Design Data)

	0 - 20% RAP			20 - 30 % RAP			> 30 % RAP		
Pb, %	± 0.7%			± 0.4%			± 0.3%		
Sieve Size, mm	Mix Type			Mix Type			Mix Type		
	Base	Inter.	Surf.	Base	Inter.	Surf.	Base	Inter.	Surf.
25.0	±10	-	-	±7	-	-	±5	-	-
19.0	±10	±10	-	±7	±7	-	±5	±5	-
12.5	-	±10	±6	-	±7	±3	-	±5	±2
9.50	-	-	±8	-	-	±5	-	-	±4
4.75	±10	-	±10	±7	-	±7	±5	-	±5
2.36	±8	±8	±8	±5	±5	±5	±4	±4	±4
1.18	±8	±8	±8	±5	±5	±5	±4	±4	±4
0.300	±8	±8	±8	±5	±5	±5	±4	±4	±4
0.150	-	-	±8	-	-	±5	-	-	±4
0.075	±4	±4	±4	±2	±2	±2	±1.5	±1.5	±1.5

1012-2 AGGREGATES FOR ASPHALT SURFACE TREATMENT

(A) General

Use coarse aggregate consisting of crushed stone, crushed gravel, or other inert material having similar characteristics. Adequately wash coarse aggregate so it is free from clay, loam, dust and other adherent materials.

Adequately clean all fine aggregate so it is free from sticks, roots, visible lumps of clay or other unsatisfactory material before use.

(B) Gradation

Use coarse aggregate for mat and seal coat and AST as required by Section 660, unless otherwise required by the contract. Use aggregate meeting the applicable gradation requirements of Table 1005-1.

Remix aggregate that has become segregated until it meets the applicable gradation requirements.

(C) Fractured Faces

Use coarse aggregate that contains at least 75% by weight of crushed pieces having 2 or more fractured faces and at least 90% by weight of crushed pieces having one or more fractured faces on that portion retained on the No. 4 sieve.

(D) Soundness

The maximum weighted average loss of either coarse or fine aggregate when subjected to 5 cycles using sodium sulfate when tested in accordance with AASHTO T 104 is 15%.

(E) Toughness (Resistance to Abrasion)

The maximum percentage loss of coarse aggregate for asphalt surface treatment when tested in accordance with AASHTO T 96 is 55%.

(F) Blending of Aggregates

Blending of two or more aggregates will not be permitted regardless of the origin of the aggregates if any one of the aggregates fails to meet the requirements for soundness or resistance to abrasion.

1012-3 BLOTTING SAND

Blotting sand is fine aggregate consisting of natural sand, commercial sand, manufactured sand, coarse screenings, or other inert material having similar characteristics. Subarticles 1012-2(D) and 1012-2(F) will be applicable to blotting sand. Adequately clean the fine aggregate so it is free from sticks, roots, visible lumps of clay or other unsatisfactory material before use.

1012-4 LIGHTWEIGHT AGGREGATE

Lightweight aggregates used in asphalt surface treatments shall be produced by the rotary kiln process and shall come from an approved Department source meeting applicable requirements of Section 1005 and 1006. The aggregate shall meet Table 1012-5 and AASHTO M 195 with the exception of any other references to concrete samples or concrete strength.

TABLE 1012-5
LIGHTWEIGHT AGGREGATE PHYSICAL PROPERTIES

Property	Specification (maximum limit)	Test Method
Sodium Sulfate Soundness	5%	AASHTO T 104
Los Angeles Abrasion	45%	AASHTO T 96 (B grading)
Percent Absorption	10%	AASHTO T 19
Micro-Deval	18%	AASHTO T 327

SECTION 1014
AGGREGATE FOR PORTLAND CEMENT CONCRETE

1014-1 FINE AGGREGATE

(A) General

Use fine aggregate from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006. A list of sources participating in the Department's QC/QA Program in North Carolina and adjoining states is available from the Materials and Tests Unit.

Use fine aggregate consisting of natural sand or manufactured sand having clean, durable, hard, uncoated particles, or other inert materials having similar characteristics. Produce manufactured sand from fractured stone material. Use fine aggregate free from dirt, wood, paper, burlap and all other foreign material.

To permit excess water to drain and the moisture content to become uniform, stockpile the aggregates either at the producer's plant or at the batch plant site for at least 24 hours before use in the concrete. Build open stockpiles of fine aggregate at the batch plant on concrete surfaces. Do not add new material to the stockpile during the 24 hour period. When the aggregates have a low and uniform moisture content and the consistency of the concrete can be satisfactorily controlled without stockpiling the aggregates for 24 hours, the minimum stockpiling period may be reduced or waived entirely by the Engineer.

The Department's list of approved sources of fine aggregate shows the target fineness modulus of each aggregate as established by the producer. Do not use fine aggregate with a fineness modulus that varies more than 0.2 from the target value until the concrete mix proportions are adjusted.

(B) Soundness

When subjected to 5 cycles of the soundness test, the weighted average loss shall not be more than 15%.

(C) Deleterious Substances

Determine the percentage of deleterious substances (clay lumps and friable particles) in accordance with AASHTO T 112. The amount of deleterious substances shall not exceed 2.0% by weight for natural sand or 1.0% by weight for manufactured sand.

(D) Organic Impurities

The color of each source of fine aggregate will be determined annually in accordance with AASHTO T 21. Should the fine aggregate show a darker color than samples previously approved from the same source, withhold its use until tests have been made to determine the quality of the sand.

(E) Mortar Strength

Mortar made with the fine aggregate shall have a compressive strength at the age of 3 and 7 days using Type III Portland cement, or 7 and 28 days using Type I or II Portland cement, of not less than 95% of that developed by a comparison mortar. Make the comparison mortar with the same cement, graded Ottawa sand with a fineness modulus of 2.40 ± 0.05, and the same water-cement ratio and consistency as the test mortar. Test the mortar strength in accordance with AASHTO T 106.

Fine aggregate that fails the mortar strength may be used with the approval of the Engineer, provided that when it is tested in concrete cylinders the compressive strength of the concrete at 14 days is equal to or greater than the strength of cylinders made with an identical mix using an acceptable sand.

(F) Gradation

Natural sand shall meet the gradation for standard size No. 2S fine aggregate. Manufactured sand shall meet the gradation for standard size No. 2MS fine aggregate.

(G) Blending Fine Aggregate

Blending fine aggregates to obtain the required gradation will be permitted if test results of each aggregate meet the durability requirements and test results of the combination indicate acceptable quality. Blend aggregates by weighing them separately at the time of batching or by other means acceptable to the Engineer.

When natural sand is blended with natural sand, the blend shall meet the gradation for No. 2S fine aggregate. When manufactured sand is blended with natural sand or with manufactured sand, the blend shall meet the gradation for No. 2MS fine aggregate and neither component shall exceed the gradation limits on the No. 200 sieve shown in Table 1005-2.

1014-2 COARSE AGGREGATE

(A) General

Use coarse aggregate from sources participating in the Department's Aggregate QC/QA Program as described in Section 1006. A list of these sources in North Carolina and adjoining states is available from the Materials and Tests Unit in Raleigh.

Use coarse aggregate that consists of crushed stone, crushed or uncrushed gravel, crushed air-cooled blast furnace slag or other inert materials that have similar characteristics. Wash all coarse aggregate for Portland cement concrete to remove clay, loam, dust and similar adherent materials unless otherwise permitted by the Engineer in writing. Keep coarse aggregate free from dirt, wood, paper, burlap and all other foreign material.

To permit excess water to drain and the moisture content to become uniform, stockpile the aggregates either at the producer's plant or at the batch plant site for at least 24 hours before use in the concrete. Build open stockpiles of coarse aggregate at the batch plant on concrete surfaces. Do not add new material to the stockpile during the 24 hour period. Where the aggregates have low and uniform moisture content and the consistency of the concrete can be satisfactorily controlled without stockpiling the aggregates for 24 hours, the minimum stockpiling period may be reduced or waived entirely by the Engineer.

Do not mix coarse aggregate from different sources or use it in alternate batches except where permitted by the Engineer in writing. Blending of coarse aggregates to obtain the required gradation will be permitted if the different sizes are from the same source. Blend coarse aggregates by weighing them separately at the time of batching or by other means acceptable to the Engineer.

(B) Soundness

When subjected to 5 cycles of the soundness test, the weighted average loss shall not exceed 15%. For concrete with a 28 day design compressive strength greater than 6,000 psi, the loss shall not exceed 8%.

(C) Deleterious Substances

Determine the percentage of deleterious substances (clay lumps and friable particles) in accordance with AASHTO T 112. The amount of deleterious substances shall not exceed 3% by weight.

(D) Resistance to Abrasion

The percentage of wear of crushed stone or gravel shall not exceed 55%. For concrete with a 28 day design strength greater than 6,000 psi, the wear shall not exceed 40%.

(E) Aggregate Sizes

(1) General

Use standard size No. 57, No. 67, or No. 78M coarse aggregate in Portland cement concrete unless otherwise indicated.

(2) Latex Modified Concrete

Use standard size No. 78M coarse aggregate in latex modified concrete.

(3) Prestressed and Precast Concrete

Use standard size No. 67 or No. 78M coarse aggregate in prestressed and precast concrete.

(4) Use of More Than One Size

All concrete used in a single component of any structure shall be made with the same size aggregate.

(5) Portland Cement Concrete Pavement

Use standard size No. 57, No. 57M, No. 67 or No. 78M coarse aggregate in concrete for Portland cement concrete pavement unless otherwise specified by the Engineer.

(6) Sand Lightweight Concrete

Use the following gradation for the lightweight coarse aggregate.

TABLE 1014-1 GRADATION FOR LIGHTWEIGHT COARSE AGGREGATE	
Sieve Size	**Passing Square Opening Sieves (Percent by Weight)**
1"	100
3/4"	90 - 100
3/8"	10 - 50
No. 4	0 - 15

(7) Drilled Pier Concrete

Use standard size No. 78M coarse aggregate in Drilled Pier concrete.

SECTION 1016
SELECT MATERIALS

1016-1 DESCRIPTION

Select material is suitable material classified by gradation and performance characteristics as shown in this section.

1016-2 USES

Use select material called for in the contract. With written approval and without additional compensation, a higher class of material may be substituted than stated in the contract.

1016-3 CLASSIFICATIONS

CLASS I

Class I select material is silty or clayey soil material meeting AASHTO M 145 for soil classification A-4. Soil materials which meet AASHTO M 145 for soil classifications A-2, A-5, A-6 and A-7 are acceptable provided such materials do not have a LL greater than 50, nor a PI of less than 7 or greater than 20.

CLASS II

Type 1 Select Material

Type 1 select material is a fine aggregate material consisting of crushed stone screenings (washed or unwashed) meeting the gradation in Table 1016-1.

TABLE 1016-1 GRADATION FOR CLASS II, TYPE 1 SELECT MATERIAL	
Sieve	**Percent Passing**
3/8"	100
No. 4	80 - 100
No. 10	65 - 95
No. 40	25 - 55
No. 200	0 - 20
LL	≤ 30
PI	≤ 6

Type 2 Select Material

Type 2 select material is a granular soil material meeting AASHTO M 145 for soil classifications A-2-4 with a maximum PI of 6 and A-4 soil containing 45% maximum passing a No. 200 sieve and a maximum PI of 6.

When a type is not specified, either type may be used, but no additional compensation will be made.

CLASS III

Type 1 Select Material

Type 1 select material is a natural or manufactured fine aggregate material meeting the requirements of standard size 2S or 2MS as described in Sections 1005 and 1006.

Type 2 Select Material

Type 2 select material is a granular soil material meeting AASHTO M 145 for soil classification A-1 or A-3.

Type 3 Select Material

Type 3 select material is a natural or manufactured fine aggregate material meeting the gradation in Table 1016-2.

TABLE 1016-2
GRADATION FOR CLASS III, TYPE 3 SELECT MATERIAL

Sieve	Percent Passing
3/8"	100
No. 4	95 - 100
No. 8	65 - 100
No. 16	35 - 95
No. 30	15 - 75
No. 50	5 - 50
No. 100	0 - 25
No. 200	0 - 8

Type 3 select material shall meet the requirements described in Sections 1005 and 1006. When a type is not specified, Type 1, Type 2 or Type 3 may be used, but no additional compensation will be made.

CLASS IV

Select material is a coarse aggregate material meeting the requirements of standard size ABC as described in Sections 1005, 1006 and 1010. When material is produced from aggregates from crushed concrete, Section 1043 requirements shall be applied.

CLASS V

Select material is a coarse aggregate material meeting the requirements of standard size 78M as described in Sections 1005 and 1006.

CLASS VI

Select material is a coarse aggregate material meeting the requirements of standard size 57 as described in Sections 1005 and 1006.

CLASS VII

Select material is clean, unweathered durable, blasted rock material. While no specific gradation is required, the below criteria will be used to evaluate the materials for visual acceptance by the Engineer.

(A) At least 50% of the rock has a diameter of from 1.5 feet to 3 feet,

(B) 30% of the rock ranges in size from 2 inches to 1.5 feet in diameter, and

(C) Not more than 20% of the rock is less than 2 inches in diameter. No rippable rock will be permitted.

SECTION 1018
BORROW MATERIAL

1018-1 GENERAL

Borrow material is used for embankments, backfill or other intended uses. Material that contains roots, root mats, stumps or other unsatisfactory material will not be acceptable.

1018-2 APPROVAL OF BORROW MATERIAL

The approval of borrow material is subject to Section 230.

(A) Statewide Criteria for Acceptance of Borrow Material

See exceptions in Subarticle 1018-2(B).

Use only natural earth materials as borrow material. Any other materials are subject to rejection.

TABLE 1018-1 PIEDMONT AND WESTERN AREA CRITERIA FOR ACCEPTANCE OF BORROW MATERIAL	
Soil with PI of 25 or less	Acceptable
Soil with PI of 26 through 35	Acceptable, but not to be used in top 3 ft of embankment or backfill
Soil with PI of more than 35	Not Acceptable

(B) Exceptions to Statewide Criteria for Acceptance of Borrow Material

(1) Soils in the Coastal Plain (area described below) will be accepted by the Engineer in accordance with the Table 1018-2.

TABLE 1018-2 COASTAL AREA CRITERIA FOR ACCEPTANCE OF BORROW MATERIAL	
Soil with PI of 15 or less	Acceptable
Soil with PI of 16 through 20	Acceptable, but not to be used in top 3 ft of embankment or backfill
Soil with PI of more than 20	Not Acceptable

Areas where Table 1018-2 is applicable are as follows:

Division 1	Entire Division except Northampton (West of I-95)
Division 2	Entire Division
Division 3	Entire Division
Division 4	Edgecombe, Wayne, Johnston (East of US 301), Wilson (East of I-95), Nash (East of I-95), Halifax (East of I-95)
Division 6	Bladen, Columbus, Robeson, Cumberland, Harnett (South of NC 27)
Division 8	Scotland, Hoke, Moore (Southeast of US 15-501, NC 73, NC 211), Richmond (East of US 220 North and US 1 South)

Table 1018-2 shall be applicable to the flood plains of the Roanoke, Tar, Neuse, Cape Fear and Lumber Rivers and their tributaries that are outside the above described areas.

(2) Waste or by-products from industrial processes or mining operations are not acceptable except by specific written approval.

(3) When tested, soils having a pH of less than 5.5 or an organic content more than 4.0% may be rejected by the Engineer.

(4) When material is to be used for placing embankments or backfilling of undercut areas that are excessively wet, the material shall consist of Class II, III or IV select material.

SECTION 1019
SHOULDER AND SLOPE MATERIAL

1019-1 GENERAL

Use shoulder and slope material to construct shoulders and plate slopes with materials capable of supporting vegetation. Material that contains roots, root mats, stumps or other unsatisfactory material will not be acceptable.

1019-2 SHOULDER AND SLOPE BORROW

Use borrow sources in accordance with Section 230.

Use soil consisting of loose, friable, sandy material with a PI greater than 6 and less than 25 and a pH ranging from 5.5 to 7.0. Remove stones and other foreign material 2 inches or larger in diameter.

Soil consisting of a pH ranging from 4.0 to 5.4 may be accepted by the Engineer if the following limestone application is used. Substitute listed limestone application rates when performing seeding and mulching operations. Standard lime application rate is 4000 lbs. per acre. Soil type should be identified during the soil analysis. Soils with a pH below 4.0 should not be used. Soils with a pH above 7.0 require acidic amendments to be added. Contact the Engineer for recommendations to lower pH below 7.0.

TABLE 1019-1
LIMESTONE APPLICATION RATE (lbs / acre) TO RAISE pH

pH Test Result	Sandy Soils	Silt Loam Soils	Clay Loam Soils
4.0 to 4.4	4000 + 1000	4000 + 4000	4000 + 6000
4.5 to 4.9	4000 + 500	4000 + 3000	4000 + 5000
5.0 to 5.4	4000	4000 + 2000	4000 + 4000

1019-3 AGGREGATE SHOULDER BORROW

Use aggregate shoulder borrow (ASB) that meets the following gradation in Table 1019-2.

TABLE 1019-2
GRADATION OF AGGREGATE SHOULDER BORROW

Sieve	Percentage Passing
1 1/2"	100
1/2"	55-95
#4	35-74

SECTION 1020
ASPHALT MATERIALS AND ADDITIVES

1020-1 DELIVERY AND ACCEPTANCE OF ASPHALT MATERIALS

Asphalt materials are accepted at the source of shipment subject to the conditions herein.

All asphalt transport tankers, including rail and truck tankers, shall have a sampling valve in accordance with *Asphalt QMS Manual*, AASHTO R66, ASTM D140 or a comparable device acceptable to the Engineer.

Each transport tanker delivering asphalt materials to the project or rail siding shall keep a running log showing the date, destination and type and grade of material hauled on each trip. Print, stamp, or write in ink information appearing in the log and have available for examination upon request.

Furnish with each shipment 2 copies of a delivery ticket. Ensure both copies accompany the shipment and are delivered to the Engineer or his representative at the destination. The delivery ticket must contain all necessary information to identify the material and meet the state requirements of the Department of Agriculture and Consumer Services or other appropriate state agency that the asphalt terminal is in, the Department's *Performance Graded Asphalt Binder QC/QA Program* and the Department's *Asphalt Emulsion QC/QA Program*.

When anti-strip additive is introduced into the asphalt binder, ensure the delivery ticket notes the brand, grade and percentage or quantity at which the additive was introduced.

Furnish a statement of certification from the supplier and a separate statement of certification from the transporter. Sign each certification by an authorized representative of the supplier or transporter. Stamp, write or print these certifications on the delivery ticket in accordance with the appropriate QC/QA Program (Department's *Performance Graded Asphalt Binder QC/QA Program* or the Department's *Asphalt Emulsion QC/QA Program*), or attach to the delivery ticket.

Failure to sign the certifications by either the supplier or transporter will be cause to withhold use of the material until a sample can be taken and tested, except where an alternative testing and invoicing procedure has been pre-approved by the Engineer.

The Engineer reserves the right to sample and test any shipment regardless of whether the above conditions have been met and to reject any material not meeting the specifications.

1020-2 ASPHALT BINDER

Use performance graded asphalt binder meeting AASHTO M 320 Table 1 and the Department's *Performance Graded Asphalt Binder QC/QA Program*. See Article 610-3 for the specified grades.

Submit a Quality Control Plan for asphalt binder production in conformance with AASHTO R 26 and the Department's *Performance Graded Asphalt Binder QC/QA Program* to the Asphalt Workgroup in the Materials and Tests Unit. The Department's *Performance Graded Asphalt Binder QC/QA Program* shall be implemented in accordance with Article 1020-6.

Where modification of the asphalt binder is required to meet the specified grade, accomplish the modification using a styrene butadiene styrene (SBS), styrene butadiene rubber (SBR), styrene butadiene (SB) polymer or other modifiers approved by the Engineer to modify asphalt to meet the grade specified before delivery to the asphalt plant. Other polymers shall be pre-approved and listed by the Materials and Tests Unit. Air blown asphalt will not be permitted.

1020-3 ASPHALT EMULSION

Use asphalt emulsion that meets the requirements in the Department's *Asphalt Emulsion QC/QA Program*. The program includes requirements for latex modified, polymer modified, and non-tracking tack emulsified asphalt products and producers. New emulsified asphalt products will need to go through the new products approval process.

Submit a QC Plan for asphalt emulsion that meets the Department's *Asphalt Emulsion QC/QA Program* to the Materials and Tests Unit.

1020-4 POLYMER MODIFIED EMULSION MEMBRANE

Use polymer modified emulsion membrane consisting of styrene butadiene block copolymer modified asphalt emulsion to form a water impermeable seal and bond the new hot mix to the existing surface. Complete polymer modification of base asphalt before emulsification. Conform to Table 1020-1.

TABLE 1020-1 EMULSION AND RESIDUE TESTING			
Property	**Requirement**		**Test Method**
EMULSION:	**Min.**	**Max.**	
Saybolt Viscosity @ 77°F, SFS	20	100	AASHTO T 59
Sieve Test, %		0.1	AASHTO T 59
24-Hour Storage Stability, %[A]		1	AASHTO T 59
Residue from Distillation, %[B]	63		AASHTO T 59
Oil portion from distillation ml of oil per 100 g emulsion		2.0	
Demulsibility	60		AASHTO T 59
RESIDUE:			
Solubility in TCE, %	97.5		AASHTO T 44
Elastic Recovery	60		AASHTO T 301
Penetration @ 77°F, 100 g, 5 sec, d_{mm}	60	150	AASHTO T 49

A. After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.

B. AASHTO T-59 with modifications to include a 400°F ± 10°F maximum temperature to be held for 15 minutes.

1020-5 PRIME COAT MATERIALS

Supply prime coat materials from pre-approved sources that are on the NCDOT APL. Verification samples taken at the point of application (destination) are subject to the following conditions:

(A) All prime coat materials shall be delivered to the project ready for use.

(B) Sampling will be made at the point of application as directed by the Engineer. The Department reserves the right to sample all materials used for prime coat applications, either at the destination or at the point of origin, and to withhold acceptance of material until analysis of such samples have been made. When a material meets specification requirements, but has a history of unsatisfactory service performance, its use for construction or maintenance purposes may be restricted by the Engineer.

(C) The sand penetration results for a material used as a prime coat are penetration depth of at least 12 mm and penetration time of not more than 90 seconds. Copies of the *Sand Penetration Test Procedure* are available upon request from the Materials and Tests Unit.

(D) Materials used as a prime coat shall have a minimum rating of fair on the coating ability and water resistance test in accordance with AASHTO T 59.

(E) For materials stored longer than one day at the destination point (Contractors'/Divisions' tanks), submit to the Engineer a certified laboratory report on the performance of the material for storage stability test in accordance with AASHTO T 59.

(F) The diluted materials shall be tested for asphalt residue percent in accordance with AASHTO T 59, and shall have a minimum asphalt residue percent of 15%.

1020-6 PERFORMANCE GRADED ASPHALT BINDER AND ASPHALT EMULSION QUALITY CONTROL/QUALITY ASSURANCE

The *Performance Graded Asphalt Binder and Asphalt Emulsion QC/QA Programs* are designed to give asphalt binder and asphalt emulsion producers/suppliers (henceforth Producer

designates producer/supplier) more responsibility for controlling the quality of material they produce and to use the quality control information they provide in the acceptance process by the Department. It requires asphalt binder and asphalt emulsion producers to perform quality control sampling, testing and record keeping on materials they ship for use by the Department. It documents that the Department will perform quality assurance sampling, testing and record keeping confirming the performance of the producers' control plan. In addition, the producer is required to participate in independent assurance comparative sample activities. The program is described in the *Performance Graded Asphalt Binder and Asphalt Emulsion QC/QA Program Manuals*. An electronic copy of the program manuals may be obtained by accessing the Materials and Tests website.

The types of samples and the lot sizes required by the Producers and the Department are described in detail in the *Performance Graded Asphalt Binder and Asphalt Emulsion QC/QA Program Manuals*.

Acceptance or rejection of material will be based on the total program. Therefore, a comparison of the quality control, quality assurance and other sample data may be used by the Department for acceptance or rejection of a lot of material.

Participation in this program does not relieve the producer of the responsibility of complying with all requirements of the specifications.

1020-7 WATERPROOFING AND DAMPPROOFING MATERIALS

(A) Asphalt Primer

Asphalt primer shall meet ASTM D41.

(B) Asphalt Binder

Asphalt Binder shall meet Article 1020-2, Grade PG 64-22.

(C) Tar

Tar shall meet ASTM D490.

(D) Woven Cotton Fabric

Bitumen-saturated woven cotton fabric for waterproofing shall meet ASTM D173.

1020-8 ANTI-STRIP ADDITIVES

Anti-strip additives may either be hydrated lime or a chemical additive or a combination of both and must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan. Use an anti-strip additive capable of preventing the separation of the asphalt binder from the aggregate and achieving the required tensile strength ratio (TSR) on the asphalt mix when tested in accordance with AASHTO T 283 as modified by the Department.

Use hydrated lime conforming to AASHTO M 303. Add hydrated lime used of anti-strip purposes at a rate of not less than 1.0% by weight of the total dry aggregate.

Add chemical anti-strip additives to the asphalt binder before introduction into the mix. Do not use any chemical additive or particular concentration of chemical additive found to be harmful to the asphalt material or which causes the performance grading of the original asphalt binder to be out of specifications for the grade required.

1020-9 SILICONE

Silicone additives shall be pre-approved by the Materials and Tests Unit.

1020-10 FIBER STABILIZING ADDITIVES

Use fiber stabilizing additives that are capable of stabilizing the asphalt film surrounding the aggregate particles to reduce drain-down of the asphalt binder. A fiber stabilizer such as mineral fiber or cellulose may be used. The selected fiber shall meet the properties described

below. Dosage rates given are typical ranges but the actual dosage rate used will be approved by the Engineer.

(A) Mineral Fibers

Mineral fibers shall be made from virgin basalt, diabase or slag treated with a cationic sizing agent to enhance disbursement of the fiber as well as increase adhesion of the fiber surface to the asphalt binder. Mineral fibers shall be in accordance with Table 1020-2. Add the fiber at a dosage rate between 0.2% and 0.4% by weight of total mix, as approved by the Engineer.

TABLE 1020-2
MINERAL FIBER PROPERTIES

Property	Requirement	Test Method
Average Fiber length	0.25" maximum	-
Average Fiber thickness	0.0002" maximum	-
Shot Content Passing No. 60 sieve	90 - 100%	ASTM C612
Shot Content Passing No. 230 sieve	65 - 100%	ASTM C612
Degradation	30% maximum	GDT-124/McNett Fractionation

(B) Cellulose Fibers

Add cellulose fibers at a dosage rate between 0.2% and 0.4% by weight of total mix as approved by the Engineer. Fiber properties shall be in accordance with the following table.

TABLE 1020-3
CELLULOSE FIBER PROPERTIES

Property	Requirement
Average Fiber Length	0.25" maximum
Alpine Sieve Method Passing No. 100 Sieve	60 - 80%
Ro-Tap Sieve Method Passing No. 20 Sieve	80 - 95%
Ro-Tap Sieve Method Passing No. 40 Sieve	45 - 85%
Ro-Tap Sieve Method Passing No. 100 Sieve	5 - 40%
Ash Content	18% ± 5% non-volatiles
pH	7.5 ± 1
Oil Absorption	5.0 ± 1 (times fiber weight)
Moisture Content	5.0 maximum

(C) Cellulose Pellets

Cellulose pellets consist of a 50/50 blend of cellulose fiber and asphalt binder. Use cellulose that complies with Subarticle 1020-10(B) and the following table. Add the cellulose pellets at a dosage rate between 0.4% and 0.8% by weight of total mix, as approved by the Engineer.

TABLE 1020-4
CELLULOSE PELLET PROPERTIES

Property	Requirement
Pellet Size	1/4 cu.in. maximum
Asphalt	25 - 80 pen.

SECTION 1024
MATERIALS FOR PORTLAND CEMENT CONCRETE

1024-1 PORTLAND CEMENT

Supply Portland cement that meets AASHTO M 85 for Type I, II or III except that the maximum fineness requirements of AASHTO M 85 do not apply to cement used in precast concrete products. Throughout these specifications Types I and II cement are referred to as regular Portland cement and Type III as high early strength Portland cement.

Certain combinations of cement and aggregate exhibit an adverse alkali-silica reaction. The alkalinity of any cement, expressed as sodium-oxide equivalent, shall not exceed 1.0%. For mix designs that contain non-reactive aggregates and cement with an alkali content less than 0.6%, straight cement or a combination of cement and SCM may be used. The SCM quantity shall not exceed the amount shown in Table 1024-1. For mixes that contain cement with an alkali content between 0.6% and 1.0% and for mixes that contain a reactive aggregate documented by the Department, use a SCM in the amount shown in Table 1024-1.

Obtain the list of reactive aggregates documented by the Department at the Materials and Tests Unit website.

TABLE 1024-1
SUPPLEMENTARY CEMENTITIOUS MATERIAL FOR USE IN PORTLAND CEMENT CONCRETE

SCM	Substitution Rate (1 lb. SCM per 1 lb. Cement)
Class F Fly Ash	20% - 30%
Ground Granulated Blast Furnace Slag	35%-50%
Microsilica	4%-8%

Blended cements meeting AASHTO M 240 may be used with permission of the Engineer. Blended cements consist of either binary blends (e.g. a mixture of hydraulic cement with one other component) or ternary blends (e.g. a mixture of hydraulic cement and two other components). The components permitted for blending with cement are slag, pozzolans, or limestone. The term pozzolan can reference natural pozzolans (e.g. metakaolins), fly ash, or silica fume. The binary blended cements are Type IS (Portland-slag cement), Type IP (Portland-pozzolan cement), and Type IL (Portland-limestone cement). The ternary blended cement is Type IT and represents blends of Portland cement with varying amounts of any two different additives, which are pozzolans, slags or limestone. See AASHTO M 240 for details on the various blend ratios for Type IT blended cement.

Type IP or IS blended cement is allowed for the cement-and-fly-ash or cement-and-slag portion of the mix. Type IT may be allowed for the cement-and- supplementary cementitious portion of the mix with the permission of the Engineer. Do not substitute fly ash or slag for a portion of Type IP, IS or IT cement.

Use white cement that meets ASTM C150, except that the ferric oxide content is limited to 0.5%.

Use Type IP blended cement that meets AASHTO M 240, except that the pozzolanic content is limited to between 20 and 30% by weight and the constituents shall be interground.

Use Type IS blended cement that meets AASHTO M 240 except that the slag content is limited to between 35% and 50% by weight and the constituents are interground.

Use Type IT blended cement that meets AASHTO M 240. The Engineer will evaluate the blend of constituents for acceptance in Department work.

Use Type IL blended cement that meets AASHTO M 240, except the constituents shall be interground. SCMs can replace a portion of Type IL blended cement and shall be replaced as outlined in Subarticle 1000-3(I) for Portland cement.

Do not use air-entraining Portland cement. Do not mix different types of cement, different brands of cement, or the same brand from different mills nor use them alternately except when authorized in writing by the Engineer.

Protect cement from contamination or damage during handling and storage. Do not use cement that is damaged, partially set, lumpy or caked.

All cement is sampled and tested by the Department as it arrives on the project or at the batching plant at such frequency as established by the Department.

1024-2 AGGREGATE

Provide aggregate that meets Section 1014.

1024-3 ADMIXTURES

(A) Basis of Acceptance

Admixtures from an approved source are accepted without further testing. Only use admixtures that are on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL.

(B) Approved Admixture

An approved admixture complies with this subarticle in order to be added to the NCDOT APL.

The manufacturer shall submit to the Product Evaluation Program an application and certified reports of tests that show that the admixture meets the applicable specifications. Tests shall be performed by AASHTO's designated AASHTO Product Evaluation & Audit Solutions laboratory for concrete admixture testing. Admixtures that contain chloride other than calcium chloride as provided herein are not permitted. The manufacturer is required to state in writing that no chloride was added during the manufacture of the admixture.

After an admixture is accepted, the manufacturer is required to submit to the Product Evaluation Program on or before February 1 of each year a notarized certification that shows that the material is of the same composition as originally accepted and has not been changed or altered. If an admixture is changed or altered, approval of the source in accordance with the above requirements is necessary before using the admixture.

The Engineer has the option to perform tests deemed desirable to verify the manufacturer's certification. Failure of the admixture in such tests is cause for discontinuation of its use. Failure of an admixture to perform satisfactorily under job conditions is cause for rejection of the admixture.

(C) Air Entraining Agent

Provide air entraining agents that meet AASHTO M 154.

(D) Chemical Admixtures

(1) Set Retarding Admixtures

Use set retarding admixtures that meet AASHTO M 194 for Type D, water reducing and retarding admixtures.

(2) Water Reducing Admixtures

Use water reducing admixtures that meet AASHTO M 194 for Type A admixtures. Mid-range water reducing admixtures will be considered as high range water reducing admixtures if they meet the requirements for Type F water reducing admixtures.

(3) Calcium Chloride

Provide calcium chloride that meets AASHTO M 144 for Type 2, concentrated flake, pellet or other granular calcium chloride. The Engineer may waive the gradation requirement.

(4) High-Range Water Reducing Admixtures

Use high-range water reducing admixtures that meet AASHTO M 194 for Type F or Type G.

(5) Calcium Nitrite Corrosion Inhibitor

Use an approved calcium nitrite corrosion inhibitor that contains 30% solids.

(E) Other Admixtures

Admixtures not otherwise classified will be reviewed on a case-by-case basis by the Materials and Tests Unit.

1024-4 WATER

Ensure that water used to condition, wash, or as an integral part of materials is clear and free from injurious amounts of oil, acid, alkali, organic matter, or other deleterious substance. It shall not be salty or brackish. Water used in the production of concrete or grout shall be from wells or public water systems which are suitable for drinking and must meet the criteria listed in Table 1024-2.

Test water from wells at all locations. Test public water supplies from all out of state locations and in the following counties: Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven, Currituck, Dare, Gates, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender, Perquimans, Tyrell and Washington unless the Engineer waives the testing requirements. Water from a municipal water supply in all other NC counties may be accepted by the Engineer without testing.

TABLE 1024-2 PHYSICAL PROPERTIES OF WATER		
Property	**Requirement**	**Test Method**
Compressive Strength, minimum percent of control at 3 and 7 days	90%	ASTM C1602
Time of set, deviation from control	From 1:00 hr. earlier to 1:30 hr. later	ASTM C1602
Chloride Ion Content, Max.	250 ppm	ASTM D512 *
Total Solids Content (Residue), Max.	1,000 ppm	SM 2540B *
Resistivity, Min.	0.500 kohm-cm	ASTM D1125 *

* Denotes an alternate method is acceptable. Test method used shall be referenced in the test report.

1024-5 FLY ASH

Provide fly ash that meets ASTM C618 for Class F or Class C, except ensure that the loss on ignition does not exceed 4%. Use fly ash that meets the optional physical requirements for uniformity shown in Table 3 of ASTM C618.

Do not use Class C fly ash in Portland cement concrete if the alkali content of the cement exceeds 0.4%.

All fly ash is sampled and tested by the Department as it arrives on the project at such frequency as established by the Department.

1024-6 GROUND GRANULATED BLAST FURNACE SLAG

Use blast furnace slag that meets AASHTO M 302, Grade 100. All slag is sampled and tested by the Department as it arrives on the project at such frequency as established by the Department.

1024-7 SILICA FUME

Provide silica fume (microsilica) that meets Tables 1, 2 and 3 of ASTM C1240. All silica fume is sampled and tested by the Department as it arrives on the project at such frequency as established by the Department.

1024-8 NATURAL POZZOLANS

Provide natural pozzolans that meet ASTM C618 for Class N pozzolans, except ensure that the loss on ignition does not exceed 4%. Use natural pozzolans that meet the optional physical requirements for uniformity shown in Table 2 of ASTM C618.

All natural pozzolan is sampled and tested by the Department as it arrives on the project at such frequency as established by the Department.

SECTION 1026
CONCRETE CURING MATERIALS

1026-1 GENERAL

All curing materials shall be free from impurities that may be detrimental to the concrete.

1026-2 LIQUID MEMBRANE CURING COMPOUNDS

(A) General

Liquid membrane curing compounds shall meet ASTM C309, except that when tested in the water retention test described in AASHTO T 155 the curing compound shall restrict the loss of water in the test specimen at the time of application of the compound to not

more than 0.007 ounces per square inch. Do not use curing compound until the applicable tests have been performed for each batch and has been approved by the Engineer.

The curing compound shall be Type 2, white pigmented, except where clear type is required for a particular application, the curing compound shall be Type 1D, clear or translucent with fugitive dye.

Deliver curing compound in the manufacturer's original clean, sealed containers. Legibly mark each container with the name of the manufacturer, the name of the compound, the type of compound, the manufacturer's batch number, the date of manufacture and the manufacturer's recommended shelf life.

Do not use curing compound that has been in storage for more than one year from the date of manufacture or more than the manufacturer's recommended shelf life, whichever is less.

(B) Test Procedures

Curing compound will be tested in accordance with ASTM C309, except the size of molds for making test specimens will be approximately 5.5 inches in diameter by approximately 1 inch deep, or any other size selected by the Engineer.

1026-3 POLYETHYLENE FILM

Polyethylene film shall meet ASTM C171 for white opaque polyethylene film, except that when tested for moisture retention efficiency the loss shall not be more than 0.007 oz./sq.in of surface area.

1026-4 WATER

All water used for curing concrete shall meet Article 1024-4 and Table 1024-2. Water from wells, streams, ponds or public water systems may be used.

1026-5 BURLAP

Burlap shall meet AASHTO M 182. Any class of burlap will be acceptable.

Use new burlap or burlap that has been used for no purpose other than curing concrete. New burlap shall be free from starch, filler or other substances added during manufacture, or shall be washed to remove such substances before use.

SECTION 1028
JOINT MATERIALS

1028-1 JOINT FILLER

Provide a nonbituminous type joint filler that meets AASHTO M 153 for Types I, II or III, or a bituminous type that meets AASHTO M 213. Furnish a Type 3 material certification in accordance with Article 106-3 with each lot of the joint material supplied to each project.

1028-2 HOT APPLIED JOINT SEALER

Provide a hot applied joint sealer listed on the NCDOT APL, that conforms to ASTM D6690 . Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. Furnish a Type 3 material certification in accordance with Article 106-3 for each lot of the joint sealer supplied to each project.

1028-3 LOW MODULUS SILICONE SEALANT

Provide a cold applied, single component, chemically curing low modulus silicone sealant from the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. Acid cure sealants are not acceptable for use on Portland cement concrete. Bond breakers shall meet Article 1028-4.

(A) Silicone Sealant Types

(1) Type NS

A non-sag silicone for use in sealing horizontal and vertical joints in Portland cement concrete pavements and bridges. Tooling is required.

(2) Type SL

A self-leveling silicone used to seal horizontal joints in Portland cement concrete pavements and bridges. Tooling is not normally required.

(B) Requirements

TABLE 1028-1
PHYSICAL PROPERTIES OF SEALANT

Property	Requirement	Test Method
Peel	Minimum of 20 lb/in of width with at least 75% cohesive failure	ASTM D903 bonded on concrete block
Movement Capability and Adhesion	No adhesive or cohesive failure after 10 cycles of test movements of +100% (extension) and –50% (compression)	ASTM C719

Silicone sealant shall meet the Table 1028-1, ASTM D5893.

Furnish a Type 3 material certification in accordance with Article 106-3 for each lot of joint sealer material supplied to each project. Deliver each lot of sealant in containers plainly marked with the manufacturer's name or trademark, lot number and date of manufacture.

1028-4 BOND BREAKER

Install silicone sealant over a bond breaker to prevent the sealant from bonding to the bottom of the joint. Use bond breakers that do not stain or adhere to the sealant and are chemically inert and resistant to oils. Furnish a Type 3 material certification in accordance with Article 106-3 for each lot of bond breaker material supplied to each project.

(A) Type L

Type L backer rod is a closed-cell expanded polyethylene foam backer rod. Use this backer rod in roadway and bridge joints and with Type NS silicone only. Use Type L backer rod that complies with Table 1028-2.

(B) Type M

Type M backer rod is a closed-cell polyolefin foam backer rod which has a closed-cell skin over an open cell core. Use this backer rod in roadway and bridge joints with both silicone sealant types. Use Type M backer rod that complies with Table 1028-2.

TABLE 1028-2 PHYSICAL PROPERTIES OF TYPE L AND TYPE M BACKER ROD		
Property	**Requirement**	**Test Method**
Min. Density	2.0 lb/cf	ASTM D 1622
Min. Tensile Strength	25 psi	ASTM D 1623
Max. Water Absorption	0.5% by volume	ASTM C 509

(C) Type N

Provide bond breaking tape made from extruded polyethylene that has a pressure sensitive adhesive on one side. Bond breaking tape may be used with both types of silicone but is suitable for bridge joints only. Bond breaking tapes shall be at least 0.005 inch in thickness.

SECTION 1030
RFID TRACKING PROGRAM FOR MANUFACTURED PRODUCTS

1030-1 DESCRIPTION

Radio Frequency Identification (RFID) tracking and tagging is used for manufactured products which includes but is not limited to Prestressed Concrete Products, Precast Concrete Products, Plastic Pipe, Reinforced Concrete Pipe, Steel Products and Metal Pipe. The RFID tag/label is used for identification of manufactured products by visually reading the 24-digit code, scanning the RFID embedded chip, or scanning the printed QR/barcode. It is the responsibility of the producer to supply RFID tags approved by the Department following the requirements of Section 1030 and place them on the products that are being manufactured. The producer manages the quality control and initial production information and assigns an RFID alternate ID. It is the producer's responsibility to manage tags placed on products and upload test results once complete.

1030-2 MANUFACTURED PRODUCTS

Place the RFID tag/label on manufactured products. When accepted, the RFID tag/label item record will be updated. RFID tags/labels are identifiers for all manufactured products that must be scanned to find the approval status on the Field Inspection Report (FIR) or NCDOT vendor alternate ID found on the NCDOT APL prior to use.

RFID tag/label parameters for use on all manufactured products are as follows:

(A) Tag/Label Copy

The tag/label copy shall be block type lettering with the company name, NCDOT Facility Plant ID Number and company logo. All information shall be subsurface printed.

(B) Colors

Color of ink must be black on white background.

(C) Serialization

The bar code and human-readable equivalent shall be subsurface printed. Code 128 in 24-character hexadecimal format shall be utilized. A QR/barcode linking to the NCDOT vendor alternate ID found on the NCDOT APL shall also be subsurface printed on the label.

(D) Adhesion

Adhesives shall be non-proprietary and have a minimum 2 year above ground life span.

(E) Tag Proof

The Materials and Tests Unit must approve the tag/label. The Producer will provide an image of the tag/label and a copy of the tag/label specification to the Manufactured Products Engineer for approval.

(F) Tag Location

The location of the RFID tag/label for all manufactured products can be found in the *Guide to Placement of RFID Tags/Labels* found on Materials and Tests Unit website.

1030-3 PLASTIC PIPE

The RFID tag/label shall be placed on Plastic Pipe Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on plastic pipes are as follows:

(A) Dimensions

Shall be a minimum size of 4.5 inches x 1 inch x 0.017 inches.

(B) Material

Use 0.002 inch thick Polyester; total tag thickness to be 0.017 inches.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. AA00xx000000002000000000 where the first six digits identify the material and NCDOT Facility Plant ID Number replaces the xx and AA will identify polyethylene pipe while AB will identify polypropylene pipe. Numbering will start with a 2 in the billions position to prevent duplication of numbers across products. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Squiggle or comparable UHF passive inlay with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 24 dBm (1/4 of maximum reader power).

1030-4 REINFORCED CONCRETE PIPE

The RFID tag/label shall be placed on Reinforced Concrete Pipe Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on reinforced concrete pipes are as follows:

(A) Dimensions

Shall be a minimum size of 4 inches x 0.75 inches x 0.02 inches, with the option of being larger as approved by the Department.

(B) Material

Use 0.003 inch thick Polyester for subsurface printing. Additional polyester layers total 0.2 inch tag must be slotted on either end and contain a textured base layer.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. AC00xx000000002000000000 where the first six digits identify the material and NCDOT Facility Plant ID Number replaces the xx and AC will identify concrete pipe. Numbering

will start with a 2 in the billions position to prevent duplication of numbers across products. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Higgs 3 Squiggle or comparable UHF passive inlay optional Smartrac Short Dipole R6 with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 30 dBm.

1030-5 CORRUGATED METAL PIPE PRODUCTS

The RFID tag/label shall be placed on Corrugated Metal Pipe Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on metal pipes are as follows:

(A) Dimensions

Shall be a minimum size of 2.875 inches x 1.375 inches x 0.085 inches, with the option of being larger as approved by the Department.

(B) Material

Use 0.002 inch thick Polyester label adhered to a non-proprietary inlay wrapped around 1/16 inch foam.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. AD00xx000000002000000000 where the first six digits identify the material and NCDOT Facility Plant ID Number replaces the xx and AD will identify metal pipe. Numbering will start with a 2 in the billions position to prevent duplication of numbers across products. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Higgs 3 or comparable UHF passive inlay with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 30 dBm.

1030-6 PRESTRESSED CONCRETE PRODUCTS

The RFID tag/label shall be placed on Prestressed Concrete Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on prestressed concrete products are as follows:

(A) Dimensions

Shall be a minimum size of 2.75 inches x 1 inch x 0.02 inches, with the option of being larger as approved by the Department.

(B) Material

Use 0.003 inch thick Polyester for subsurface printing. Additional polyester layers total 0.2 inch tag must be slotted on either end and contain a textured base layer. Alternatively, the proprietary Cast-A-Tag can be utilized.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. 000xxx000000000000000000 where the first six digits identify the material and NCDOT

Facility Plant ID Number replaces the xx. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Higgs 3 Squiggle or comparable UHF passive inlay, optional Smartrac Short Dipole R6 with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 30 dBm.

1030-7 PRECAST CONCRETE PRODUCTS

The RFID tag/label shall be placed on Precast Concrete Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on precast concrete products are as follows:

(A) Dimensions

Shall be a minimum size of 2.75 inches x 1 inch x 0.02 inches, with the option of being larger as approved by the Department.

(B) Material

Use 0.003 inch thick Polyester for subsurface printing. Additional polyester layers total 0.2 inch tag must be slotted on either end and contain a textured base layer. Alternatively, the proprietary Cast-A-Tag can be utilized.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. 000xxx000000002000000000 where the first six digits identify the material and NCDOT Facility Plant ID Number replaces the xx. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Higgs 3 Squiggle or comparable UHF passive inlay, optional Smartrac Short Dipole R6 with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 30 dBm.

1030-8 SIGN PRODUCTS

The RFID tag/label shall be placed on Sign Products in accordance with Subarticle 1030-2(F).

RFID tag/label parameters for use on signs products found on Article 901-2 and Subarticle 901-3(A) are as follows:

(A) Dimensions

Shall be a minimum size of 5 inches x 3 inch x 0.085 inches, with the option of being larger as approved by the Department.

(B) Material

Use 0.002 inch thick Polyester label adhered to a non-proprietary inlay wrapped around a 1/16 inch foam.

(C) Numbering Scheme

The 24-character numbering scheme will be utilized as follows. 000xxx000000002000000000 where the first six digits identify the material and NCDOT

Facility Plant ID Number replaces the xx. Numbering scheme must be approved by the Materials and Tests Unit.

(D) RFID inlay

The inlay shall be Alien Higgs 3 or comparable UHF passive inlay with a frequency range of 860-960 MHz.

(E) Read Range

The RFID tag/label shall have a minimum read range of 18 feet with a reader at 30 dBm.

SECTION 1032
CULVERT PIPE

1032-1 CORRUGATED METAL CULVERT PIPE

Use corrugated metal culvert pipe that is NCDOT approved, found on the Department's producer/supplier list that participate in the Department's Brand Registration program for metal culvert pipe. The producer/supplier must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. The Department will remove a manufacturer of metal culvert pipe from this program if the monitoring efforts indicated that non-specification material is being provided or test procedures are not being followed.

The following types of steel and aluminum alloy pipe and all associated accessories may be accepted under this program.

(A) Coated corrugated metal culvert pipe and pipe arches,

(B) Coated corrugated metal end sections, coupling band and other accessories,

(C) Corrugated aluminum alloy structural plate pipe and pipe arches,

(D) Corrugated aluminum alloy end sections, coupling band and other accessories, and

Field joints for each type of corrugated steel pipe or corrugated aluminum pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installation. Coupling bands may be of the following types: bands with annular corrugations; bands with helical corrugations; bands with projections (dimples); channel bands for upturned flanges, with or without annular corrugations; flat bands; and smooth sleeve-type couplers. Coupling bands shall be installed in accordance with details in plans and/or in accordance with manufacturer's recommendations.

Corrugated metal pipe, pipe arches and coupling bands shall conform to AASHTO M 196 for Corrugated Aluminum Pipe, AASHTO M 36 for Galvanized Corrugated Steel Pipe, AASHTO M 36 for Aluminized Coated Corrugated Steel Pipe.

Aluminum and aluminized pipe shall have a barrier coat applied to the faying surfaces and edges of those components coming into contact with concrete. Surface preparation and barrier coat paint systems are found in the *Thermal Spray Coatings (Metallization) Program*.

1032-2 CORRUGATED ALUMINUM ALLOY CULVERT PIPE

(A) Corrugated Aluminum Alloy Culvert Pipe and Pipe Arch

Corrugated aluminum alloy culvert pipe and corrugated aluminum alloy pipe arch culvert shall meet AASHTO M 196, except that Type IA and Type IIA pipe will not be permitted.

When elongated pipe is called for by the contract, use pipe that is shop formed to provide for a 5% vertical elongation.

(1) Coupling Bands

(a) Use corrugated coupling bands except as otherwise provided below.

(b) A hugger type corrugated band having one annular corrugation at each outside edge of the band will be acceptable.

(c) Coupling bands with projections (dimples) may be used where it is necessary to join new pipe to existing pipe having helical corrugations at the joint locations. The bands shall be formed with projections in annular rows with one projection for each corrugation of helical pipe. Use an approved sealer with this type of coupling band. Coupling bands with projections (dimples) may be used for circumferential pipe, heliacal pipe, or a combination of both.

(d) Fasten coupling bands on the ends with at least two 1/2 inch bolts.

(e) Annular corrugated bands shall have a minimum width of 10 1/2 inches where 2 2/3 inches x 1/2 inch corrugations are used.

(B) Corrugated Aluminum Alloy Pipe Tees and Elbows

Corrugated aluminum alloy pipe and corrugated aluminum alloy pipe arch tees and elbows shall meet all applicable requirements of AASHTO M 196.

(C) Acceptance

Acceptance by the Engineer of corrugated aluminum alloy culvert pipe and corrugated aluminum alloy pipe arch culvert and its accessories will be based on, but not limited to, visual inspections, classification requirements and check samples taken from material delivered to the project and conformance to the annual Brand Registration.

1032-3 CORRUGATED STEEL CULVERT PIPE

(A) Corrugated Steel Culvert Pipe and Pipe Arch

Corrugated steel culvert pipe and pipe arch shall meet AASHTO M 36 with the following exceptions:

(1) Coupling Bands

(a) Use corrugated coupling bands except as otherwise provided below.

(b) A hugger type corrugated band having one annular corrugation at each outside edge of the band will be acceptable.

(c) Coupling bands with projections (dimples) may be used where it is necessary to join new pipe to existing pipe having helical corrugations at the joint locations. The bands shall be formed with projections in annular rows with one projection for each corrugation of helical pipe. Use an approved sealer with this type of coupling band. Coupling bands with projections may be used for circumferential pipe, heliacal pipe, or a combination of both.

(d) Fasten coupling bands on the ends with at least two 1/2 inch bolts.

(e) Annular corrugated bands shall have a minimum width of 10 1/2 inches where 2 2/3 inches x 1/2 inch corrugations are used.

(2) Corrugations

Where 1/4 inch deep corrugations are permitted by AASHTO M 36, the maximum pitch of the corrugations shall be 1 7/8 inches.

Where 3 inches x 1 inch corrugations are required, the Contractor will be permitted to use 5 inches x 1 inch corrugations.

Pipe with helical corrugations shall have rerolled ends with at least 2 annual corrugations at each end.

(3) Elongated Pipe

When elongated pipe is called for by the contract, use pipe that is shop formed to provide for a 5% vertical elongation.

(4) Lifting Straps

The pipe may be furnished either with or without lifting straps for handling. Attach the lifting straps by bolting or by welding. Bolt holes for attaching the straps shall be a smooth hole that is either punched or drilled. No burning of holes will be permitted. Design the lifting straps so the holes can be plugged to prevent infiltration of backfill material.

Design the placement of lifting straps to ensure the pipe is equally supported along its axis.

(5) Coating Repair

Repair shall be in accordance with Section 1076-7.

(6) Type IA and Type IIA Pipe

Type IA and Type IIA pipe will not be permitted.

(7) Aluminized Pipe

Aluminized pipe shall meet all requirements herein except that the pipe and coupling bands shall be fabricated from aluminum coated steel sheet meeting AASHTO M 274.

(8) Marking Requirements

Pipe sections and special attachments for pipe 60 inches or larger diameter pipe shall be alphanumerically match-marked at the plant site before shipping. There may be additional markings as required by the Department's Brand Certification Program.

(B) Prefabricated Corrugated Steel Pipe End Sections

Corrugated steel end sections shall be in accordance with the details shown in the plans and Subarticle 1032-3(A). Repair end sections on which the spelter coating has been bruised or broken either in the shop or in shipping in accordance with AASHTO M 36.

(C) Corrugated Steel Pipe Tees and Elbows

Corrugated steel tees and elbows shall be in accordance with Subarticle 1032-3(A).

(D) Corrugated Steel Eccentric Reducers

Corrugated steel eccentric reducers shall be in accordance with Subarticle 1032-3(A) and the additional requirements shown below.

Construct the eccentric reducer so the invert or flow line from the large pipe through the reducer and into the small pipe is a continuous straight line.

Make the reducer from the same thickness corrugated metals as the large diameter pipe. The reducing section may be riveted or welded.

(E) Acceptance

Acceptance by the Engineer of corrugated steel culvert pipe and its accessories will be based on, but not limited to, visual inspections, classification requirements and check samples taken from material delivered to the project and conformance to the annual Brand Registration.

The reducing section shall reduce in diameter no more than 3 inches in 24 inches of length. Rivet or weld a 24 inches long constant diameter stub to each end of the reducing section to form the complete reducer.

Have the completed reducer show careful, finished workmanship in all particulars. Repair reducers on which the spelter coating has been bruised or broken either in the shop or in shipping in accordance with AASHTO M 36. Reducers that show defective workmanship will be rejected by the Engineer. The following defects are evidence of poor workmanship, and the presence of any of them in any individual reducer will constitute sufficient cause for rejection:

(1) Not meeting required dimensions,
(2) Not of the specified shape,
(3) Uneven laps,
(4) Ragged or diagonal sheared edges,
(5) Loose, unevenly lined or spaced rivets,
(6) Poorly formed rivet heads,
(7) Lack of rigidity,
(8) Dents or bends in the metal itself,
(9) Uneven welds, or
(10) Gaps in welds.

1032-4 POLYPROPYLENE CULVERT PIPE

(A) General

Use polypropylene pipe that is NCDOT approved as found on the Departments producer/supplier list and participating in the Department's *Polypropylene Pipe QA/QC Program*. The producer/supplier must be current with the applicable Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. The Department will remove a manufacturer of polypropylene pipe from this program if the monitoring efforts indicated that non-specification material is being provided or test procedures are not being followed.

Use polypropylene culvert pipe that meets AASHTO M 330 for Type S or Type D, or ASTM F2881 or ASTM F2764 Double or Triple wall; and has been evaluated by AASHTO Product Evaluation & Audit Solutions. Bell and spigot joint seals shall meet ASTM F477.

(B) End Treatments, Pipe Tees, Elbows, and Couplers

End treatments, pipe tees and elbows shall meet AASHTO M 330, Section 7.7, ASTM F2881, Section 7.11, or ASTM F2764, Section 6.6. Couplers, where indicated on the plans, shall meet AASHTO M 330, Section 7.7, ASTM F2881, Section 7.11, or ASTM F2764, Section 6.6.

(C) Marking

Clearly mark each section of pipe, end section, tee and elbow and other accessories according to the Department's *Polypropylene Pipe QC/QA Program*:

(1) AASHTO or ASTM Designation

(2) The date of manufacture

(3) Name or trademark of the manufacturer

Clearly apply a Department approved self-adhesive RFID tag/label tagged in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F). When polypropylene pipe, end sections, tees, elbows and couplers have been inspected the Department will update the RFID tag/label item record as found in the Field Inspection Report (FIR) or NCDOT alternate ID.

1032-5 WELDED STEEL PIPE FOR DRAINAGE

Welded steel pipe shall meet ASTM A139 for the grade of pipe called for in the plans.

Acceptance of welded steel culvert pipe and its accessories will be based on, but not limited to, visual inspections, classification requirements and check samples taken from material delivered to the project and conformance to the Department's welded steel pipe program.

1032-6 CONCRETE CULVERT PIPE

(A) General

Use concrete pipe from sources participating in the Department's *Concrete Pipe QC/QA Program*. A list of participating sources is available on the Department's producer/supplier approved list . The producer/supplier must be current with American Concrete Pipe Association (ACPA) or National Precast Concrete Association (NPCA) audit program to remain on the NCDOT producer/supplier list. The Department will remove a manufacturer of concrete pipe from this program if the monitoring efforts indicated that non-specification material is being provided or testing procedures are not being followed.

(B) Reinforced Concrete Culvert Pipe

Reinforced concrete culvert pipe shall meet AASHTO M 170 for the class of pipe called for in the plans except as follows:

(1) The permissible wall thickness outside of the joint configuration shall not be more than that shown in the design by more than 5% or 3/16 inch, whichever is greater.

(2) The maximum weighted average loss for both fine and coarse aggregates shall be 15% when subjected to 5 cycles of the soundness test.

(3) The maximum percentage of wear for coarse aggregates is 55%.

The design wall thickness shall be either the wall thickness shown in AASHTO M 170 for the applicable class and wall or the wall thickness shown in a modified design that has been approved by the Engineer. A wall thickness greater than permitted by the above tolerance will be cause for rejection of the pipe. The circumferential steel in single cage pipe shall not be more than 3 inches from either end of the pipe section excluding the tongue and groove. On double cage pipe, extend one cage into the tongue or groove. Place the other cage so a circumferential wire shall be not less than 2 inches from the other end of the barrel of the pipe.

(C) Precast Concrete Pipe End Sections

Precast concrete pipe end sections shall meet AASHTO M 170 and Section 1077 except those requirements pertaining to design.

Design concrete pipe end sections in accordance with the plans or with plans prepared by the manufacturer which have been approved by the Engineer. Reinforce all concrete pipe end sections. Use air entrained concrete in pipe end sections with a strength of 3,500 psi when tested in accordance with AASHTO T 22.

(D) Concrete Pipe Tees and Elbows

Concrete pipe tees and elbows shall meet AASHTO M 170 for the class of pipe tee or elbow called for in the plans.

(E) Marking

(1) Clearly etchmark the following information on the outside of each section of pipe, pipe end section, tee and elbow:

(a) Pipe class and type of wall if reinforced,

(b) The date of manufacture, and

(c) Name or trademark of the manufacturer.

Clearly apply a Department approved self-adhesive RFID tag/label tagged in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F). When concrete pipe and pipe end sections have been inspected the Department will update the RFID tag/label item record as found in the Field Inspection Report (FIR) or NCDOT alternate ID. Failure of as much as 20% of any lot of pipe due to cracks, fractures, variation in alignment or other manufacturing defects will be cause for the rejection of the entire lot. The lots shall be as designated by the manufacturer before inspection. Individual lengths of pipe within the lot which were not specifically rejected but which are considered acceptable by the manufacturer may be removed from the rejected lot and resubmitted for inspection as a separate lot.

(F) Joint Materials

For connections to precast structures using grout, cement shall meet Article 1024-1, sand shall meet Article 1014-1 for fine aggregate or Article 1040-7 for mortar sand. Hydrated lime shall meet Article 1040-6.

Flexible plastic joint material shall meet ASTM C990 for flexible plastic gaskets, except as follows:

(1) The flash point, Cleveland Open Cup (C.O.C.) shall be at least 325°F.

(2) The fire point, C.O.C. shall be at least 350°F.

1032-7 CORRUGATED POLYETHYLENE (HDPE) CULVERT PIPE

(A) General

Use corrugated polyethylene pipe that is NCDOT approved as found on the Department's producer/supplier list and participating in the Department's *HDPE Pipe QC/QA Program*. The producer/supplier must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. A list of participating sources is available from the Materials and Tests Unit. The Department will remove a manufacturer of polyethylene pipe from this program if the monitoring efforts indicated that non-specification material is being provided or test procedures are not being followed.

Use corrugated polyethylene culvert pipe that meets AASHTO M 294 for Type S or Type D and has been evaluated by AASHTO Product Evaluation & Audit Solutions. Bell and spigot joint seals shall meet ASTM F477.

(B) End Treatments, Pipe Tees, Elbows and Couplers

End treatments, pipe tees and elbows shall meet AASHTO M 294, Section 7.8. Couplers, where indicated on the plans, shall meet AASHTO M 294, Section 7.8.

(C) Marking

Clearly mark each section of pipe, end section, tee and elbow and other accessories according to the Department's HDPE Pipe QC/QA Program:

(1) AASHTO Designation

(2) The date of manufacture

(3) Name or trademark of the manufacturer

Clearly apply a self-adhesive Department approved RFID tag/label tagged in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F). After polyethylene pipe, end sections, tees, elbows and couplers have been inspected the Department will update the RFID tag/label item record as found in the Field Inspection Report (FIR) or NCDOT alternate ID.

1032-8 PVC PROFILE WALL DRAIN PIPE

PVC pipe shall conform to AASHTO M 304. Bell and spigot joint seals shall meet ASTM F477. The gasket shall be the sole element relied on to maintain a tight joint. Watertight joints shall be watertight in accordance with AASHTO M 304, unless a higher pressure rating is specified in the plans.

SECTION 1034
SANITARY SEWER PIPE AND FITTINGS

1034-1 CLAY PIPE

Use extra strength vitrified clay sewer pipe conforming to ASTM C700. Manufacture all joints and seals in accordance with ASTM C425.

1034-2 PLASTIC PIPE

(A) PVC Gravity Flow Sewer Pipe

Use PVC pipe that conforms to ASTM D3034 with a minimum SDR of 35. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3212.

(B) PVC Force Main Sewer Pipe

(1) Pressure Rated Pipe

Use PVC pipe conforming to ASTM D2241 or AWWA C905 with a minimum SDR of 21 and minimum pressure rating of 200 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139 or pipe with butt fused joints made from ASTM D1784 Class 12454B plastic formulated for fusing.

Use PVCO pipe conforming to ASTM F1483 or AWWA C909 for molecularly oriented pipe with a minimum pressure rating of 200 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139.

(2) Pressure Class Pipe

Use PVC pipe conforming to AWWA C900 with a minimum DR of 18 and a minimum pressure class of 235 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139 or pipe with butt fused joints made from ASTM D1784 Class 12454B plastic formulated for fusing.

(C) Polyethylene (PE) Pipe Force Main Sewer Pipe

Use PE pipe and tubing that conforms to AWWA C901 or AWWA C906 with a minimum pressure class of 200 psi.

1034-3 CONCRETE SEWER PIPE

Use reinforced concrete sewer pipe conforming to ASTM C76 or AASHTO M 170 with a Class III minimum rating. Use pipe with gasket joints conforming to ASTM C443 or ASTM C990 as specified in the plans.

1034-4 DUCTILE IRON PIPE

(A) Gravity Flow Sewer Pipe

Use ductile iron pipe that conforms to ASTM A746 or AWWA C151/A21.51.

Use ductile iron pipe fittings and specials conforming to AWWA C110/A21.10 for standard size fittings or AWWA C153/A21.53 for compact fittings.

Use pipe and fittings with push-on joints conforming to AWWA C111/A21.11.

(B) Force Main Sewer Pipe

Use ductile iron pipe that conforms to AWWA C151/A21.51.

Use ductile iron pipe fittings and specials conforming to AWWA C110/A21.10 for standard size fittings or AWWA C153/A21.53 for compact fittings. Manufacture fittings with a cement mortar lining and a seal coat in accordance with AWWA C104/A21.4.

Use pipe and fittings with either mechanical joints or push-on joints conforming to AWWA C111/A21.11. When required or necessary, use approved type joint restraint devices with a minimum working pressure rating of 200 psi and a factor of safety of 2.

SECTION 1036
WATER PIPE AND FITTINGS

1036-1 GENERAL

All materials when used to convey potable drinking water shall meet the National Sanitation Foundation Standard No. 61. All materials in contact with potable water shall be in conformance with Section 1417 of the Safe Drinking Water Act.

1036-2 COPPER PIPE

For indoor plumbing use copper pipe and sweated fittings conforming to ASTM B88 for the type and temper called for in the plans and specifications. Cast fittings for copper pipe shall meet ASTM B61 or ASTM B62.

For buried service, use copper water pipe and tube conforming to ASTM B88 soft annealed Type K. Use flared or compression type fittings conforming to AWWA C800 and local plumbing codes to connect pipe and tube.

1036-3 PLASTIC PIPE

(A) PVC Pipe

(1) Pressure Rated Pipe

Use PVC pipe conforming to ASTM D2241 or to AWWA C905 with a minimum SDR of 21 and minimum pressure rating of 200 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139 or pipe with butt fused joints made from ASTM D1784 Class 12454B plastic formulated for fusing.

Use PVCO pipe conforming to ASTM F1483 or to AWWA C909 for molecularly oriented pipe with a minimum pressure rating of 200 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139.

(2) Pressure Class Pipe

Use PVC pipe conforming to AWWA C900 with a minimum DR of 18 and a minimum pressure class of 235 psi. Use pipe with push-on type joints having bells made as an integral part of the pipe conforming to ASTM D3139 or pipe with butt-fused joints made from ASTM D1784 Class 12454B plastic formulated for fusing.

(B) Polyethylene (PE) Pipe

Use PE water pipe and tubing that conforms to AWWA C901 or AWWA C906 with a minimum pressure class of 200 psi.

1036-4 STEEL PIPE

(A) Water Pipe

Use galvanized steel pipe meeting ASTM A53 for standard weight. Fittings for steel water pipe shall meet ASTM A126 for Class B iron or of ASTM A197. Galvanize all fittings in accordance with ASTM A153.

(B) Encasement Pipe

Use steel pipe meeting an ASTM specification with the minimum yield strength of 35,000 psi. Use pipe that is circular in shape and straight in length.

1036-5 DUCTILE IRON PIPE AND FITTINGS

Use ductile iron pipe that conforms to AWWA C151/A21.51.

Use ductile iron pipe fittings and specials conforming to AWWA C110/A21.10 for standard size fittings or AWWA C153/A21.53 for compact fittings. Manufacture fittings with a cement mortar lining and a seal coat in accordance with AWWA C104/A21.4.

Use either mechanical joints or push-on joints conforming to AWWA C111/A21.11. When required or necessary, use approved type joint restraint devices with a minimum working pressure rating of 200 psi and a factor of safety of 2.

1036-6 FIRE HYDRANTS

Use dry barrel type fire hydrants conforming to AWWA C502 with a minimum 4 1/2 inch diameter valve opening with a 6 inch mechanical joint inlet connection, with two 2 1/2 inch hose connections and with one 4 1/2 inch pumper connection. Outlets shall have national standard fire hose coupling threads. Use fire hydrants with a minimum bury length of 36 inches. Securely chain nipple caps to the barrel. Paint hydrants with one coat of primer paint and two coats of an approved paint of the owner's standard color. Apply the final coat after hydrant installation.

1036-7 WATER VALVES

(A) Gate Valves

Use iron body gate valves which conform to AWWA C500 for bronze mounted, double disc, parallel seat type valves or to AWWA C509 for resilient seat-type valves or to AWWA C515 for reduced-wall, resilient seat gate valves. For buried service use gate valves with non-rising stems, 2 inch square operating nuts, O-ring seals and which open by turning counter clockwise. Gate valves shall have mechanical joint ends conforming to AWWA C111/A21.11. Gate valves shall have a design working water pressure of 200 psi.

(B) Bronze Gate Valves

Use bronze gate valves conforming to ASTM B62 with tee head operating nuts and solid wedges. Use valves with a design working pressure of 200 psi.

(C) Tapping Valves

Use tapping valves conforming to Subarticle 1036-7(A) with appropriately sized openings, with flanged by mechanical joint ends and pressure rated at 200 psi.

(D) Insertion Valves

(1) Housing-Seated Insertion Valves

Use iron body insertion valves which conform to AWWA C515 for reduced-wall, resilient seat gate valves, with the exception that the valve body may be constructed of two pieces. For buried service use insertion valves with non-rising stems, 2 inch square operating nuts, O-ring seals and which open by turning counterclockwise. Insertion valves shall have mechanical joint ends conforming to AWWA

C111/A21.11. Insertion valves shall have a minimum design working water pressure of 200 psi.

(2) Pipe-Seated Insertion Valves

Use a pipe-seated insertion valve composed of a tapping sleeve assembly and a valve bonnet. Use ductile iron or Type 304 stainless steel tapping sleeve type bodies. Use either the split sleeve type with mechanical joint ends or the full circle type with double seals. Manufacture the outlet flange to mate with the bonnet. For buried service use insertion valves with non-rising stems, 2 inch square operating nuts, O-ring seals and which open by turning counterclockwise. Insertion valves shall have a minimum design water pressure of 200 psi. Coat iron bodies and bonnets at the factory with an epoxy in conformance with AWWA C210 or AWWA C213.

(E) Plug Valves

Use plug valves which conform to AWWA C517. Provide mechanical joint ends conforming to AWWA C111/A21.11.

1036-8 SLEEVES, COUPLINGS AND MISCELLANEOUS

(A) Tapping Sleeves

Use ductile iron or Type 304 stainless steel tapping sleeves pressure rated at 200 psi. Use either the split sleeve type with mechanical joint ends or the full circle type with double seals. Manufacture the outlet flange to mate with the tapping valve flange.

(B) Transition Sleeves and Couplings

Use sleeve type couplings for transitioning between plain ends of different pipe types. Manufacture couplings in conformance with AWWA C219 for a rated working pressure of 200 psi. Coat the coupling at the factory with an epoxy in conformance with AWWA C210 or AWWA C213.

1036-9 SERVICE LINE VALVES AND FITTINGS

Use corporation stops and curb stops of all bronze material and high-pressure construction conforming to AWWA C800.

Use tapping saddles of high-pressure construction, shaped to conform to the pipe and in conformance with AWWA C800.

Use high-pressure fittings manufactured in conformance with AWWA C800.

SECTION 1040
MASONRY

1040-1 BRICK

Use clay or shale brick that meets ASTM C62 or ASTM C216 for Grade SW, except as otherwise provided herein.

Use brick of uniform standard commercial size, with straight and parallel edges and square corners that are burned hard and entirely true, free from injurious cracks and flaws, tough, strong and have a clear ring when struck together. The sides, ends and faces of all brick shall be plane surfaces at right angles and parallel to each other.

Brick of the same manufacturer shall not vary more than ± 1/16 inch in thickness, ± 1/8 inch in width and ± 1/4 inch in length.

Concrete brick may be used instead of clay or shale brick when designated in the plans or in the specifications. Concrete brick shall meet ASTM C55 for Grade S-II except that the absorption of brick used in minor drainage structures shall not exceed 10 pcf.

1040-2 CONCRETE BUILDING BLOCK

Use concrete building block from sources that participate in the Department's *Solid Concrete Masonry Brick/Unit QC/QA Program*. A list of these sources in North Carolina and adjoining states is available from the Materials and Tests Unit in Raleigh.

Use concrete building block that meets ASTM C90. Block shall be pink in color and substantially free from chips and cracks.

Use solid concrete block instead of clay brick for minor drainage structures that meet ASTM C139 except that the nominal dimensions shall be 4 inches x 8 inches x 16 inches.

Concrete block for block manholes shall meet ASTM C139.

1040-3 CONCRETE PAVING BLOCK

Use concrete paving block from sources that participate in the Department's Solid Concrete Masonry Brick/Unit QC/QA Program. A list of these sources in North Carolina and adjoining states is available from the Materials and Tests Unit in Raleigh.

Use concrete paving block that meet ASTM C139, except that the nominal dimensions shall be 4 inches x 8 inches x 16 inches. The block shall have a uniform surface color and texture.

1040-4 SEGMENTAL RETAINING WALL UNITS

Use segmental retaining wall (SRW) units from sources that participate in the Department's *Solid Concrete Masonry Segmental Retaining Wall Units QC/QA Program*. A list of these sources in North Carolina and adjoining states is available from the Materials and Tests Unit in Raleigh.

Use freeze-thaw durable SRW units when noted in the contract. Unless required otherwise in the contract, provide SRW units with a vertical straight face and a concrete gray color with no tints, dyes or pigments. Do not begin unit production until sample SRW units of the type, face and color proposed for the project are approved by the Engineer.

Use SRW units that meet ASTM C1372 except for Table 1040-1 requirements.

TABLE 1040-1
SRW UNIT REQUIREMENTS

Property	Requirement	Test Method
Compressive Strength for SRW Units	4,000 psi min	ASTM C140
Compressive Strength for Freeze-Thaw Durable SRW Units	5,500 psi min	ASTM C140
Absorption	5% max	ASTM C140
Durability for Freeze-Thaw Durable SRW Units	1% max[A]	ASTM C1262

A. Weight loss for 4 of 5 specimens after 150 cycles in water.

1040-5 CEMENT

Portland cement shall meet Article 1024-1.

Masonry cement shall meet ASTM C91.

1040-6 HYDRATED LIME

Hydrated lime shall meet ASTM C207 for Type N.

1040-7 MORTAR SAND

Mortar sand shall meet Article 1014-1, except it shall meet the gradation requirements for No. 4S sand shown in Table 1005-2.

1040-8 WATER

Water shall meet Article 1024-4.

1040-9 MORTAR

Proportion mortar used in all brick and block masonry by volume as shown below. Do not add any more water than is necessary to make a workable mixture.

Mix No. 1: 1 part Portland cement
1/4 part hydrated lime
3 3/4 parts mortar sand (maximum)

Mix No. 2: 1 part Portland cement
1 part masonry cement
6 parts mortar sand (maximum)

Apply Articles 1040-5, 1040-6, 1040-7 and 1040-8 to all cement, hydrated lime, mortar sand and water.

For the hydrated lime and cement portion of Mix No. 1, the Contractor may substitute Type M or Type S masonry cement that meets ASTM C270 for Type S masonry cement the minimum compressive strength of the test specimens shall be 2,500 psi at 28 days and the test specimens shall be composed of one part Type S masonry cement and 3 parts sand. Furnish a Type 3 certification for the Type M or Type S masonry cement in accordance with Article 106-3.

1040-10 ADMIXTURES

Use admixtures that are on the NCDOT APL.

SECTION 1042
RIP RAP MATERIALS

Use field stone or rough unhewn quarry stone for plain rip rap. Use stone that is sound, tough, dense, resistant to the action of air and water and suitable in all other respects for the purpose intended. Where broken concrete from demolished structures or pavement is available, it may be used in place of stone provided that such use meets with the approval of the Engineer. However, the use of broken concrete that contains reinforcing steel will not be permitted.

All stone shall meet the approval of the Engineer. While no specific gradation is required, there shall be equal distribution of the various sizes of the stone within the required size range. The size of an individual stone particle will be determined by measuring its long dimension.

Stone or broken concrete for rip rap shall meet Table 1042-1 for the class and size distribution.

TABLE 1042-1
ACCEPTANCE CRITERIA FOR RIP RAP AND STONE FOR EROSION CONTROL

Class	Required Stone Sizes, inches		
	Minimum	Midrange	Maximum
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

No more than 5.0% of the material furnished can be less than the minimum size specified nor no more than 10.0% of the material can exceed the maximum size specified.

SECTION 1043
AGGREGATE FROM CRUSHED CONCRETE

1043-1 GENERAL

Aggregate from crushed concrete is a recycled product made by crushing concrete obtained from concrete truck clean out, demolition of existing concrete structures or pavement, or similar sources, which have been processed at a crushing facility. It does not include concrete pavements that are rubblelized, broken or otherwise crushed in place on the roadway, without having been processed at a crushing facility.

The crushed material must meet all sources approval requirements described in Sections 1005 and 1006 with the exception of the sodium sulfate test requirement.

Sampling and acceptance for the determination of gradation, LL and PI will be performed as described in the *Aggregate QC/QA Program Manual* and the *Aggregate Sampling Manual*.

1043-2 AGGREGATE BASE COURSE AND SELECT MATERIAL CLASS IV

The material shall meet the ABC gradation. The LL of the material shall be raised 5 points to no more than 35.

1043-3 AGGREGATE SHOULDER BORROW

The material shall meet Section 1019.

1043-4 CLEAN COARSE AGGREGATE FOR ASPHALT

The material shall meet the gradation of a standard size in Table 1005-1 and Subarticle 1012-1(B). Use of the material shall be approved by the Engineer, and the mix shall meet all requirements.

1043-5 CLEAN COARSE AGGREGATE FOR CONCRETE

The material shall meet the gradation of a standard size in Table 1005-1 and Subarticle 1014-2(C). Use of the material is restricted to Class B concrete mixes only. Use of the material shall be approved by the Engineer, and the concrete shall meet all requirements.

SECTION 1044
SUBSURFACE DRAINAGE MATERIALS

1044-1 SUBDRAIN FINE AGGREGATE

Subdrain fine aggregate shall meet Class III select material, Type 1 or Type 3.

1044-2 SUBDRAIN COARSE AGGREGATE

Subdrain coarse aggregate shall meet Class V select material.

1044-3 PIPE AND FITTINGS

Pipe and fittings may be, at the option of the Contractor, either concrete, corrugated steel, bituminized fiber or corrugated plastic.

1044-4 CONCRETE PIPE AND FITTINGS

Non-perforated concrete pipe and pipe fittings shall meet AASHTO M 86 for standard strength nonreinforced concrete pipe.

Perforated concrete pipe shall meet AASHTO M 175 for standard strength perforated nonreinforced concrete underdrainage pipe.

Joint materials shall meet Section 1028.

1044-5 CORRUGATED STEEL PIPE AND FITTINGS

Non-perforated corrugated steel pipe and pipe fittings shall meet Subarticle 1032-3(A).

Perforated corrugated steel pipe shall meet AASHTO M 36.

Fabricate the corrugated steel pipe from steel sheets having a minimum thickness of 0.052 inch.

1044-6 PVC PIPE

Solid Wall PVC pipe shall meet ASTM D1785.

Perforated Solid Wall PVC pipe shall meet AASHTO M 278.

1044-7 CORRUGATED PLASTIC PIPE AND FITTINGS

Corrugated HDPE pipe and fittings shall meet AASHTO M 252, except that the maximum stretch resistance shall be 10%.

1044-8 OUTLET PIPE

Outlets constructed of PVC Schedule 40 pipe shall meet ASTM D1785. HDPE pipe shall meet AASHTO M 252.

SECTION 1046
GUARDRAIL MATERIALS

1046-1 GENERAL

Use guardrail materials meeting requirements of the Department's Brand Registration Program for guardrail and are listed on Department's approved producer/suppliers list or NCDOT APL. The producer/supplier and products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list and NCDOT APL.

The following types of guardrail materials and all associated accessories may be accepted under this program: rail elements, posts and offset blocks, terminal sections, anchor units, transition sections and hardware.

1046-2 RAIL ELEMENTS

The rail element and terminal sections shall meet AASHTO M 180 for Class A, Type 2.

1046-3 POSTS AND OFFSET BLOCKS

(A) General

(1) The Contractor may furnish any one of the following types of steel guardrail posts. Only one type of post will be permitted at any one continuous installation.

Use structural steel posts throughout the project, unless otherwise directed by the Engineer or detailed in the plans.

(a) Steel W6 x 8.5 or W6 x 9.0 posts

(b) Steel 4.5 inches x 6.0 inches C-shape posts

(2) The Contractor may at his option furnish either of the following types of treated timber posts if specifically directed by the Engineer or detailed in the plans. Only one type of post will be permitted at any one continuous installation.

(a) Timber 6 inch x 8 inch posts

(b) Timber 8 inch x 8 inch posts

(B) Structural Steel Posts

Fabricate steel posts for guardrail of the size and weight shown in the plans from structural steel complying with Section 1072. Metal from which C-shape posts are fabricated shall meet ASTM A1011 for any grade of steel except mechanical requirements that shall meet ASTM A36. Punch or drill the holes for connecting bolts. Burning will not be permitted. After fabrication the posts shall be galvanized in accordance with Section 1076.

(C) Treated Timber Posts

Timber guardrail posts shall be of treated southern pine meeting Section 1082.

Bore bolt holes to a driving fit for the bolts. A minus tolerance of 1% will be allowed in the length of the post. Perform all framing and boring before the posts receive preservative treatment.

(D) Offset Blocks

Provide 8 inch deep recycled plastic or composite offset blocks approved for use with the guardrail shown in the plans. Only one type of offset block will be permitted at any one continuous installation.

Treated timber offset blocks with steel beam guardrail will not be allowed unless directed by the Engineer or detailed in the plans. Steel offset blocks with steel beam guardrail will not be allowed.

Recycled plastic or composite offset blocks shall be made from no less than 50% recycled plastic or composite and shall meet the requirements in Table 1046-1.

TABLE 1046-1
COMPOSITE OFFSET BLOCKS

Property	Requirement
Minimum Specific Gravity	0.950
Min. Compressive Strength in Lateral Direction	1,600 psi
Maximum Water Absorption	10% by weight
Maximum Termite and Ant Infestation	10%
Approval	Approved for use on the NCDOT APL

1046-4 HARDWARE

Provide all hardware as indicated in the plans that is galvanized in accordance with ASTM A153.

1046-5 ANCHORS AND ANCHOR ASSEMBLIES

Each shipment of guardrail terminal end sections, anchors and anchor assemblies shall be shipped from the manufacture with a current parts list and installation guide. Units not having the above documents will be rejected by the Engineer.

Articles 1046-1, 1046-2 and 1046-3 are applicable to rail elements, terminal sections, posts, offset blocks and hardware.

Reinforcing steel shall meet Article 1070-2. Steel plates shall meet ASTM A36. Anchor rods shall meet ASTM A663 for Grade 65.

Anchor cable shall be 3/4 inch wire rope having a minimum breaking strength of 21.4 tons and galvanized. Use commercial quality galvanized steel cable thimbles. Use commercial quality drop forged galvanized steel cable clips. The fitting and stud for the anchor cable shall be suitable for cold swaging and be galvanized. After being swaged on the cable, the fitting and stud assembly, including swaged joint and cable, shall have a minimum breaking strength of 21.4 tons.

Perform welding in accordance with Article 1072-18.

Welded components shall be galvanized after welding in accordance with ASTM A123. All other metal parts shall be galvanized in accordance with ASTM A153, except where otherwise specified in Articles 1046-1, 1046-2 and 1046-3.

1046-6 REPAIR OF GALVANIZING

Perform repair of galvanizing in accordance with Article 1076-7.

1046-7 CABLE GUIDERAIL

Posts, hardware and miscellaneous components shall meet the applicable requirements of this Section, the plans and the manufacture's requirements.

Furnish cable guiderail manufactured in accordance with AASHTO M 30, Type 1, Class A.

For concrete anchors, furnish Class A concrete if cast in place or use concrete meeting Section 1077, if using precast concrete anchors.

Cable guiderail must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan and is not covered under the Brand Certification Program for guardrail materials. Sample cable guiderail according to the *Minimum Sampling Guide*.

1046-8 ACCEPTANCE

Acceptance of guiderail materials and its accessories will be based on, but not limited to, visual inspections, classification requirements and check samples taken from material delivered to the project and conformance to the annual Brand Registration.

SECTION 1050
FENCE MATERIALS

1050-1 GENERAL

All fencing material and accessories shall meet Section 106.

(A) Chain Link Fence

Furnish either galvanized steel fence framework or aluminum alloy fence framework unless otherwise specified. Use the same type of fabric and framework materials throughout the project.

Where galvanized steel framework is used, the fence fabric may be either galvanized steel or aluminum coated steel, except where galvanized steel fabric is specified in the contract. The Contractor may furnish any of the following galvanized steel framework systems:

System G1

Line Posts:	Steel Pipe
Terminal Posts (End, Corner, or Brace Posts):	Steel Pipe
Gate Posts, Double Gate:	Steel Pipe
Gate Posts, Single Gate:	Steel Pipe
Brace Rail and Top Rail [A]	Steel Pipe

System G2

Line Posts:	Steel H Post
Terminal Posts (End, Corner, or Brace Posts):	Steel Pipe
Gate Posts, Double Gate:	Steel Pipe
Gate Posts, Single Gate:	Steel Pipe
Brace Rail and Top Rail [A]	Steel Pipe

System G3

Line Posts:	Roll Formed Steel
Terminal Posts (End, Corner, or Brace Posts):	Steel Pipe
Gate Posts, Double Gate:	Steel Pipe
Gate Posts, Single Gate:	Steel Pipe
Brace Rail and Top Rail [A]:	Steel Pipe or Roll Formed Pipe

A. Top rail to be used instead of tension wire only where called for in the itemized proposal.

Where an aluminum alloy framework is used, the fence fabric may be either aluminum alloy or aluminum coated steel. The Contractor may furnish any of the following aluminum alloy framework systems:

System A1

Line Posts:	Aluminum Post
Terminal Posts (End, Corner, or Brace Posts):	Aluminum Pipe
Gate Posts, Double Gate:	Aluminum Pipe
Gate Posts, Single Gate:	Aluminum Pipe
Brace Rail and Top Rail[A]:	Aluminum Pipe

System A2

Line Posts:	Aluminum H Post
Terminal Posts (End, Corner, or Brace Posts):	Aluminum Pipe
Gate Posts, Double Gate:	Aluminum Pipe
Gate Posts, Single Gate:	Aluminum Pipe
Brace Rail and Top Rail[A]:	Aluminum Pipe

A. Top rail to be used instead of tension wire only where called for in the itemized proposal.

(B) Wire Gauge

TABLE 1050-1
WIRE DIAMETER

Size Coated Wire, gauge	Nominal Diameter of Wire, inch
6	0.192
7	0.177
9	0.148
10 1/2	0.128
11	0.120
11 1/2	0.113
12	0.106
12 1/2	0.099
13	0.092
13 1/2	0.086
14	0.080
15 1/2	0.067
16 1/2	0.058

Whenever the term gauge is used in this section to refer to a size of wire, it will be construed to mean the United States Steel Wire Gauge, SWG (U.S.), regardless of whether or not the base metal of the wire is steel or a nonferrous metal.

1050-2 TIMBER POSTS AND BRACES

(A) General

Use treated southern pine meeting Articles 1082-2 and 1082-3 for all timber posts and braces, except as otherwise specified herein. Posts and braces may be either round or square provided that the same shape is used throughout the project for both the posts and the braces. Post and brace sizes are shown in the plans in inches. The size refers to the diameter for round pieces, or to the edge dimension for square pieces. Square posts and braces shall be fully dressed S4S. An allowable tolerance of 1/2 inch scant for square pieces will be permitted from the dimensions called for in the plans.

Cut round wood posts and braces from sound solid trees, free from short or reverse bends in more than one plane. Do not use log veneer cores for posts and braces unless they contain at least 1 inch of sapwood for their entire circumference on both ends. The post or brace shall not deviate more than 1 inch at any point from a straightedge held longitudinally against the piece.

All posts shall be free from ring shake, season cracks more than 1/4 inch wide, splits in the ends and contain no unsound knots. Sound knots will be permitted provided the width of the knot does not exceed 1/3 the diameter of the post where it occurs. Groups of knots or any combination of defects that will impair the strength of the piece will not be permitted. The pieces shall show not less than 3 annual rings per inch and not less than 30% of summer wood.

A tolerance of 1 inch plus and 1/2 inch minus will be allowed for the diameter of round posts and braces, measured at the small end after peeling. Where they are out of round, this tolerance will apply to the smaller diameter, and the larger diameter shall not exceed the smaller by more than 20%. The maximum rate of increase in diameter at the butt shall be 1 1/2 inches in 10 feet.

A minus tolerance of 1% will be allowed in the length of both round and square posts. Cut the ends square.

(B) Optional Steel Posts and Braces

Steel posts and braces for woven wire fence instead of timber posts and braces are permitted in areas located in or west of Vance, Franklin, Wake, Lee, Moore and Richmond Counties. Use the same type of fence post and brace throughout the project. The optional steel posts and braces shall meet Subarticle 1050-3(B).

1050-3 METAL POSTS AND RAILS

(A) Chain Link Fence

Posts shall meet AASHTO M 181 except as otherwise provided herein.

Steel H posts shall have a minimum yield strength of 45,000 psi and weigh 3.26 lbs/ft. Galvanize steel H posts in accordance with ASTM F1043 with a Type A coating. Aluminum H posts shall weigh 1.25 lbs/ft.

Roll formed steel line posts shall be a 1.625 inch x 1.875 inch section weighing 2.40 lbs/lf after galvanizing and be formed from 0.121 inch thick sheet having a minimum yield strength of 45,000 psi. Roll formed steel brace rails and top rails shall be a 1.250 inch x 1.625 inch section weighing 1.35 lbs/lf after galvanizing and be formed from 0.080 inch thick sheet steel having a minimum yield strength of 45,000 psi. Galvanize all roll formed members after fabrication in accordance with ASTM F1043 with a Type A coating.

Vinyl coated posts shall be pipe posts meeting AASHTO M 181 with a fusion bonded vinyl coating at least 6 mils thick. The vinyl shall meet Section 6 of AASHTO M 181, or if a standard color not listed in AASHTO M 181 is used, the vinyl shall meet the color requirements in ASTM F934, Table 1.

Furnish brace rails with suitable metal connections to fasten them securely to the posts. Provide the top rail not less than 6 inches long with a thickness of at least 0.051 inch if steel, or 0.062 inch if 6063-T6 aluminum alloy and in lengths of at least 15 feet. The complete top rail assembly shall form a continuous rail passing through the top fittings of the line posts and be furnished with suitable metal connections to fasten it to the posts at each end.

For pipe 1.90 inches O.D. and under, the outside diameter at any point shall not vary more than 1/64 inch over no more than 1/32 inch under the standard specified. For pipe 2.375 inches O.D. and over, the outside diameter shall not vary more than ± 1% from the standard specified nor shall the minimum wall thickness at any point be more than 12.5% under the nominal wall thickness specified.

A 10% minimum weight tolerance will be allowed for all steel posts and rails.

(B) Woven Wire Fence

Steel posts used instead of 4 inch timber posts shall be a standard studded T-section 7.5 feet long designed exclusively for use as a fence post and be equipped with a metal anchor plate securely attached to the post. The T-posts shall weigh 1.33 lbs/lf exclusive of the weight of the anchor plate, and have a total weight, including anchor plate, of 10.65 lbs. Nominal dimensions of the T-post shall be 1 3/8 inches wide and 1 3/8 inches deep. A tolerance of ± 3/16 inch will be permitted from these nominal dimensions. The anchor plate shall be sufficiently sturdy to withstand the strain of driving with no loss of effectiveness, and have a minimum area of 14.0 square inches.

Steel posts used instead of 5 inch timber posts may be either tubular posts or angle posts. They shall be 8 feet long and be embedded in a concrete anchor at least 3.3 feet deep and 10 inches in diameter. Fit tubular posts with ornamental tops that fit over the top of the post to cap against moisture. Fabricate the tubular posts from 2 inch diameter pipe meeting AASHTO M 181 for Grades 1 or 2 metallic coated posts and rails. Fabricate angle posts from angle sections measuring 2 1/2 inches x 2 1/2 inches x 1/4 inch, ± 1/16 inch on the 2 1/2 inch dimensions and ± 0.015 inch on the 1/4 inch dimension and weighing 4.10 lbs/ft.

Use steel braces with steel posts and either tubular braces or angle braces to match the posts. Furnish the braces with suitable metal connections to fasten them securely to the posts. Fabricate tubular braces from 1 1/4 inch diameter pipe meeting AASHTO M 181 for Grades 1 or 2 metallic coated posts and rails. Fabricate angle braces from angle sections measuring 2 inches x 2 inches x 1/4 inch ± 3/64 inch on the 2 inch dimensions and ± 0.010 inch on the 1/4 inch dimension and weighing 3.19 lbs/ft.

A 10% minimum weight tolerance will be allowed for all steel posts and braces.

For pipe 1.90 inches O.D. and under, the outside diameter at any point shall not vary more than 1/64 inch over nor more than 1/32 inch under the standard specified. For pipe 2.375 inch O.D. and over, the outside diameter shall not vary more than ± 1% from the standard specified nor shall the minimum wall thickness at any point be more than 12.5% under the nominal wall thickness specified.

Galvanize all steel posts and braces other than tubular members in accordance with ASTM A123.

1050-4 BARBED WIRE

Barbed wire shall meet ASTM A121 except as otherwise provided in this subarticle.

The barbed wire may be either galvanized steel or aluminum coated steel except where aluminum chain-link fabric is used, galvanized steel barbed wire shall not be used. Use the same type of material throughout the project. All barbed wire shall have 4 point barbs spaced not more than 5 inches apart. Single strand barbed wire will not be acceptable.

Two strand galvanized steel barbed wire shall be fabricated from either 12 1/2 gauge or 15 1/2 gauge strand wire with 4 point galvanized steel 14 gauge barbs. The 12 1/2 gauge shall be Standard Grade with a Class 3 coating on the wire and a Class 1 coating on the barbs. The 15 1/2 gauge shall be Chain Link Fence Grade with a Class 3 coating on both the wire and barbs.

Two strand aluminum coated steel barbed wire shall be fabricated from two strands of 12 1/2 gauge aluminum coated steel wire with the 4-point barbs being either 14 gauge aluminum coated steel or aluminum alloy wire.

1050-5 WOVEN WIRE

Woven wire fencing shall conform to ASTM A116 or AASHTO M 279. The fence fabric shall be 47 inches high, with 10 horizontal strands. Space the strands 3 inches apart at the bottom and 8 inches apart at the top with progressive spacing between. Space vertical strands at 6 inch intervals. Any of the following styles and coating classes may be used.

(A) Style 1047-6-9, Grade 60 (all horizontal and vertical strands of wire shall be 9 gauge) with a Class 3 zinc coating.

(B) Style 1047-6-11, Grade 60 (top and bottom horizontal strands to be 9 gauge wire, all other strands to be 11 gauge) with a Class 3 zinc coating.

(C) Style 1047-6-12 1/2, Grade 125 (top and bottom horizontal strands of wire to be no smaller than 10 1/2 gauge with a minimum breaking strength of 1610 lbs., all other strands to be no smaller than 12 1/2 gauge with a minimum breaking strength requirement for horizontal strands of 960 lbs. with a Class 3 coating.

Brace wire shall be a 9 gauge steel in accordance with ASTM A641, except that the minimum zinc coating shall be 0.80 ounces per sf.

1050-6 CHAIN LINK FABRIC

Chain link fence fabrics shall meet AASHTO M 181. Galvanized steel fabric shall have a Class D coating. Polyvinyl coated fabric shall be Type IV, Class A or B and the vinyl coating shall be a standard color meeting AASHTO M 181 or ASTM F934 Table 1. Glare screen fabric with a 0.5 inch mesh shall have a Class 1 zinc coating in accordance with ASTM A392. The height of the chain link fence fabrics shall be as shown in the pay item description. Weave the fabric from 11 gauge wire, unless otherwise required by the contract. Glare screen fabric shall be 11 1/2 gauge unless otherwise required by the contract.

1050-7 FENCE FITTINGS, HARDWARE AND ACCESSORIES

All fittings, hardware and accessories shall meet AASHTO M 181, AASHTO M 232, ASTM F626 OR ASTM A641 or ASTM A809 except for the size, type and coating requirement as shown below in Table 1050-2 and elsewhere in this article.

Galvanize bolts, nuts, washers and other threaded items in accordance with AASHTO M 232.

Where shown in the plans, fit the posts with ornamental tops. The base of tops to be used with pipe posts shall fit over the top of the post to guard against moisture.

Tension wire for use with galvanized steel chain link fabric shall meet AASHTO M 181 for zinc coated tension wire. Tension wire for use with aluminum or aluminum coated chain link fabric may be either aluminum coated tension wire meeting AASHTO M 181, or solid aluminum wire with a minimum diameter of 0.192 inch. The aluminum for solid aluminum wire shall meet ASTM B211 for Alloy 5056 or 6061, and have a minimum breaking strength of 1,216 lbs. force and a minimum elongation of 10%. Tension wire for use with guardrail mounted glare screen fabric shall be 6 gauge and for barrier mounted glare screen the wire shall be 9 gauge unless otherwise required by the contract.

Vinyl coated fittings and accessories shall be galvanized steel or aluminum coated steel meeting this article and have a bonded vinyl coating. The vinyl shall meet Section 6 of AASHTO M 181 and be a standard color meeting AASHTO M 181 or ASTM F934 Table 1. The vinyl

coating shall be at least 6 mils thick, except that the coating on tension wire, hog rings and tie wires shall be 6 to 10 mils thick.

1050-8 REPAIR OF GALVANIZING

Repair of galvanizing shall be in accordance with Article 1076-7. Do not use aerosol can products for repairs

TABLE 1050-2
PROPERTIES OF FENCING MATERIALS

Item	Gauge or Diameter, inch	Coating, oz/sf	Coating, oz/sf, Aluminum	Remarks
Tie wires, steel	9	0.90	0.40	For fastening chain link fabric and tension wire to tubular sections or to roll formed steel line posts.
Tie wires, Aluminum	6	-	-	Alloy 1350-H19 or approved equal.
Clips, steel wire	7	0.90	-	For fastening chain link fabric and tension wire to H- posts.
Clips, steel wire	11	0.85	-	For fastening woven wire fabric to steel posts.
Hog rings, steel	12	0.80	0.40	For fastening chain link fabric to tension wire.
Hog rings, aluminum	9	-	-	Alloy 1350-H19 or approved equal.
Truss rod, steel	5/16	2.00	-	-
Tension (stretcher) bars, steel	3/16 x 3/4	1.50	-	For connection of 1 3/4" or 2" fabric to end, gate and corner posts for fabric heights over 5 ft.
Tension (stretcher) bars, steel	3/16 x 5/8	1.50	-	For connection of 1 3/4" or 2" fabric to end, gate and corner posts for fabric heights up to 5 ft.
Tension (stretcher) bars, steel	1/4 x 3/8	1.50	-	For connection of 1" fabric to end, gate, and corner posts.
Staples, Nails or	9	0.35	-	For fastening woven wire to timber posts. Shall be the size and shape shown in the plans.
Tension wire braces	9	0.90	0.40	For woven wire fence.
Post and line caps	-	1.30	-	For installation on top of posts to guard against moisture.
Rail and brace ends (pressed steel or cast iron)	-	1.30	-	-
Top rail steel sleeves	0.051	1.30	-	For rail connections. shall be fabricated to prevent movement along the rail.
Tension band	14	1.30	-	For fastening tension bar to posts.
Brace band	12	1.30	-	For fastening rail to posts.
Barbed wire extension arms (pressed steel or cast iron)	14	1.30	-	Shall be fitted with clips or slots for attaching the barbed wire to the arms.
Hinges, latches	-	2.00	-	-

SECTION 1052
LIME STABILIZERS

1052-1 LIME

(A) Chemical Requirements

Quicklime and hydrated lime for soil stabilization shall meet ASTM C977 except that it shall contain at least 86% available calcium oxide (CaO) on an LOI-free basis.

(B) Physical Requirements

(1) Hydrated Lime

Hydrated lime shall have at least 85% passing a No. 200 sieve.

(2) Quicklime

Grade quicklime so 100% passes a 1/4 inch sieve.

(C) Sampling and Inspection

Furnish Type 1 or Type 2 material certifications with each shipment of lime attesting that the lime meets the specifications in accordance with Article 106-3; however, the material will be subject to inspection, test or rejection by the Engineer at any time.

Lime from more than one source or more than one type may be used on the same project, but the different limes shall not be mixed. Protect the lime from exposure until used and sufficiently dry it to flow freely when handled.

SECTION 1054
DRAINS

1054-1 DECK DRAINS

Provide deck drains made of PVC pipe. Use the type of pipe as shown in the plans.

PVC pipe shall meet ASTM D1785 or D2665, and have four 1/2 inch square lugs shop glued at approximately equal spacing around the pipe at 4 inches from the top end of each deck drain.

SECTION 1056
GEOSYNTHETICS

1056-1 DESCRIPTION

Provide geosynthetics for subsurface drainage, separation, stabilization, reinforcement, erosion control, filtration and other applications in accordance with the contract. Use geotextiles, geocomposite drains and geocells that are on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. Prefabricated geocomposite drains include sheet, strip and vertical drains (PVDs), i.e., "wick drains" consisting of a geotextile attached to and/or encapsulating a plastic drainage core. Geocells are comprised of ultrasonically welded polymer strips that when expanded form a 3D honeycomb grid that is typically filled with material to support vegetation. Define geotextiles, geogrids, geocomposite drains and geocells as geosynthetics.

If necessary or required, hold geotextiles, geogrids and sheet drains in place with new wire staples, i.e., "sod staples" that meet Subarticle 1060-8(D) or new anchor pins. Steel anchor pins shall have a diameter of at least 3/16 inch, a length of at least 18 inches, a point at one end and a head at the other end that will retain a steel washer with an outside diameter of at least 1.5 inches.

1056-2 HANDLING AND STORING

Load, transport, unload and store geosynthetics so geosynthetics are kept clean and free of damage. Label, ship and store geosynthetics in accordance with Section 7 of AASHTO M 288. Geosynthetics with defects, flaws, deterioration or damage will be rejected by the Engineer. Do not unwrap geosynthetics until just before installation. Do not leave geosynthetics exposed for more than 7 days before covering except for geotextiles for temporary wall faces and erosion control.

1056-3 CERTIFICATIONS AND IDENTIFICATION

Provide Type 1, Type 2 or Type 4 material certifications in accordance with Article 106-3 for geosynthetics except certifications are not required for Type 1 through Type 3 geotextiles and Type 5a geotextiles. Type 1, Type 2 or Type 4 material certifications in accordance with Article 106-3 are required for Type 4a geotextiles. Define "machine direction" (MD), "cross-machine direction" (CD) and "minimum average roll value" (MARV) in accordance with ASTM D4439. Provide certifications with MARV for geosynthetic properties as required. Test geosynthetics using laboratories accredited by the Geosynthetic Accreditation Institute (GAI) to perform the required test methods. Sample geosynthetics in accordance with ASTM D4354.

Allow the Engineer to visually identify geosynthetic products before installation. Open packaged geosynthetics just before use in the presence of the Engineer to verify the correct product. Geosynthetics that are missing original packaging or product labels or that have been unwrapped or previously opened will be rejected unless otherwise approved by the Engineer.

1056-4 GEOTEXTILES

Provide geotextile types and classes in accordance with the contract.

Use woven or nonwoven geotextiles with properties that meet Table 1056-1.

TABLE 1056-1
GEOTEXTILE REQUIREMENTS

Property[A]	Requirement (MARV[A])					Test Method
	Type 1	**Type 2**	**Type 3[B]**	**Type 4a**	**Type 5a[C]**	
Typical Application	*Shoulder Drains*	*Under Rip Rap*	*Silt Fence Fabric*	*Soil Stabilization*	*Subgrade Stabilization*	
Elongation (MD & CD)[A]	≥ 50%	≥ 50%	≤ 25%	< 50%	< 50%	ASTM D4632
Grab Strength (MD & CD)[A]	Table 1[D], Class 3	Table 1[D], Class 1	100 lb	-	-	ASTM D4632
Tear Strength (MD & CD)[A]			-			ASTM D4533
Puncture Strength			-			ASTM D6241
Ultimate Tensile Strength (MD & CD)[A]	-	-	-	2,400 lb/ft	Table 12[D], Class 4A	ASTM D4595
Permittivity	Table 2[D], 15% to 50% *in Situ* Soil Passing 0.075 mm	Table 6[D], 15% to 50% *in Situ* Soil Passing 0.075 mm	Table 7[D]	Table 12[D], Class 4A	Table 12[D], Class 4A	ASTM D4491
Apparent Opening Size						ASTM D4751
UV Stability (Retained Strength)						ASTM D4355

A. MD, CD and MARV per Article 1056-3.
B. Minimum roll width of 36 inches required.
C. Minimum roll width of 13 feet required unless otherwise approved by the Engineer for the application.
D. Per AASHTO M 288.

1056-5 GEOCOMPOSITE DRAINS

Provide geocomposite drain types in accordance with the contract and with properties that meet Table 1056-2.

TABLE 1056-2
GEOCOMPOSITE DRAIN REQUIREMENTS

Property	Requirement			Test Method
	Sheet Drain	**Strip Drain**	**Wick Drain**	
Width	≥ 12"	12" ±1/4"	4" ±1/4"	N/A
In-Plane Flow Rate[A] (with gradient of 1.0 and 24-hour seating period)	6 gpm/ft @ applied normal compressive stress of 10 psi	15 gpm/ft @ applied normal compressive stress of 7.26 psi	1.5 gpm[B] @ applied normal compressive stress of 1.45 psi	ASTM D4716

A. MARV per Article 1056-3.
B. Per foot of width tested.

For sheet and strip drains, use accessories (e.g., pipe outlets, connectors, fittings, etc.)

recommended by the Drain Manufacturer. Provide sheet and strip drains with Type 1 geotextiles heat bonded or glued to HDPE, polypropylene or high impact polystyrene drainage cores that meet Table 1056-3.

TABLE 1056-3
DRAINAGE CORE REQUIREMENTS

Property	Requirement		Test Method
	Sheet Drain	Strip Drain	
Thickness	1/4"	1"	ASTM D1777 or D5199
Compressive Strength[A]	40 psi	30 psi	ASTM D6364

A. MARV per Article 1056-3.

For wick drains with a geotextile wrapped around a corrugated drainage core and seamed to itself, use drainage cores with an ultimate tensile strength of at least 225 lbs. per 4 inch width in accordance with ASTM D4595 and geotextiles with properties that meet Table 1056-4.

TABLE 1056-4
WICK DRAIN GEOTEXTILE REQUIREMENTS

Property	Requirement	Test Method
Elongation	≥ 50%	ASTM D4632
Grab Strength	Table 1[A], Class 3	ASTM D4632
Tear Strength		ASTM D4533
Puncture Strength		ASTM D6241
Permittivity[B]	0.7 sec^{-1}	ASTM D4491
Apparent Opening Size (AOS)	Table 2[A], > 50% *in Situ* Soil Passing 0.075 mm	ASTM D4751
UV Stability (Retained Strength)		ASTM D4355

A. Per AASHTO M 288.
B. MARV per Article 1056-3.

For wick drains with a geotextile fused to both faces of a corrugated drainage core along the peaks of the corrugations, use wick drains with an ultimate tensile strength of at least 1,650 lbs. per 4 inch width in accordance with ASTM D4595 and geotextiles with a permittivity, AOS and UV stability that meet Table 1056-4.

1056-6 GEOCELLS

Manufacture geocells from virgin polyethylene resin with no more than 10% rework, also called "regrind", materials. Use geocells made from textured and perforated HDPE strips with an open area of 10% to 20% and properties that meet Table 1056-5.

TABLE 1056-5 GEOCELL REQUIREMENTS		
Property	**Requirement**	**Test Method**
Cell Depth	4"	N/A
Fully Expanded Cell Area	100 sq.in. max	N/A
Sheet Thickness	50 mil -5%, +10%	ASTM D5199
Density	58.4 pcf min	ASTM D1505
Carbon Black Content	1.5% min	ASTM D1603 or D4218
ESCR[A]	5000 hr min	ASTM D1693
Coefficient of Direct Sliding (with material that meets AASHTO M 145 for soil classification A-2)	0.85 min	ASTM D5321
Short-Term Seam (Peel) Strength (for 4" seam)	320 lb min	USACE[C] Technical Report GL-86-19, Appendix A
Long-Term Seam (Hang) Strength[B] (for 4" seam)	160 lb min	

A. Environmental Stress Crack Resistance.

B. Minimum test period of 168 hours with a temperature change from 74°F to 130°F in 1-hour cycles.

C. USACE

Provide geocell accessories (e.g., stakes, pins, clips, staples, rings, tendons, anchors, deadmen, etc.) recommended by the Geocell Manufacturer.

SECTION 1060
LANDSCAPE DEVELOPMENT MATERIALS

1060-1 GENERAL

Supply certifications for all landscape development materials as required below. If no certification is required, supply the Department with a statement certifying that all materials conform to these specifications and those of the NC Department of Agriculture and Consumer Services (NCDA&CS) or both. All landscape development materials shall comply with all applicable Federal and State domestic plant quarantines.

1060-2 FERTILIZER

The quality of all fertilizer and all operations in connection with the furnishing of this material shall comply with the North Carolina Commercial Fertilizer Law and with the rules and regulations, adopted by the North Carolina Board of Agriculture in accordance with said law, in effect at the time of sampling. All fertilizer will be subject to sampling and testing by the Engineer, or by an authorized representative of the North Carolina Department of Agriculture and Consumer Services, or both.

Dry fertilizer shall be manufactured from cured stock. Care for the fertilizer during handling and storing in such a manner that it will be protected against hardening, caking or loss of plant food values. Pulverize any hardened or caked fertilizer to its original condition before using.

1060-3 LIMESTONE

The quality of all limestone and all operations in connection with the furnishing of this material shall comply with the North Carolina Agricultural Liming Materials and Landplaster Act, and with the rules and regulations, adopted by the North Carolina Board of Agriculture and Consumer Services in accordance with said law, in effect at the time of sampling. All limestone will be subject to sampling and testing by the Engineer, or by an authorized representative of the North Carolina Department of Agriculture, or both.

Limestone shall be agricultural grade ground limestone. Either dolomitic or calcitic limestone may be used.

All limestone shall contain not less than 90% calcium carbonate equivalents. Dolomitic limestone shall contain not less than 10% of magnesium. Grade dolomitic limestone so at least 90% will pass through a U.S. Standard 20 mesh screen and at least 35% will pass through a U.S. Standard 100 mesh screen. Grade calcitic limestone so at least 90% will pass through a U.S. Standard 20 mesh screen and at least 25% will pass through a U.S. Standard 100 mesh screen. Where the current grading requirements of the North Carolina Board of Agriculture are different from the above, the requirements of the Board of Agriculture will apply.

During handling and storing, care for the limestone in such manner that it will be protected against hardening or caking. Pulverize any hardened or caked limestone to its original condition before using.

1060-4 SEED

The quality of all seed and all operations in connection with the furnishing of this material shall comply with the North Carolina Seed Law and with the rules and regulations, adopted by the North Carolina Board of Agriculture and Consumer Services in accordance with said law, in effect at the time of sampling, and with the quality requirements of the specifications. All seed will be subject to sampling by the Engineer, or by an authorized representative of the North Carolina Department of Agriculture and Consumer Services, or both; and will be tested by the North Carolina Department of Agriculture. Supplementary testing for seed germination may be performed by the Engineer.

The quality of all seed will be based on the percentage of pure live seed, which will be computed by multiplying the percentage of purity by the percentage of germination and dividing the result by 100.

Seed shall have been approved by the North Carolina Department of Agriculture and Consumer Services before being sown. No seed will be accepted with a date of test more than 8 months before the date of sowing, excluding the month in which the test was completed. Such testing, however, will not relieve the Contractor from responsibility for furnishing and sowing seed that meets these specifications at the time of sowing. The Engineer may retest seed for germination after 5 months of storage; at the beginning of each normal seeding season for the particular kind of seed involved or at any time that the condition of the seed appears to have deteriorated.

When a low percentage of germination causes the quality of the seed to fall below the minimum pure live seed specified, the Contractor may elect, subject to the approval of the Engineer, to increase the rate of application sufficiently to obtain the minimum pure live seed content specified, provided that such an increase in the rate of application does not cause the quantity of noxious weed seed per acre or square yard, as the case may be, to exceed the quantity that would be allowable at the regular rate of application.

Furnish and deliver each of the species or varieties of seed in separate bags. If seed is to be mixed before sowing, perform such mixing in a commercial seed mixing machine, or by an equally thorough means, after sampling and testing have been completed.

During handling and storing, care for the seed in such a manner that it will be protected from damage by heat, moisture, rodents or other causes.

1060-5 MULCH FOR EROSION CONTROL

Mulch for erosion control shall consist of grain straw, or other acceptable material, and be approved by the Engineer before being used. All mulch shall be reasonably free from mature seedbearing stalks, roots or bulblets of Johnson Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Crotalaria, Witchweed and an excessive amount of restricted noxious weeds as defined by the North Carolina Board of Agriculture at the time of use of the mulch. Loose and separate straw mulch that is matted or lumpy before being used.

Tacking material shall be one of the following:

(A) Emulsified Asphalt

Asphalt emulsion tack shall conform to the requirements of AASHTO M 140. The emulsified asphalt may be rapid setting, medium setting or slow setting.

(B) Cellulose Hydromulch

Cellulose hydromulch products shall be non-toxic, weed-free, prepackaged cellulose fiber (pulp) material containing no more than 3% ash or other inert materials. Cellulose hydromulches may contain dyes or binders specifically formulated to enhance the adhesive qualities of the hydromulch.

Wood fiber or wood fiber blend hydromulches may be substituted for cellulose hydromulch at the same application rate.

(C) Other Tackifiers

Other approved materials, specifically designed and manufactured for application as a straw mulch tacking agent, may be used at the manufacturer's recommended rate.

1060-6 SPRIGS

Sprigs shall consist of freshly dug live stolons or rhizomes of perennial grasses, at least 2 inches in length, and be first class representatives of the required species or varieties specified in the specifications. The areas from which sprigs are to be obtained shall be free from Johnson Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Crotalaria, Witchweed and an excessive amount of restricted noxious weeds as defined by the North Carolina Board of Agriculture at the time of digging the sprigs. The areas shall have been mowed and raked, burned off, or otherwise prepared in a manner acceptable to the engineer before digging of sprigs begins.

1060-7 SOD

Sod shall consist of a live, dense, well-rooted growth of permanent grasses, free from Johnson Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Crotalaria, Witchweed and an excessive amount of restricted noxious weeds as defined by the North Carolina Board of Agriculture and Consumer Services at the time of cutting the sod. Mow the area from which sod is to be obtained to a height of not more than 2 inches. Rake free of grass clippings and debris and otherwise prepared in a manner satisfactory to the Engineer before cutting of sod begins.

Cut the sod into rectangular sections of sizes convenient for handling without breaking or loss of soil. Cut it with a sod cutter or other acceptable means to a depth that will retain in the sod practically all of the dense root system of the grass.

During wet weather, allow the sod to dry sufficiently before lifting to prevent tearing during handling and placing. During extremely dry weather, water it before lifting if such watering is necessary to ensure its vitality and to prevent loss of soil during handling.

1060-8 MATTING FOR EROSION CONTROL

(A) General

Matting for erosion control shall be excelsior matting or straw matting. Furnish a Type 3 material certification in accordance with Article 106-3 certifying that the matting meets this article. Other acceptable material manufactured especially for erosion control may be used when approved by the Engineer in writing before being used. Matting for erosion control shall not be dyed, bleached or otherwise treated in a manner that will result in toxicity to vegetation.

(B) Excelsior Matting

Excelsior matting shall consist of a machine produced mat of curled wood excelsior at least 47 inches in width and weigh 0.975 lb/sy with a tolerance of ± 10%. At least 80% of the

individual excelsior fibers shall be 6 inches or more in length. Evenly distribute the excelsior fibers over the entire area of the blanket. Cover one side of the excelsior matting with an extruded plastic mesh. The mesh size for the plastic mesh shall be no more than 1 inch x 1 inch.

(C) Straw Matting

Straw matting shall consist of a machine produced mat of 100% grain straw. The straw matting shall have a width of at least 48 inches and no more than 90 inches and weighing at least 0.50 lb/sy and no more than 0.75 lb/sy. Evenly distribute the straw over the entire area of the blanket. Cover one side of the blanket with photodegradable netting with a maximum mesh (netting) size of 0.75 inch x 0.75 inch sewn together with a degradable thread. The grain straw shall contain no weed seeds. Package each roll separately.

(D) Wire Staples

Staples shall be machine made of No. 11 gauge new steel wire formed into a U-shape. The size when formed shall be not less than 6 inches in length with a throat of not less than 1 inch in width.

1060-9 WATER

Water used in the planting or care of vegetation shall meet Class C freshwaters as defined in 15A NCAC 02B.0200.

1060-10 NURSERY GROWN PLANT MATERIALS

(A) General

Use all plants as called for by the contract.

Container grown plants may be used instead of balled and burlapped plants or bare rooted plants provided written approval for such use has been obtained from Engineer.

Grading of plants, size of root balls and type and minimum dimensions of containers shall conform to the *American Standard for Nursery Stock*. Do not cut back plants from larger sizes to meet the sizes called for in the contract.

Botanical names referred to in the contract are taken from *Hortus Third, the Bailey Hortorium* (MacMillan Publishing Co., Inc.). All plants delivered shall be true to name. Each plant, or group of the same species, variety and size of plant, shall be legibly tagged with the name and size of the plant.

All plants shall be first-class representatives of their species or varieties. The root system shall be vigorous and well developed. The branch systems shall be of normal development and free from disfiguring knots, sun scald injuries, abrasions of the bark, dead or dry wood, broken terminal growth or other objectionable disfigurements. Trees shall have reasonably straight stems and be well branched and symmetrical in accordance with their natural habits of growth.

All plants shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the states of origin and destination, as well as with Federal regulations governing interstate movement of nursery stock. Any nursery stock used on highway landscape projects shall be accompanied by a valid copy of a certificate of inspection, which has been granted by the North Carolina Department of Agriculture and Consumer Services, Entomology Division. Fire ant treatment certification, where applicable, is required.

When nursery stock from other states is used on projects in North Carolina, this stock shall be accompanied by a tag or certificate stating that the nursery stock has been inspected and certified by an authorized official of the state of origin as apparently free from injurious plant pests.

All plant materials are subject to inspection at any time by the Engineer. Any such inspection before or during planting operations, however, will not be construed as final acceptance of the plants involved.

All geophytes; bulbs, corms and tuberous plants; shall be synonymous to the term “plant” within the contract. Examples include, but are not limited to, Narcissi (Daffodil), Tulipa (Tulip), Iris and Canna; the terms “bulb”, “corm”, “tuber”; and specific plant names such as “Daffodil”, “Tulip”, “Canna lily”, etc.

(B) Balled and Burlapped Plants

Dig plants to be balled and burlapped so as to retain a firm ball of soil and the plant’s fibrous root system. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. Dig, wrap, transport and handle the plant so the soil in the ball shall not become frozen, loosened, cause stripping of the small feeding roots nor movements of the soil away from contact with such roots.

(C) Container Grown Plants

Container grown plants shall be healthy, vigorous, well-rooted and established in the container in which they are delivered. These plants shall be in the container long enough for the fibrous roots to have developed so the root mass will retain its shape and hold together when removed from the container. The container shall be sufficiently rigid to firmly hold the soil protecting the root mass during transporting, handling and planting. The soil shall not be allowed to become frozen.

(D) Bare Root Plants

Bare root plants shall have a heavy fibrous root system that has been developed by proper cultural treatment. Dig, package, transport and handle bare root plants in a manner that will prevent injury to or drying out of the trunks, branches or roots, or freezing of the roots. Bare root plants damaged through improper handling, freezing, drying out, etc. will result in rejection of material.

(E) Plant Substitution

No change in the specifications (species, variety, size, caliper, furnish) will be made without written approval of the Engineer. Present all requests for substitutions in writing and include a listing of the sources contacted in an attempt to secure specified plant material. Requests for substitutions shall include the botanical name, common name, cultivar, where applicable, size, caliper and furnish description of the proposed substitute. No increase in compensation will be made to the Contractor as a result of the use of approved substitute plants. The Department reserves the right to locate specified plant material for the project when it has knowledge that specified material is available.

(F) Geophytes

Geophytes; bulbs, corms and tuberous plants; shall be healthy and free of disease caused by fungi, nematodes, bacteria and wilt. Plants that are lightweight and lacking adequate mass will result in rejection. Plants shall be firm and absent of discolored patches with soft or spongy areas or signs of rot, slime or mold. Plants with new root growth will result in rejection.

Dig, package, transport and handle these plants as to prevent injury, drying out, excessive wetness or freezing. Damaged plants through improper handling, freezing, drying out or excessive moisture will result in rejection.

All geophytes, bulbs, corms and tuberous plants shall be inspected for size and condition and plants rejected by the Engineer shall be removed from the supply before planting.

1060-11 MULCH FOR PLANTING

Use mulch for planting as specified in the specifications, shown in the plans, or approved by the Engineer. Mulch for planting shall not contain substances injurious to plants or which will inhibit normal development and growth of plants. Mulch for a project shall come from a single source, as approved by the Engineer, unless an additional source is submitted and approved before use.

1060-12 MATERIALS FOR STAKING OR GUYING

(A) Stakes

Use stakes made of cypress, cedar, oak, locust or other acceptable wood free from defects that would compromise the strength of the stake. Stakes shall be at least 2 inches x 2 inches (nominal). Use stakes of the size and length as shown in the plans.

(B) Wire

Wire shall be new soft No. 14 gauge steel wire or as shown in the plans.

(C) Hose

Hose to be used with wire shall have a minimum inside diameter of 1/2 inch. All hose shall be garden type hose composed of rubber and fabric, or as shown in the plans.

(D) Other

Other staking and guying materials may be used if a sample is submitted and approved by the Engineer before use.

1060-13 HERBICIDES

The herbicide to be used for a particular application shall be as specified or approved by the Engineer prior to their application.

Herbicides shall be properly labeled and registered with the United States Department of Agriculture and the North Carolina Department of Agriculture and Consumer Services. A container shall contain only the herbicide that meets the analysis guaranteed on the label. Keep all herbicides in such original labeled containers until used.

Herbicide application shall only be conducted by individuals who possess a pesticide license from the NC Department of Agriculture and Consumer Services or individuals under their direction and who has read, understands, and follows the herbicide labeling before applying the product.

1060-14 COIR FIBER MAT

Coir fiber mat shall consist of 100% coconut fiber (coir) twine woven into high strength matrix. The coir fiber mat shall have a thickness of at least 0.30 inch and weigh at least 20 ounces per square yard. The coir fiber mat shall have a dry tensile strength of at least 1,348 x 626 lbs/ft. The coir fiber mat shall have an observed flow velocity of 11 feet per second. The coir fiber mat shall have a C-Factor of 0.002. The minimum width of the coir fiber mat shall be 6.5 feet and the measured open area shall be 50%.

1060-15 COMPOST

Test methods for the compost should follow USCC TMECC guidelines for laboratory procedures. A sample shall be submitted to the Engineer for approval prior to being used and must comply with all local, state and federal regulations.

(A) Chemical Requirements

pH between 5.0-8.0 in accordance with TMECC 04.11-A, "Electrometric pH Determinations for Compost".

(B) Physical Requirements

(1) Weed free.
(2) Derived from a well-decomposed source of organic matter.
(3) Produced using an aerobic composting process meeting CFR 503 regulations Including time and temperature data indicating effective weed seed, pathogen and insect larvae kill.
(4) Free of any refuse, contaminants or other materials toxic to plant growth.
(5) Non-composted products will not be accepted by the Engineer.
(6) For seeded Compost Blankets, seed should be incorporated at the time of application in the entire depth of the compost blanket, at rates per foot, per square yard, or per acre, as acceptable to the Engineer. The following particle sizes shall also be followed: 100% passing a 2 inch sieve; 99% passing a 1 inch sieve; minimum of 60% passing a 1/2 inch sieve. All other testing parameters remain the same. The seeding rates are generally similar or slightly higher than those used when considering application of seed via hydroseeding or other seeding methods.
(7) Moisture content of less than 60% in accordance with standardized test methods for moisture determination.
(8) Material shall be relatively free (<1% by dry weight) of inert or foreign man-made materials.

SECTION 1070
REINFORCING STEEL

1070-1 GENERAL

All reinforcing steel and welded wire reinforcement must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan. Standard drawing details for reinforcement products are found in the *Roadway Standard Drawings.*

Steel reinforcement shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other nonmetallic coatings which could reduce bond as determined by the Engineer. Reinforcing steel placement and fastening shall conform to the requirements of AASHTO LRFD Bridge Construction Specifications, Section 9 and these specifications of which the more stringent shall apply.

When approved by the Engineer, field welding of reinforcing steel materials shall be performed in accordance with Section 1072 and at a minimum, comply with the current edition of AWS D1.4.

1070-2 STEEL BAR REINFORCEMENT FOR ROADS AND STRUCTURES

Use reinforcing steel provided by a NCDOT approved facility as found on the Department's producer/supplier list. All producer/suppliers must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. Supply deformed steel bar reinforcement conforming to ASTM A615 for Grade 60. For uncoated deformed and/or plain reinforcing, furnish the Engineer a Type 1 certification in accordance with Article 106-3 and attach it to *Materials and Tests Form 913* for each shipment of reinforcing material. Bend and cut during fabrication with tolerances in accordance with the AASHTO LRFD Bridge Construction Specifications, Section 9. Bend the bars cold to the details shown in the plans.

Weld steel bar reinforcement only where shown in the plans or approved by the Engineer. When welding steel bar reinforcement use bars conforming to ASTM A706.

1070-3 COLD DRAWN STEEL WIRE AND WIRE REINFORCEMENT

Provide cold drawn steel wire for use as spirals or in fabricated form for the reinforcement of concrete meeting AASHTO M 336. When required by the plans, apply epoxy coating by a NCDOT approved facility.

Use steel welded wire reinforcement, plain or deformed, conforming to AASHTO M 336.

1070-4 REINFORCING STEEL BAR SUPPORTS

Provide all wire bar supports of smooth cold drawn industrial quality basic wire having a minimum tensile strength of 65,000 psi. When the legs of the bar supports are in contact with the forms, ensure that the entire leg of the bar support is stainless steel wire or a minimum thickness of 1/4 inch stainless steel at points of contact with the forms. Use stainless steel wire meeting ASTM A493 except having a minimum chromium content of 16% and a minimum tensile strength of 95,000 psi. Ensure that wire sizes, height tolerance, and leg spacing for wire bar supports are in accordance with the *Manual of Standard Practice* published by the Concrete Reinforcing Steel Institute.

As an option to the stainless steel wire for the legs of bar supports at points of contact with the forms, provide legs of cold drawn steel wire plastic protected in accordance with the *Manual of Standard Practice* published by the Concrete Reinforcing Steel Institute, except provide plastic protection by dipping or by premolded plastic tips in accordance with ANSI/CRSI-RB4. Do not use plastic legs molded to the top wire.

Use plastic bar supports meeting the requirements listed in ANSI/CRSI-RB4 published by the Concrete Reinforcing Steel Institute only when approved by the Engineer.

1070-5 PRESTRESSING STRAND

Use prestressing strands for use in prestressed concrete consisting of seven wire strands, stress relieved after manufacture to remove internal stresses. Use the size and the grade of the strand as shown in the plans. Use strands conforming to AASHTO M 203 except provide a specimen for test purposes, if required, from each reel of cable instead of each 20 ton production lot.

For precast prestressed deck panels, use 3/8 inch round seven-wire stress-relieved Grades 250 or 270 prestressing strands meeting AASHTO M 203.

Mark the outer layer of each reel pack of strand with a wide color band as follows: white for Grade 270 stress relieved strand, green for low relaxation strand, and a double marking of green and red for special low relaxation strand. In addition, attach a metal tag to each reel pack labeled in accordance with AASHTO M 203.

1070-6 DOWELS AND TIE BARS FOR PORTLAND CEMENT CONCRETE PAVEMENT

Use dowel and tie bars from the Department's approved producer/supplier list. Use smooth plain round steel dowel bars conforming to AASHTO M 31 Grade 60 conforming to the *Roadway Standard Drawings*. Do not use dowel bars with burred ends. A tolerance of ± 1/4 inch is permitted from the dowel length required by the plans. A straightness tolerance of 0.075 inch from a straight line is permitted.

Epoxy coat and fabricate all dowel bars/baskets by a NCDOT approved facility as found on the Department's producer/supplier list.

Use dowel assemblies for supporting dowel bars of rigid construction capable of holding the dowel bars in proper position during placing of concrete, and of such design to permit unrestricted movement of the pavement slab. Use wire for dowel assemblies meeting AASHTO M 336. Use a dowel assembly that holds the dowels in the required position within a tolerance

of ± 1/4 inch in vertical and horizontal planes. Obtain written approval from the Engineer for the dowel assembly before use.

Coat dowel bars and the entire dowel assembly with an approved wax base coating. Apply the coating by dipping or spraying such that the wax coating on the dowel bars is of uniform thickness sufficient to allow pulling of the dowel from the concrete as provided in AASHTO T 253 Type B coated dowel.

When required by the Department's Minimum Sampling Guide, furnish for testing one dowel basket assembly for each 200 assemblies incorporated into the project. Each Department approved producer/supplier, coater and fabricator shall provide the Department a Type 1 material certification in accordance with Article 106-3, M&T DB-06 Dowel Basket Fabrication Report and when required by the Engineer the *Materials and Tests Form 913* for all coated dowel baskets and loose dowels with each shipment.

Use deformed tie bars conforming to AASHTO M 31 for Grade 40 or Grade 60.

Storage, handling and transportation of epoxy coated dowel and/or tie bars shall be in accordance with Section 1070-7(D).

1070-7 EPOXY COATED REINFORCING STEEL

(A) General

Use reinforcing steel from the Department's approved producer/supplier list. All producer/suppliers must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. Facilities coating and fabricating epoxy coated reinforcing steel shall establish proof of their competency and responsibility in accordance with the Concrete Reinforcing Steel Institute's Fusion Bonded Epoxy Coating Applicator Plant Certification Program. Registration and certification of the plant or shop under the CRSI Program and submission of the valid annual certificate to the State Materials Engineer is required before beginning any coating. The same requirement applies to coaters subcontracting work from the coater directly employed by the contractor.

Obtain approval of each coater and/or fabricator of epoxy coated reinforcing steel before coating or fabrication of bars. The coating applicator and/or fabricator is responsible for establishing and maintaining an effective quality control program, and employ equipment for cleaning, coating and/or fabricating that produces coated material conforming to the *Standard Specifications.*

Include in requests for approval a well-defined quality control program and direct the requests to the State Materials Engineer. Before Department approval is issued, the condition of equipment for blast cleaning, coating and/or fabricating material is evaluated by the Engineer for determining the equipment capability of producing a coated product conforming to the *Standard Specifications*. Use Department approved epoxy coating and fabricating companies as found on the Department's approved producer/supplier list.

(B) Coating Materials

Obtain approval for the epoxy resin powder before use. A list of prequalified powder sources is available from the State Materials Engineer.

(C) Coated Reinforcing Steel

Use coated steel reinforcing bars meeting AASHTO M 31, Grade 60 and free of contaminants such as oil, grease and paint. Use bars free of surface irregularities as defined in ASTM A775 and/or that produce holidays in the coating.

(D) Handling, Storage and Transportation

When handling, storing and transporting coated steel reinforcing bars, all contact areas shall be padded.

All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All bundles of coated steel reinforcing bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion from sags in the bundles of coated steel reinforcing bars. Packaging of uncoated and coated bars is strictly prohibited. When loading/unloading coated bars; pallets, bags or bundles shall not be dropped or dragged.

During storage, protect steel reinforcement at all times from damage and make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials until the time of placement. For storage outside at the fabrication shop and project site, store epoxy coated reinforcing steel bars at least 1 foot above the ground on wooden or padded supports placed 10 feet apart, and completely cover with an opaque cloth, canvas or woven fiber reinforced polyethylene white tarp. Storage of uncoated and coated material shall not be mixed or in direct contact. Do not use solid plastic sheeting. Cover the bars such that adequate ventilation is provided to prevent condensation from forming on the material during storage, and completely protect the bars from direct sunlight. Do not allow water to pond under the epoxy coated reinforcing steel. Do not expose epoxy coated reinforcing steel to outdoor weather for more than 30 days. If the coated steel reinforcing bars are stored outdoors without cover, the date on which the coated bars are placed outdoors shall be recorded on the identification tag for the bundled steel.

Transport the bundled bars from the producer/supplier to the project site with padding, such as carpet padding, placed over each bundle of steel upon which another bundle of steel is placed unless wooden spacers are placed between each bundle to prevent contact. Load all bundles of bars horizontally for transporting. Transport the bars on a flatbed trailer. Do not allow the length of bars to exceed 8 feet beyond the trailer bed. Repair coating damage associated with handling and transporting or other causes in accordance to Subarticle 1070-7(E). Coated steel reinforcing bars should be off-loaded as close as possible to their points of placement or under the crane so that the bars can be hoisted to the area of placement to minimize re-handling. If the material is being transported in adverse weather conditions the producer/supplier, coater, fabricator and/or Contractor shall co-coordinate a material protection plan, test for the presence of chlorides, and, if necessary, clean the material as directed by the Engineer.

(E) Field Coating Repair

The maximum amount of repaired damaged coating shall not exceed 1% of the total surface area in each 0.3 m [1 foot] of the bar. This limit on repaired damaged coating shall not include sheared or cut ends that are coated with patching material. When degraded coating is observed additional inspection or non-destructive testing may be required by the Engineer at no additional cost to the Department.

Ensure the Contractor uses a Department approved patching or repair material that is compatible with the coating and inert in concrete. When repair is required, clean the areas in accordance to SSPC-SP 1 prior to performing additional surface preparation. Surface preparation shall be in accordance with SSPC-SP 11 (Power Tool Cleaning to Bare Metal) and/or in accordance with the manufacturers recommendations. The more stringent of the two shall apply. Ensure that the material is suitable for making repairs with a minimum dry film thickness of 7 mils. Ensure that the Contractor has a copy of the manufacturer's written instructions for application of the patching material and the instructions are closely followed during any coating damage repair. Do not apply any patch material when the surface temperature of the steel or the air temperature is below 40°F. Do not ship or place steel until the patch material is dry to the touch.

1070-8 SPIRAL COLUMN REINFORCING STEEL

Furnish spiral column reinforcing steel with the following areas and weights as required in Table 1070-1 and in the plans.

TABLE 1070-1 SPIRAL COLUMN REINFORCEMENT STEEL PROPERTIES			
Material	**Size**	**Area, sq.in.**	**Weight, lb/ft**
Plain Cold Drawn Wire	W 20	0.20	0.668
	W 31	0.31	1.043
Deformed Cold Drawn Wire	D-20	0.20	0.680
	D-31	0.31	1.054
Plain or Deformed Bar	#4	0.20	0.668
	#5	0.31	1.043

Use cold drawn wire conforming to AASHTO M 336. Use plain or deformed bars conforming to AASHTO M 31 for Grade 60. Use deformed cold drawn wire conforming to AASHTO M 225.

The diameter of the spiral reinforcing steel is the outside to outside measurement of the bars or wire, with an allowance of 1/2 inch more or 1/2 inch less than the specified diameter as shown in the plans.

Furnish spirals with 1.5 extra turns at top and at bottom of the completed spiral cage. Where splicing of the spirals is necessary other than those shown in the plans, provide a minimum lap splice of 3 feet.

Do not weld on the spiral reinforcing steel.

When required by the plans, use epoxy coated spiral column reinforcing steel and spacers provided by a NCDOT approved supplier available on the Department's approved producer/supplier list.

Use the minimum number of spiral spacers as shown in the plans. Ensure a minimum section modulus per spiral spacer of 0.030 cu. in.

1070-9 MECHANICAL BUTT SPLICES

When called for by the contract or when approved by the Engineer, use a mechanical butt reinforcing steel splice from an approved source that is found on the Department's producer/supplier list. Use a standard metal filled sleeve, cement mortar filled sleeve, threaded steel couplings, forged steel sleeve or cold-forged sleeve. An exothermic process whereby molten filler metal, contained by a high strength steel sleeve of larger inside diameter than the bars, is introduced into the annular space between the bars and the sleeve and between the ends of the bars may be used. Provide a splice that is capable of transferring at least 125% of the yield strength of the bars from one bar to the other by the mechanical strength of the splice components.

For splices not on the approved list, before use and as a condition of approval, assemble three test splices in the presence of the Engineer for each size of bar which is proposed for use on the project. Forward the test splices to the Materials and Tests Unit in Raleigh, NC for testing and approval.

1070-10 REJECTION

Reinforcing material that does not meet the *Standard Specifications* is rejected by the Engineer. When required by the Engineer, replace reinforcing material that is bent, deformed, exhibits cracked material or welds, contaminated and when the maximum amount of coating damage exceeds the limits herein or degraded coating is observed and as determined by the Engineer.

SECTION 1072
STRUCTURAL STEEL

1072-1 GENERAL

Furnish and fabricate all structural steel and related incidental materials including sign supports and high mount light standards and use materials in accordance with this section.

(A) Department Steel Bridge Qualification Program

Fabricators furnishing structural steel bridge members for Department projects shall comply with this program. Qualifications shall be submitted to the State Materials and Tests Engineer prior to project letting.

(B) Fabricator Qualification

Use steel fabricators on the Department's Approved Structural Steel Fabricators List that have undergone and successfully completed the Department's audit process for the type work being performed as outlined below. The list is available from the Materials and Tests Unit or on the Department's website.

Fabricators shall possess an AISC Bridge Quality Management Systems (QMS) certification. Employ fabricators that possess an AISC Bridge Component Quality Management Systems (QMS) Certified Component Manufacturer Certification (CPT) for the following:

(1) High mount light standards in excess of 80 feet in length

(2) Structural steel components of fender systems,

(3) Solar array platforms

(4) Retaining walls and noise walls

(5) Sign supports and sign structures

(6) Expansion joints (except modular joints)

Employ fabricators that possess an AISC certification category of Simple Bridge Requirement (SBR) for the following:

(1) Pot and expansion bearings

(2) Simple span rolled beams (unspliced rolled sections), including those requiring cover plates,

(3) Pedestrian bridge truss sections

(4) Modular expansion joints

Employ fabricators that possess an AISC certification category of Certified Bridge Fabricator - Intermediate (IBR) for the following:

(1) A rolled beam bridge with field or shop splices, either straight or with a radius over 500 feet.

(2) A built-up I-shaped plate girder bridge with constant web depth (except for dapped ends), with or without splices, either straight or with a radius over 500 feet.

(3) A built-up I-shaped plate girder with variable web depth (e.g., haunched), either straight or with a radius over 1,000 feet.

(4) A truss with a length of 200 ft or less that is entirely or substantially preassembled at the certified facility and shipped in no more than three subassemblies.

Employ fabricators that possess an AISC certification category of Certified Bridge

Fabricator – Advanced (ABR) for the following: Rail structures, heat curved rolled beams, rolled beams for continuous spans and plate girders, tub or trapezoidal box girders, closed box girders, large or non-preassembled trusses, arches, bascule bridges, cable-supported bridges, moveable bridges, and bridges with particularly tight curve radius. Employ fabricators that possess an AISC certification category of Fracture Critical Endorsement (FC) for the following: Fracture critical bridge beams and girders. This applies to steel bridge members or components that are designated as "fracture critical".

Fabricators performing shop coating applications shall meet the minimum requirements outlined in Section 442.

When AISC certification is required, submit proof of registration and certification of the plant or shop under the AISC program to the State Materials Engineer before beginning fabrication and on an annual basis. The same requirements apply to fabricators subcontracting work from the fabricator directly employed by the Contractor.

(C) Office

Ensure that fabricators of main structural steel components of bridges provide an office area with an approximate floor space of 100 sf, a desk or drafting table, 2 chairs, telephone, facilities for proper heating and cooling, telephone, internet access and adequate lighting and located at the plant site for the exclusive use of the Engineer or their designee. Ensure fabricators of other structural steel items furnish reasonable work areas for the Engineer.

1072-2 SHAPES, PLATES, BARS AND SHEETS

Use shapes, plates, bars and sheets meeting AASHTO M 270 Grade 36 unless otherwise required by the contract. For painted beams or girders, use sheet material of 1/32 inch in thickness meeting ASTM A1008 or A1011, and sheet material of 1/16 inch through 5/32 inch thickness meeting ASTM A1011 for Grades 36, 40 or 45. For unpainted beams or girders, use sheet material less than 3/16 inch thickness meeting ASTM A606 for Type 4.

1072-3 BEARING PLATE ASSEMBLIES

Unless otherwise shown in the plans, galvanize steel bearing assemblies for both structural steel beams and girders and prestressed concrete girders. Galvanize anchor bolts, nuts and washers in accordance with AASHTO M 232. Cut pipe sleeves and collars from Schedule 40 PVC pipe meeting ASTM D1785.

Except for attachments of bearing plates to beams, fabricate and weld bearing plate assemblies before galvanizing the steel. Seal all joints of welded parts with weld material. After the fabrication of the bearing plate assembly is complete, galvanize the assembly in accordance with AASHTO M 111. For prestressed concrete girders, clean welds made for attaching bearing plates to beams or girders and give them two coats of organic zinc repair paint having a minimum total coating thickness of 3 dry mils. For steel beams and girders, clean and paint in accordance with Article 442-10.

Repair galvanized surfaces that are abraded or damaged at any time after the application of the zinc coating by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which give the cleaned area two coats of organic zinc repair paint having a minimum total coating thickness of 3 dry mils. Use zinc rich paint meeting Article 1080-7.

1072-4 ANCHOR BOLTS

Unless otherwise stated herein, use anchor bolts meeting ASTM A307 for Grade A.

Provide anchor bolts for bearing plate assemblies meeting ASTM A449.

Swedge anchor bolts for a distance equal to the embedment length minus 3 inches measured from the embedded end.

Hot-dip galvanize anchor bolts, nuts and washers in accordance with AASHTO M 232.

1072-5 HIGH STRENGTH BOLTS, NUTS AND WASHERS

(A) General

Furnish all high-strength bolts, nuts and washers, including direct tension indicators (DTI's), in accordance with the appropriate AASHTO or ASTM materials specifications as amended and revised herein.

Furnish the Engineer a copy of the manufacturer's test report for each component. Ensure the report indicates the testing date, the city and state where the components were manufactured, the lot number of the material represented, the rotational capacity tests lot number and the source identification marking used by the manufacturer of each component. On test reports for direct tension indicators, include the tension load at which indicators are tested, gap clearance, nominal size and coating thickness.

Produce each permanent fastener component installed in a structure from domestically processed material containing the grade identification markings required by the applicable reference specification and the manufacturer's source identification marking. A copy of the source identification marking used by each manufacturer is on file with the Department's Materials and Tests Unit.

Obtaining permanent bolts, nuts and washers in any one structure from different manufacturers is allowed provided:

(1) All bolts are produced by only one manufacturer.

(2) All nuts are produced by only one manufacturer.

(3) All washers are produced by only one manufacturer.

Have all fasteners used in a structure furnished by the fabricator of the steel. When required, submit the fasteners for sampling and testing at least five weeks before delivery to the project site. The fabricator shall sample and test each diameter bolt, nut and washer assembly to be used on the project. In accordance with Table 1072-1, a minimum of three assemblies per Lot/Heat number shall be submitted by the fabricator to the Materials and Test Laboratory.

TABLE 1072-1
SAMPLING REQUIREMENTS FOR
HIGH STRENGTH BOLTS, NUTS AND WASHERS TO INCLUDE DTI's

Lot / Heat Number	Number of Samples
0-800	3 Assemblies
801-8000	6 Assemblies
> 8000	9 Assemblies

Ship only those fasteners to the project that are sampled, tested and approved by the Department. Protect the material from moisture during storage such that it does not contain any indication of rust at the time of installation. Ensure that each component contains a thin coat of lubricant at the time of installation.

When galvanized high strength bolts are required, use bolts, nuts and washers meeting Subarticle 1072-5(F).

When corrosion resistant structural steel is required by the plans, provide fasteners with atmospheric corrosion resistance and weathering characteristics comparable to that of the structural steel.

(B) Specifications

Ensure that all bolts meet ASTM F3125.

Ensure that all nuts meet ASTM A194 as applicable or ASTM A563. Completely coat each nut with a wax lubricant.

Ensure that all washers meet ASTM F436.

Ensure that all direct tension indicators meet ASTM F959.

(C) Manufacturing

(1) Bolts

Hardness for bolts shall be in accordance with ASTM F3125.

(2) Nuts

(a) Heat treat galvanized nuts to Grades 2H, DH or DH3.

(b) Use plain (ungalvanized) nuts of Grades 2, C, D or C3 meeting the hardness values in accordance with ASTM A194 or heat treat to Grades 2H, DH or DH3.

(c) Tap oversize galvanized nuts the minimum amount required by ASTM A563. Overtap the nut such that the nut assembles freely on the bolt in the coated condition and meets mechanical requirements of ASTM A563 and the rotational-capacity test herein.

(3) Mark all bolts, nuts and washers in accordance with the appropriate ASTM Specifications.

(4) Direct Tension Indicators

(a) For Type 3 high strength bolts, mechanically galvanize direct tension indicators to ASTM B695, Class 55, and then apply baked epoxy to a thickness of 1 mil minimum. Direct tension indicators need not be mechanically galvanized or epoxy coated if they are made from material conforming to ASTM F3125, Type 3 bolts.

(b) For plain Type 1 high strength bolts, provide direct tension indicators that are plain or mechanically galvanized to ASTM B695, Class 55.

(c) For galvanized Type 1 high strength bolts, mechanically galvanize direct tension indicators to ASTM B695, Class 55.

(D) Testing

(1) Bolts

(a) Proof load tests in accordance with ASTM F606, Method 1, are required at the minimum frequency as specified in ASTM F3125.

(b) Wedge tests on full size bolts in accordance with ASTM F606. If bolts are galvanized, perform the tests after galvanizing. Test at a minimum frequency as specified in ASTM F3125.

(c) If galvanized bolts are supplied, measure the thickness of the zinc coating. Take measurements on the wrench flats or top of bolt head.

(2) Nuts

(a) Proof load tests in accordance with ASTM F606, Paragraph 4.2, are required at the minimum frequency of as specified in ASTM A563 and ASTM A194. If nuts are galvanized, perform the tests after galvanizing, overtapping and lubricating.

(b) If galvanized nuts are supplied, measure the thickness of the zinc coating. Take measurements on the wrench flats.

(3) Washers

(a) If galvanized washers are supplied, perform hardness testing after galvanizing.

(b) Remove the coating before taking hardness measurements.

(c) If galvanized washers are supplied, measure the thickness of the zinc coating.

(d) Test direct tension indicators in accordance with ASTM F959.

(4) Assemblies

Rotational-capacity tests are required to be performed by an AASHTO accredited laboratory. Ensure the manufacturer or distributor perform such tests on all black or galvanized (after galvanizing) bolt, nut and washer assemblies before shipping. Washers are required as part of the test.

The following applies:

(a) Except as modified herein, perform the rotational-capacity test in accordance with ASTM F3125.

(b) Test each combination of bolt production lot, nut lot and washer lot as an assembly. Where washers are not required by the installation procedures, do not include in the lot identification.

(c) Assign a rotational-capacity lot number to each combination of lots tested.

(d) The minimum frequency of testing is two assemblies per rotational-capacity lot.

(e) Assemble the bolt, nut and washer assembly in a Skidmore-Wilhelm Tension Indicating Device (Calibrator) or an acceptable equivalent device (This requirement supersedes the current ASTM F3125 requirement to perform the test in a steel joint). For short bolts that are too short for assembly in the Skidmore-Wilhelm, see Subarticle 1072-5(D)(4)(i).

(f) The minimum rotation, from a snug tight condition (10% of the specified proof load), is: 240° (2/3 turn) for bolt lengths less than 4 diameters; 360° (1 turn) for bolt lengths greater than 4 diameters and less than 8 diameters; 480° (1 1/3 turn) for bolt lengths greater than 8 diameters.

(g) These values differ from ASTM F3125.

(h) Achieve tension at the above rotation equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown in Table 1072-2.

TABLE 1072-2
BOLT TENSION REQUIREMENTS

Diameter, inch	**1/2"**	**5/8"**	**3/4"**	**7/8"**	**1"**	**1 1/8"**	**1 1/4"**	**1 3/8"**	**1 1/2"**
Req. Installation Tension, kips	12	19	28	39	51	64	81	97	118
Turn Test Tension, kips	14	22	32	45	59	74	94	112	136

(i) After the required installation tension listed in Table 1072-2 is exceeded, one reading of tension and torque is taken and recorded. The torque value shall conform to the following equation:

$$\textbf{Torque} \leq 0.25(P \times D)$$

Where:

Torque = measured torque in foot-lbs.
P = measured bolt tension in lbs.
D = bolt diameter in feet

For bolts that are too short to test in a Skidmore-Wilhelm Calibrator, test in a steel joint. The tension requirement of Subarticle 1072-5(D)(4)(h) is computed using a value of **P** equal to the turn test tension shown in the Table 1072-2.

(5) Reporting

(a) Record the results of all tests, including zinc coating thickness, required herein and in the appropriate specifications.

(b) Report the location where tests are performed and date of tests on the appropriate document.

(6) Witnessing

Witness of the test by an inspection agency is not required; however, ensure the manufacturer or distributor performing the tests certifies that the recorded results are accurate.

(7) Documentation

(a) Mill Test Report(s) (MTR)

(i) Furnish Mill Test Report(s) for all mill steel used in the manufacture of the bolts, nuts or washers.

(ii) Indicate in the Mill Test Report the place where the material was melted and manufactured, the lot number of the material represented and the source identification used by the manufacturer.

(b) Manufacturer Certified Test Report(s) (MCTR)

(i) Have the manufacturer of the bolts, nuts and washers furnish Manufacturer Certified Test Report(s) for the item furnished.

(ii) Include in each Manufacturer Certified Test Report the relevant information required in accordance with Subarticle 1072-5(D)(5).

(iii) Have the manufacturer or distributor performing the rotational-capacity test include on the Manufacturer Certified Test Report:

A) The lot number of each of the items tested.

B) The rotational-capacity lot number as required in Subarticle 1072-5(D)(4)(c).

C) The results of the tests required in Subarticle 1072-5(D)(4).

D) The pertinent information required in Subarticle 1072-5(D)(5)(b).

E) A statement that the Manufacturer Certified Test Report for the items are in conformance to the *Standard Specifications* and the appropriate AASHTO specifications.

F) The location where the bolt assembly components were manufactured.

(c) Distributor Certified Test Report(s) (DCTR)

(i) Ensure that the Distributor Certified Test Report(s) includes Manufacturer Certified Test Reports above for the various bolt assembly components.

(ii) Ensure the rotational-capacity test is performed by a distributor or a manufacturer and reported on the Distributor Certified Test Report.

(iii) Include in the Distributor Certified Test Report the results of the tests required in Subarticle 1072-5(D)(4).

(iv) Include in the Distributor Certified Test Report the pertinent information required in Subarticle 1072-5(D)(5)

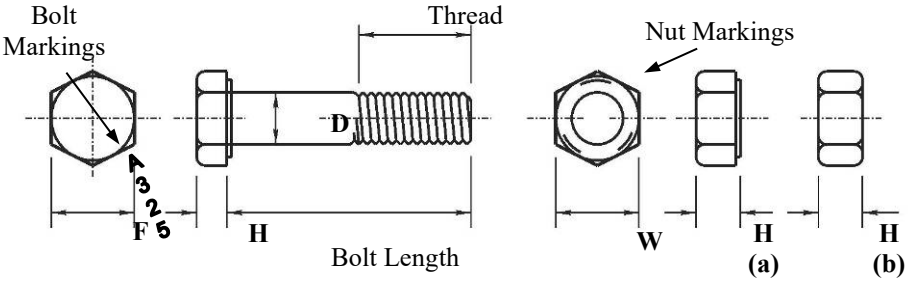
(v) Include in the Distributor Certified Test Report the rotational-capacity lot number as required in Subarticle 1072-5(D)(4)(c).

(vi) Ensure that the Distributor Certified Test Report certifies that the Manufacturer Certified Test Reports are in conformance to this *Standard Specifications* and the appropriate ASTM specifications.

(E) Shipping

(1) Ship bolts, nuts and washers, where required, from each rotational-capacity lot in the same container. If there is only one production lot number for each size of nut and washer, shipping of the nuts and washers in separate containers is allowed. Permanently mark each container on the side with the rotational-capacity lot number such that identification is possible at any stage before installation.

(2) Provide the appropriate MTR and MCTR or DCTR to the contractor or owner as required by the contract.



(3) Figure 1072-1. Bolt and nut description. Bolt and nut marking varies. Refer to Subarticle 1072-5(B). F is the width across the flats of the bolt. H is the height of the bolt or nut. Nuts may be washer facing as in (a) or double chamfered as in (b). D is the bolt diameter and nominal bolt size. W is the width across the flats of the nut.

TABLE 1072-3
HIGH STRENGTH BOLTS
BOLT AND NUT DIMENSIONS

Nominal Bolt Size, inch	Heavy Hexagon Structural Bolt Dimensions, inch			Semi-Finished Heavy Hexagon Nut Dimensions, inch	
	Width Across Flats	Height	Thread Length	Width Across Flats	Height
(D)	*(F)*	*(H)*	*(Thread)*	*(W)*	*(H)*
1/2	7/8	5/16	1	7/8	31/64
5/8	1 1/16	25/64	1 1/4	1 1/16	39/64
3/4	1 1/4	15/32	1 3/8	1 1/4	47/64
7/8	1 7/16	35/64	1 1/2	1 7/16	55/64
1	1 5/8	39/64	1 3/4	1 5/8	63/64
1 1/8	1 13/16	11/16	2	1 13/16	1 7/64
1 1/4	2	25/32	2	2	1 7/32
1 3/8	2 3/16	27/32	2 1/4	2 3/16	1 11/32
1 1/2	2 3/8	15/16	2 1/4	2 3/8	1 15/32

TABLE 1072-4
HIGH STRENGTH BOLTS WASHER DIMENSIONS

Bolt Size D, inch	Circular Washers Dimensions, inch				Square or Rectangular Beveled Washers Dimensions for American Standard Beams and Channels, inch		
	Nominal Outside Diameter	Nominal Diameter of Hole	Thickness Min.	Thickness Max.	Minimum Side Dimension	Mean Thickness	Slope of Taper in Thickness
1/2	1 1/16	17/32	.097	.177	1 3/4	5/16	1:6
5/8	1 5/16	11/16	.122	.177	1 3/4	5/16	1:6
3/4	1 15/32	13/16	.122	.177	1 3/4	5/16	1:6
7/8	1 3/4	15/16	.136	.177	1 3/4	5/16	1:6
1	2	1 1/8	.136	.177	1 3/4	5/16	1:6
1 1/8	2 1/4	1 1/4	.136	.177	2 1/4	5/16	1:6
1 1/4	2 1/2	1 3/8	.136	.177	2 1/4	5/16	1:6
1 3/8	2 3/4	1 1/2	.136	.177	2 1/4	5/16	1:6
1 1/2	3	1 5/8	.136	.177	2 1/4	5/16	1:6
1 3/4	3 3/8	1 7/8	.178[A]	.28[A]	-	-	-
2	3-3/4	2-1/8	.178[A]	.28[A]	-	-	-
Over 2 to 4 Incl.	2**D**-1/2	**D**+1/8	.24[B]	.34[B]	-	-	-

A. 3/16 inch nominal
B. 1/4 inch nominal

(F) Galvanized High Strength Bolts, Nuts and Washers

Use galvanized high strength bolts, nuts and washers meeting all other requirements of this subarticle except as follows:

(1) Use Type 1 bolts.

(2) Quench and temper washers.

(3) Mechanically galvanize in accordance with ASTM B695, Class 55.

(4) Ship galvanized bolts and nuts in the same container.

(5) Use organic zinc repair paint for touch-up of galvanized surfaces meeting Article 1080-7.

(6) Include in manufacturer's test reports results of the zinc coating thickness measurements.

(7) Have each galvanized nut coated with a wax lubricant with a color contrast to that of the zinc coating.

1072-6 WELDED STUD SHEAR CONNECTORS

Use Type B shear studs in accordance with the Bridge Welding Code as defined in Article 1072-18.

Use and install welded stud shear connectors meeting Article 1072-18. Ensure that shear studs and the areas of beams, girders or other structural steel to which the studs are welded are free of rust, rust pits, oil, grease, moisture, paint, galvanizing, loose mill scale or other deleterious matter which adversely affects the welding operation. Shear studs may be applied on steel with tightly adhering mill scale, provided acceptable results are achieved and the installed studs meet the Bridge Welding Code, as determined by the Engineer. Unless otherwise directed by the contract, studs shall be welded with automatically timed stud welding equipment in accordance with AWS D1.5 Bridge Welding Code and manufacture's requirements. Welding voltage,

current, time, and gun settings for lift and plunge should be set at optimum settings based on past practice, recommendations of stud and equipment manufacturer, or both.

1072-7 INSPECTION

(A) General

Give the Materials and Tests Unit 72 hours' notice for in-state producers and 192 hours' notice for producers out-of-state before beginning work in the shop. The "hours' notice" is defined as working hours' Monday thru Friday, 8 AM to 5 PM. Do not manufacture or fabricate any material, other than stock items, before the Materials and Tests Unit is notified and the final shop drawings are reviewed, accepted by the Engineer and returned to the fabricator. The fabricator shall have a stamped approved set of shop drawings assigned to the NCDOT assigned inspection staff and delivered to him upon his/her arrival on site. Shop drawings shall include all current revisions.

The shop inspection performed by the Department or inspection agency hired by the Department is intended as QA to assure to the Department that the fabricator is following all quality control requirements and is providing a product conforming to the Contract requirements. The inspection is not expected to replace the fabricator's quality control. The inspection and acceptance of the work performed by the Department or its representative does not relieve the fabricator of providing materials and finished products as specified.

The Department may reject defective or non-conforming materials at any time. Replace rejected materials promptly at no additional cost to the Department.

The contractor/fabricator shall be responsible for and shall be required to perform all quality control inspections and nondestructive testing in accordance with the Bridge Welding Code as defined in Article 1072-18 and as required by the contract. Perform all quality control inspection and nondestructive testing in the presence of the Department's inspector unless otherwise approved by the Department's inspector. Obtain approval for all quality control inspectors from the Department's inspector and ensure their qualification in accordance with the Bridge Welding Code and these specifications. Maintain all QC reports as required by the Bridge Welding Code, including, but not limited to, visual and nondestructive testing reports and all phases of coating application inspection. Provide copies of all QC reports, including all radiographic films, to the Department inspector upon request. These copies become the property of the Department and shall bear certification (written testimony) signature of the quality control inspector. No separate payment is made for this inspection and testing. The entire cost of this work is included in the unit contract price for the structural steel items involved.

Furnish facilities for the inspection of material and work in the mill and shop, and allow the inspectors unescorted, free access to the necessary parts of the mill or shop. Do not ship any member or component of the structural steel from the shop to the job site before approval by the Department's inspector. Such approval is stamped on the member or appropriate container by the fabricator's quality control and the Department's inspector only after piece mark, quantity, and contract compliance have been verified.

Furnish the Engineer with as many copies of mill orders and shipping statements as directed by the Engineer. The acceptance of any material or finished member by the Department's inspector is not a bar to their subsequent rejection, if found defective. Replace rejected material and correct rejected work promptly and satisfactorily.

(B) Shop and Mill Inspection

Shop inspection is performed on all structural steel used on any project. Mill inspection of structural steel is performed when so noted in the plans or in the specifications. Furnish complete certified Mill Test Reports for all structural steel used except a Type 6 (Supplier Certification) material certification in accordance with Article 106-3 as to the grade of steel

used is acceptable for small amounts of structural steel items which are furnished from the supplier's stock and which are difficult to identify on any Mill Test Report.

Show in the supplier's certification the items fabricated from stock material and the pounds of steel required for each item. A supplier's certification represents only anchor bolts, pipe sleeves, masonry plates, sole plates, diaphragm tees, connector plates and web stiffener plates. Represent all other items required for a structure by certified Mill Test Reports as specified above.

Indicate in the complete certified Mill Test Reports the pounds of steel and the item or items they represent and show heat number of steel, mechanical tests, chemical analyses, Department's project number, station number, the ASTM or AASHTO specification to which the material conforms and a signed statement certifying where the steel was melted and manufactured.

Forward to the Materials and Tests Unit a letter which states by contract number, project number, structure number and station number the items and pounds of steel that are represented by a supplier's certification and those represented by the certified Mill Test Reports identifying the beam and/or plate material for each main member.

The Department reserves the right to select any item for test. Bear any expense of obtaining the sample. The tests are performed at the Department's expense.

(C) Sampling Structural Steel

Furnish samples of structural steel at the beginning of fabrication when random sampling is required.

Furnish one 2 1/2 inch x 26 inch sample for each grade of steel used on a project per 1,000,000 lbs. No more than 2 are required per project.

Take all samples at the location and in the manner directed by an authorized representative of the Engineer. Furnish the necessary personnel and equipment for obtaining samples and be responsible for providing a smooth finish to the areas from which the samples are taken. Fabricator shall be responsible for obtaining representative samples in the presence of the Department's inspector and submitting to the Materials and Test Laboratory.

(D) Charpy V-Notch Tests

Furnish all structural steel for girders, beams and diaphragm components connecting horizontally curved members meeting the longitudinal Charpy V-Notch Tests specified in the supplementary requirements in AASHTO M 270 for Zone 1. Unless otherwise noted in the plans, mark and test the materials as non-fracture critical. Sample and test in accordance with AASHTO T 243 and use the (H) frequency of heat testing. Use the grade or grades of structural steel required in the plans. Obtain and submit certified Mill Test Reports to the Materials and Tests Unit to show the results of each test required by the *Standard Specifications*.

1072-8 WORKING DRAWINGS

Working drawings shall include Contract number, project number, structure number and station number. Submit checked structural steel shop drawings and changes thereto, including shipping diagrams for review, comments, acceptance and distribution as follows:

(A) Submit an electronic set for review, comments and acceptance on all steel structures. After review, comments and acceptance, submit 3 hard copy sets for distribution and an electronic set.

(B) Submit an electronic set for review, comments and acceptance for all bridges carrying railroad traffic, and after acceptance, submit 3 hard copy sets for distribution and an electronic set.

(C) Furnish any additional sets requested by the Engineer or for his use, review, comments, acceptance and/or distribution.

Shop drawings are not checked by the Engineer except to ascertain general compliance with the design and the *Standard Specifications*. Thoroughly check all shop drawings in all respects. Review, comments and acceptance of shop drawings by the Engineer is not considered as relieving the Contractor of his responsibility for the accuracy of his drawings, or for the fit of all shop and field connections and anchors.

Provide prints for shop drawings that are 22 inches x 36 inches, including borders which are at least 1 inch at the left edge of the sheet. Provide shop drawings on any medium provided they are legible and are reproducible. Upon completion of the project, furnish to the Engineer one complete set of reproducible shop drawings that represent the as-built condition of the structural steel including all approved changes if any. Supply drawings that are 22 inches x 36 inches. These drawings will become the property of the Department.

Changes on shop drawings after acceptance or distribution are subject to the approval of the Engineer. Furnish a record of such changes.

Make substitution of sections different from those on the structure plans only when approved in writing by the Engineer.

1072-9 HANDLING AND STORING MATERIALS

Load, transport, unload and store structural material so the metal is kept clean and free from damage. Repair any coating damage per Section 442. Do not use chains, cables or hooks without softeners that could result in damage or scarring of the material. Repair all materials which are scarred or damaged and inspect at the fabricators expense as deemed necessary by the Engineer.

Use lifting equipment and rigging equipment with adequate capacity to handle the material at all times. Do not bend, twist, damage or excessively stress any materials. Do not perform hammering which injures or distorts the members. In the event that damage or overstressing does occur, prepare and submit an inspection and testing verification plan to the Engineer for approval. Operate and maintain all lifting equipment in a safe manner and in accordance with the manufacturer's directions.

When lifting main structural steel members, use spreader bars. Do not use one point pick-ups on members over 50 feet in length. Use two point pick-ups so the amount of overhang and the distance between hooks does not exceed the distances as noted in Table 1072-5.

TABLE 1072-5
SPREADER BAR PICKUP REQUIREMENTS

Property	Beam Size			
	30" or Less	33" WF	36" WF	Plate Girders
Maximum Distance Between Hooks	74 lf	80 lf	85 lf	100 lf
Maximum Overhang	25 lf	28 lf	30 lf	35 lf

Store structural material, either plain or fabricated, above the ground upon platforms, skids or other supports. Keep free from blast media, dirt, grease, vegetation and other foreign matter, and protect from corrosion.

Keep material clean and properly drained. Transport and store girders and beams with the web in the vertical plane and the top flange up. Request permission in writing and await approval to invert haunched girders and beams for transport for safety reasons. Use extreme care in turn-over operations to prevent excessive bending stresses in the edge of flanges. Support long members on blocking placed near enough together to prevent damage from deflection.

Do not use any beam, girder, diaphragm, cross frame or other material, in any stage of fabrication that will be permanently incorporated into the finished structure as a workbench, lifting device or dunnage for any purpose for which it was not specifically intended.

1072-10 STRAIGHTNESS, CAMBER AND DIMENSIONAL TOLERANCES

(A) General

Ensure that rolled material, before being laid out or fabricated, is straight. If straightening is necessary, use methods that do not damage the metal. Kinks or sharp bends are cause for rejection of the material.

Ensure that heat straightened parts are substantially free from external forces, except those resulting from mechanical means used in conjunction with the application of heat.

Heat curving and heat cambering shall be completely free from any external forces. Any heating operation to address straightening, cambering, or curving shall be monitored by the Fabricator's QC department. Personnel performing heating operations shall have adequate training (documented), shall possess proper temperature indicating devices and shall have received instructions for appropriate use.

After heating, allow the metal to cool, without artificial cooling, down to 600°F. Below 600°F, only dry compressed air is permitted to artificially cool steels having minimum yield strength greater than 36,000 psi as indicated by a Type 1 (Certified Mill Test Report) material certification in accordance with Article 106-3.

(B) Straightening

Straighten distorted members and bent material by mechanical means or, if approved the Engineer, by the carefully planned and supervised application of a limited amount of localized heat. Do not allow the temperature of the heated area to exceed 1,150°F as controlled by temperature indicating crayons or other approved methods.

Following the straightening of a bend or buckle, verify the surface is free of evidence of fracture as indicated by visual inspection or, if directed by the Engineer, by appropriate nondestructive testing.

Shop straighten the bottom flanges of steel beams or girders at bearings as necessary to provide uniform contact between the flanges and the bearings. If bearings are to be field installed, the Fabricator shall demonstrate appropriate bearing contact surfaces as defined by the AWS Bridge Welding Code prior to shipping.

(C) Camber

Show the required camber on the drawings.

Make adequate provision in the fabrication of structural members to compensate for change of camber due to welding of the shear connectors and other fabrication work.

Fabricate camber into the members on built-up plate girders and trusses. Where camber is required on rolled sections, induce it by heat cambering, except that for rolled sections within the depth, length and camber ordinate range shown in Table 1072-6, induce camber by cold cambering or "gagging" at the mill or in the shop provided approval procedures for cold cambering are employed.

Where reverse curvature is required in a single rolled shape, induce it by heat cambering.

Show camber diagrams showing the required offset at each tenth point of the span and at any web splice or field splice location and blocking diagrams on the shop drawings. Show additional points if desired by the fabricator. Ensure that the beams, girders or other members with field splices meet all of the blocking ordinates without inducing stress into the members.

Following cambering or camber correction, correct evidence of fracture indicated by visual inspection or, if directed by the Engineer, by appropriate nondestructive testing.

Show camber and blocking diagrams on the shop drawings. Shop assemble continuous beams meeting all the blocking ordinates without inducing stress into the members.

TABLE 1072-6 ACCEPTABLE COLD CAMBER FOR ROLLED SECTIONS		
Beam Length, feet	**Section Designation and Nominal Depth**	
	W-Shapes 14" to 21" Inclusive S-Shapes 12" and Over	**W-Shapes 24" and Over**
Over 30 through 42	3/4" to 2 1/2" inclusive	1" to 2" inclusive
Over 42 through 52	1" to 3" inclusive	1" to 3" inclusive
Over 52 through 65	2" to 4" inclusive	2" to 4" inclusive
Over 65 through 85	2 1/2" to 5" inclusive	3" to 5" inclusive
Over 85 through 100	As directed by the Engineer	3" to 6" inclusive

(D) Heat Cambering of Rolled Beams and Welded Plate Girders

(1) General

Where heat cambering is used, only V-type heating is permitted. Perform V-type heating by the carefully planned and supervised application of a limited amount of localized heat.

When minor corrections in camber are required, use small, localized heats limited to the flange material. Perform major corrections in camber by V-type heating to prevent web distortion.

Begin heating at the apex of the heating pattern and progress slowly towards the base of the pattern as each area is brought up to temperature as stated in Subarticle 1072-10(D)(5). Do not progress the heating torches toward the base of the heating pattern until the apex of the pattern is brought up to the specified temperature. Do not return the heating torch toward the apex of the heating triangle after heating has progressed towards the base. Continue heating to successive areas until the base of the triangular heating pattern is brought up to the required temperature across the full width of the flange.

(2) Heat Cambering of Rolled Beams

Heat cambering of rolled beams is allowed to provide the required vertical curvature. Space triangular heating patterns throughout the length of the member to provide the required curvature. Locate the apex of the heating triangle at a point not less than 75% of the depth of the member measured from the flange that is concave after cambering. Limit the total included angle of the heating pattern to 20°.

Weld all detail material such as connection plates, bearing stiffeners and gusset plates attached to the member to the rolled beam after the beam is cambered as required.

(3) Heat Cambering of Welded Plate Girders

Heat cambering of welded plate girders is only permitted when approved in writing by the Engineer as a necessary repair procedure for plate girders rejected for camber deviation.

When it is necessary to correct camber deviation in welded plate girders, heating is permitted in V-type heating patterns centered on intermediate stiffeners and connection plates. Where necessary, add stiffeners for this purpose if approved by the Engineer. Locate the apex of the heating pattern not less than 3/4 of the depth of the member from the flange that is shortened after cooling. The maximum included angle of the heating pattern is 10°. The maximum width of the base of the heating pattern is 10 inches. Where shallow members or thin webs prescribe heating patterns with a width substantially less than 10 inches at the junction of the web to flange, extend the heating pattern in the flange at that location beyond the limits of the heating pattern in

the web by no more than 1 inch provided the total width of pattern in the flange does not exceed the 10 inch limit stated above.

(4) Support of Members for Heat Cambering

Heat camber members with the web vertical and supports spaced to take the maximum advantage of dead load in the member before applying heat. Ensure all supports are approved by the Department's Inspector before beginning work.

Do not place any combination of support system or external load on the member that causes a compressive stress in the flange to exceed 20,000 psi before heating for AASHTO M 270 Grades 36, 50 and 50W steels.

(5) Heating Process and Equipment

Confine heating to the patterns described herein and conduct to bring the steel within the planned pattern to a temperature between 1,100°F and 1,150°F as rapidly as possible without overheating the steel.

Any heating procedure which causes a portion of the steel to exceed a temperature greater than 1,150°F is destructive heating and is automatically cause for rejection of the steel. Steel rejected for destructive heating is investigated for reacceptance, repair or replacement if allowed by the Engineer. Bear the cost of such tests and any necessary repair or replacement.

(6) Heat Measurement

Specified temperatures are checked using portable digital pyrometers or temperature indicating crayon. When using a temperature indicating crayon, the following procedure shall be employed; mark on the surface of metal or sheet with the required crayon. Once the surface reaches the rated temperature of the crayon, the mark will melt and show liquid smear appearance. At this point, the heating operation shall cease to prevent overheating. Exceeding the specified temperature is strictly prohibited.

(E) Heat Curving Girders

(1) Type of Heating

With approval, use continuous or V-type heating methods to curve girders. For the continuous method, simultaneously heat a strip along the edge of the top and bottom flanges that is of sufficient width and temperature to obtain the required curvature. For V-type heating, heat the top and bottom flanges simultaneously in truncated triangular or wedge-shaped areas. Position the areas with their base along the flange edge and spaced at regular intervals along each flange. Set the spacing and temperatures to approximate the required curvature by a series of short chords. Heat along the top and bottom flanges at approximately the same rate.

For V-type heating, terminate the apex of the truncated triangular area applied to the inside flange surface just before the juncture of the web and flange. To avoid web distortion, make certain that heat is not applied directly to the web when heating the inside flange surfaces (the surfaces that intersect the web). Extend the apex of the truncated triangular heating pattern applied to the outside flange surface to the juncture of the flange and web. Use an included angle of approximately 15° to 30° in the truncated triangular pattern, but do not allow the base of the triangle to exceed 10 inches. Vary the patterns prescribed above only with the Engineer's approval.

For both types of heating, heat the flange edges that will be on the inside of the horizontal curve after cooling. Concurrently heat both inside and outside flange surfaces for flange thicknesses of 1.25 inches and greater. Adhere to the temperature requirements presented below.

(2) Temperature

Conduct the heat curving operation so the temperature of the steel never exceeds 1,150°F as measured by temperature indicating crayons or other suitable means. Do not artificially cool the girder until it naturally cools to 600°F. Below 600°F, use dry compressed air to artificially cool the girder.

(3) Position for Heating

Heat-curving the girder with the web in either a vertical or horizontal position is permitted. When curved in the vertical position, brace or support the girder so the tendency of the girder to deflect laterally during the heat-curving process does not cause the girder to overturn.

When curved in the horizontal position, support the girder near its ends and at intermediate points, if required, to obtain a uniform curvature. Do not allow the bending stress in the flanges to exceed 27,000 psi. To prevent a sudden sag due to plastic flange buckling when the girder is positioned horizontally for heating, place intermediate safety catch blocks at the midlength of the girder within 2 inches of the flanges at all times during the heating process.

(4) Sequence of Operations

Conduct the heat-curving operation either before or after completing all the required welding of transverse intermediate stiffeners to the web. However, unless provisions are made for shrinkage, position and attach connection plates and bearing stiffeners after heat-curving. In any event, weld the stiffeners, connection plates, and bearing stiffeners to the girder flanges after the member is curved. If longitudinal stiffeners are required, heat-curve or oxygen-cut these stiffeners separately before welding to the curved girder.

(5) Camber and Curvature

Camber the girders before heat-curving. Cut the web to the prescribed camber allowing for shrinkage due to cutting welding and heat-curving. If approved, a carefully supervised application of heat is permitted to correct moderate deviations from the specified camber.

Horizontal curvature and vertical camber is measured for final acceptance after all welding and heating operations are complete and the flanges have cooled to a uniform temperature. Horizontal curvature is checked with the web in the vertical position by measuring offsets from a string line or wire attached to both flanges or by using other suitable means. Camber is checked with the web in the horizontal position. Camber the girder so it meets the horizontal and vertical curvature ordinates without inducing stress into the girders by mechanical force.

Compensate for loss of camber in the heat-curved girders as residual stresses dissipate during service life of the structure. Compute this anticipated loss of camber in accordance with the *AASHTO LRFD Bridge Design Specifications*.

(6) Procedure Specification and Shop Drawings

Submit structural steel shop drawings, including a detailed written procedure specification for heat curving the girders, supplemented by calculations and sketches, for review, comments and acceptance. On the shop drawings, indicate the type, location and spacing of heat sectors, if used, supports and catch blocking for each field section of girders. Include suitable blocking diagrams for measuring horizontal curvature similar to those usually prepared for camber and vertical curvature.

(F) Camber Measurement

At the time of acceptance at the shop and after erection, ensure that all stringers and girders for bridges meet the required camber values within the tolerances specified in Subarticle 1072-10(G). Follow the procedure for measuring camber as outlined below:

(1) Assemble the member at the shop as specified in Article 1072-19 and measure with the member lying on its side.

(2) Camber repairs are only allowed when approved by the Engineer. Camber deviation is judged irreparable if corrective measures in the shop produce web buckling in excess of the specified tolerance, in which case the member is rejected.

(3) The final camber measurement is made by the Engineer in the field after erection. At the time of this measurement, ensure that the members have all of the specified camber less the dead load deflection of the steel as specified in Subarticle 1072-10(G).

(G) Dimensional Tolerances

Ensure that dimensions of all material covered by Section 1072 conform to ASTM A6 when received at the fabrication shop. Fabricate member dimensions conforming to this subarticle whether designated to be straight, cambered or curved and regardless of whether curvature is heat-induced (when so permitted). Dimensional tolerances not listed in this subarticle shall be as specified by the Bridge Welding Code as defined in Article 1072-18 and applied to rolled shapes where applicable as well as to welded members.

Place welded butt joints no further than 1/2 inch from the point detailed. Intermediate stiffeners varying ± 1/2 inch from the point detailed are allowed. Connector plates for field connections varying ± 1/8 inch from the point detailed are allowed. Ensure that the actual centerline of bearing lies within the thickness of the bearing stiffener.

Members with end milled for bearing and members with faced end connection angles deviating from the detailed length by -0, +1/32 inch are acceptable. All other members varying from detailed length by ± 1/8 inch are acceptable.

Align to within ± 1/8 inch from the location shown on the approved shop drawings all steel requiring shop assembly for reaming, drilling from the solid or weld joint preparation.

Deviation from specified camber of fabricated members as verified during shop assembly and before shipment from the fabrication shop is limited to:

-0;

$$\frac{+3/32\text{" x No. of ft from nearest bearing}}{10}, \quad \text{up to 3/4" maximum.}$$

Deviation from specified camber of erected steel bridge superstructures measured when the steel work is complete and the superstructure is subject to steel dead load stresses only is limited to:

-0;

$$\frac{+1/8\text{" x No. of ft from nearest bearing,}}{10} \quad \text{up to 1" maximum.}$$

If the plans do not require shop induced camber, provide an actual member that is straight or one of the following:

(1) If natural camber "turned up" is required, the maximum plus camber is the algebraic sum of the allowable deviation, dead load deflection, vertical curve ordinate and superelevation ordinate;

(2) If natural camber ‘turned down" is required, the maximum negative camber is equal to the algebraic sum of the dead load deflection, vertical curve ordinate and superelevation ordinate.

Do not exceed 1/8 inch per 10 foot length for the actual deviation from curvature shown in the plans.

1072-11 OXYGEN CUTTING

Oxygen cutting of structural steel is allowed, provided a smooth surface free from cracks and notches is secured and an accurate profile is secured by the use of a mechanical guide. Hand cut only where approved by the Engineer and grind smooth leaving no burnt edges.

In all oxygen cutting, adjust and manipulate the cutting agent to avoid cutting beyond (inside) the prescribed lines. Provide oxygen cut surfaces meeting the ANSI surface roughness rating value of 1,000 except ensure that oxygen cut surfaces of members not subject to calculated stress meet the surface roughness value of 2,000 (AWS C4.1-G Surface Roughness Gauge). Round corners of oxygen cut surfaces of members carrying calculated stress to a 1/16 inch radius, or an equivalent flat surface at a suitable angle, by grinding after oxygen cutting.

Fillet re-entrant cuts to a radius of not less than 1 inch.

Remove surface roughness exceeding the above values and occasional notches and gouges not more than 3/16 inch deep on otherwise satisfactory oxygen cut surfaces by chipping or grinding. Such removal shall be faired to the material edge with a slope not steeper than one in ten and with machine and grinding marks parallel to the surfaces.

Repair occasional gouges of oxygen cut edges more than 3/16 inch deep, but not more than 7/16 inch deep, by welding with low hydrogen electrodes not exceeding 5/32 inch in diameter and with a minimum preheat of 250°F. Grind the completed weld smooth and flush with the adjacent surface. Radiographically test any gouge repaired by welding.

1072-12 EDGE PLANING

Plane sheared edges of plates more than 5/8 inch in thickness that carry calculated stress to a depth of 1/4 inch. Pre-drill re-entrant cuts before cutting. Round all edges of plates and shapes parallel to calculated stress and all free edges of plates and shapes intended for coating or galvanizing to 1/16 inch radius or provide an equivalent flat surface at a suitable angle. Flame cut edges found to have a Rockwell Hardness Value of C 30 or greater will be considered unacceptable. A portable Rockwell Hardness Tester shall be employed by the Quality Control Inspector to determine conformance with these requirements. Unacceptably hard surfaces shall be removed by grinding or machining, or by a heat treating procedure approved by the Engineer. Grind edges of all other plates and shapes to remove burrs, slag or shear lip. The ends of all steel piles, intended for coating or galvanizing, are not required to be radiused, but remove all burrs, slag and shear lip.

1072-13 FACING OR BEARING SURFACES

Provide a surface finish of bearing and base plates and other bearing surfaces that come in contact with each other or with concrete that meet Table 1072-7 following ANSI surface roughness requirements as defined in ASME B46.1.

TABLE 1072-7 SURFACE ROUGHNESS REQUIREMENTS	
Item	**ANSI Surface Roughness**
Steel slabs	ASME 2,000
Heavy plates in contact in shoes to be welded	ASME 1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ASME 500
Bridge rollers and rockers	ASME 250
Pins and pin holes	ASME 125
Sliding bearings	ASME 125

1072-14 ABUTTING JOINTS

Face and bring to an even bearing abutting joints in compression members, girder flanges and tension members where so indicated on the drawings. Where joints are not faced, do not exceed an opening of 1/4 inch.

1072-15 BENT PLATES

Provide cold-bent, load carrying rolled-steel plates conforming to the following:

(A) Take from the stock plates so the bendline is at right angles to the direction of rolling.

(B) Use a radius of bends such that no cracking of the plate occurs. Use minimum bend radii, measured to the concave face of the metal, as shown in Table 1072-8.

If a shorter radius is essential, bend the plates hot at a temperature not greater than 1,200°F and air cool slowly down to a temperature of 600°F. Below 600°F, use only dry compressed air to artificially cool steels having a minimum yield strength greater than 36,000 psi. Use hot bent plates conforming to Subarticle 1072-15(A) above.

(C) Before bending, round the corners of the plates to a radius of 1/16 inch throughout the portion of the plate at which bending occurs.

TABLE 1072-8 MINIMUM BEND RADII	
Plate Thickness (t)	**Minimum Bend Radii, Ratio of Thickness**
Up to 1/2"	2**t**
Over 1/2" to 1"	2 1/2**t**
Over 1" to 1 1/2"	3**t**
Over 1 1/2" to 2 1/2"	3 1/2**t**
Over 2 1/2" to 4"	4**t**

Hot bend low alloy steel in thicknesses over 1/2 inch for small radii, if required.

1072-16 HOLES FOR BOLTS AND OTHER FASTENERS

(A) General

Punch or drill all holes and remove any burrs. Punching material forming parts of a member composed of not more than 5 thickness of metal 1/16 inch larger than the nominal diameter of the fastener is allowed whenever the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high-strength steel or 1/2 inch for quenched and tempered alloy steel, unless subpunching and reaming is required by Subarticle 1072-16(D).

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high-strength steel or 1/2 inch for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

When required by Subarticle 1072-16(D), subpunch or subdrill all holes (subdrill if thickness limitation governs) 1/4 inch smaller and, after assembling, ream 1/16 inch larger or drill full size to 1/16 inch larger than the nominal diameter of the fastener.

(B) Punched Holes

Do not use a diameter of the die exceeding the diameter of the punch by more than 1/16 inch. If any holes require enlargement to admit the fasteners, ream such holes. Clean cut holes without torn or ragged edges. Poor matching of holes is cause for rejection. Grind all burrs smooth.

(C) Reamed or Drilled Holes

Make reamed or drilled holes cylindrical and perpendicular to the member complying with the size requirements of Subarticle 1072-16(A). Where practicable, direct reamers by mechanical means. Grind all burrs smooth. Poor matching of holes is cause for rejection. Ream and drill with twist drills. If required, take assembled parts apart for removal of burrs caused by drilling. Assemble connecting parts requiring reamed or drilled holes, securely hold while reaming or drilling and match mark before disassembling.

(D) Subpunching and Reaming of Field Connections

Subpunch or subdrill, if required according to Subarticle 1072-16(A), holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames. Subsequently ream while assembled as required by Article 1072-19. Subpunch and ream to a steel template or ream while assembled all holes for floor beam and stringer field end connections. Ream or drill full size field connection holes through a steel template after the template is located with utmost care as to position and angle and firmly bolted in place. Use templates for reaming matching members, or the opposite faces of a single member that are exact duplicates. Accurately locate templates used for connections on like parts of members such that the parts or members are duplicates and require no match-marking.

(E) Accuracy of Punched and Subdrilled Holes

Accurately punch or subdrill all holes punched full size, subpunched or subdrilled such that after assembling, and before any reaming is done, a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the hole enters perpendicular to the face of the member, without drifting, in at least 75% of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces are rejected. If any hole does not pass a pin 3/16 inch smaller in diameter than the nominal size of the hole, this is cause for rejection.

(F) Accuracy of Reamed and Drilled Holes

When holes are reamed or drilled, ensure that 85% of the holes in any contiguous group, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal.

Use all steel templates with hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. Use the centerlines in locating accurately by the template from the milled or scribed ends of the members.

(G) Alternate Methods

As an option, make the fastener holes by procedures other than those described in Subarticles 1072-16(A) through 1072-16(F) provided that the requirements for quality and for dimensional accuracy are met. Plasma cutting of holes for high strength fasteners is prohibited. Wherever an alternate method is employed, demonstrate the ability of each alternate method to produce holes and connections consistently meeting all requirements for quality and dimensional accuracy for the type of joint fabricated. When such ability of an alternate method is previously demonstrated on similar work for the Department,

continue its use by certifying, on each subsequent project, that the procedure and equipment are the same as the method previously qualified, and that the equipment involved is in good repair and adjustment. Failure of joints to meet the quality and accuracy requirements is cause for rejection. In the case of repeated failures revise and/or requalify the method or discontinue its use.

At the time of qualification of an alternate method, submit for approval a written procedure specification describing the procedures and equipment and giving upper and lower value limits and tolerances for all pertinent variables. Accurately reflect the actual procedures, equipment and values used in the qualification tests. In addition to the certification on each subsequent project, the Engineer may request copies of the approved procedure specification.

(H) Oversize, Short-Slotted, and Long-Slotted Holes

Where shown in the plans or permitted in writing, use oversize, short-slotted and long-slotted holes with high strength bolts 5/8 inch and larger in diameter. Do not allow the distance between edges of adjacent holes or edges of holes and edges of members to be less than permitted under the AASHTO specification. Oversize, short-slotted and long-slotted holes are defined as follows:

(1) Oversize holes are 3/16 inch larger than bolts 7/8 inch and less in diameter, 1/4 inch larger than bolts 1 inch in diameter, and 5/16 inch larger than bolts 1 1/8 inches and greater in diameter. When oversized holes are permitted, they are allowed in any or all plies of friction type connections. Install hardened washers over exposed oversize holes.

(2) Short-slotted holes are 1/16 inch wider than the bolt diameter and have a length that does not exceed the oversize diameter requirements of Subarticle 1072-16(H)(1) by more than 1/16 inch. When short-slotted holes are permitted, they are allowed in any or all plies of friction-type or bearing-type connection. Locate holes without regard to direction of loading in friction-type connections, but orient normal to the direction of the load in bearing-type connections. Install hardened washers over exposed short-slotted holes.

(3) Long-slotted holes are 1/16 inch wider than the bolt diameter and have a length more than allowed in Sub-paragraph 2 but not more than 2 1/2 times the bolt diameter. Structural plate washers or a continuous bar not less than 5/16 inch in thickness are required to cover long slots that are the outer plies of joints. Ensure that these washers have a size sufficient to completely cover the slot after installation. When long-slotted holes are permitted, they are allowed in only one of the connected parts of either a friction-type or bearing-type connection at an individual faying surface.

When used in slip critical connections, locate holes without regard to direction of loading if one-third more bolts are provided than needed to satisfy the allowable unit stresses except as herein restricted.

When used in bearing-type connections, orient the long diameter of the slot normal to the direction of loading. No increase in the number of bolts over those necessary for the allowable unit stress is required.

(I) Misfits

When misfits occur for any reason, enlargement of the holes by reaming is limited to 1/16 inch over the nominal size hole called for unless otherwise permitted in writing.

(J) Erection Bolt Holes

At field welded connections where erection bolts are used, provide holes 3/16 inch larger than the nominal erection bolt diameter.

1072-17 INSTALLING BOLTS

Install high strength bolts in accordance with Article 440-8.

1072-18 WELDING

(A) Definition

The Bridge Welding Code referred to herein is the edition of the ANSI/AWS/AASHTO Bridge Welding Code D1.5 and any applicable interim that is current on the date of advertisement for the project, and as modified by the *Standard Specifications*.

(B) General

Commercially blast clean all steel used in girders, beams and connecting members to SSPC-SP 6 before welding. With the exception of rolled beams, the Contractor at their option may submit to the Department for review, an alternate cleaning method for main member material exposed to welding.

Weld all steel in the shop or in the field for bridges, whether permanent or temporary, and perform all other work related to welding including, but not limited to, testing and inspection of welds, preparation of material, oxygen cutting, electrodes, shielding and shear studs, meeting the Bridge Welding Code. Weld other steel items not covered under the Bridge Welding Code in accordance with the applicable AWS Welding Code. Some examples may include but not limited to; Structural Welding Code-Steel (AWS D1.1), Structural Welding Code-Aluminum (AWS D1.2), Structural Welding Code-Sheet Steel (AWS D1.3), Structural Welding Code-Steel Reinforcing Bars (AWS D1.4) and Structural Welding Code-Stainless Steel (AWS D1.6).

Weld only where shown in the plans or where called for in the *Standard Specifications* unless requesting and receiving written approval from the Department for additional welding.

Show all permanent and all temporary welds on the shop drawings. For groove welds, indicate on the shop drawings the particular detail and process to be employed in production of the work. For prequalified joints, use of the Bridge Welding Code letter classification designation of the joint (B-L2b-S etc.) along with the appropriate symbol satisfies this requirement. Tack welds that become part of a permanent weld are not required on the shop drawings.

Provide fillet welds, including seal welds, at least the minimum size allowed by the Bridge Welding Code for the thickness of material welded or the size called for in the plans, whichever is larger. For exposed, bare, unpainted applications of steel, the basic requirements for weld filler metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal are mandatory. The variations from these basic requirements listed in the Bridge Welding Code for single pass welds are not permitted.

All welds designated as Fracture Critical (FC) and subject to tension shall be so designated on the shop drawings. Unless otherwise directed by the Engineer, any flange to web (FC) complete joint penetration (CJP) groove weld subjected to calculated tensile stress normal to the weld axis, shall be so designated on the design and shop drawings.

(C) Qualification of Personnel

Ensure that each welder, welding operator and tacker is qualified in accordance with the Bridge Welding Code or other applicable AWS Welding Code as determined by the Engineer. For field applications, employ welders that are qualified by the Department. Welders shall be requalified by the Department every 5 years. Contact the Materials and Tests Unit to schedule qualification tests.

Permanent in-shop welders employed by a fabricator who passed the appropriate welding tests and whose weldments are radiographically tested with regularly acceptable results are exempt from additional testing when approved by the Engineer. Welder qualification testing shall be administered and witnessed by a current AWS Certified Welding Inspector (CWI). Ensure all welder qualification testing is witnessed by an independent testing agency approved by the Department. As evidence of such qualification, furnish a satisfactory certificate, or a copy thereof, issued by a fabricator or Department approved testing agency as applicable. Submit certification for each welder, welding operator or tacker, and for each project, stating the name and identification number of the welder, welding operator or tacker; the name and title of the person who conducted the examination; the kind of specimens; the position of welds; the AWS electrode classification used; the results of the tests; the date of the examination and witness thereof. Such certifications are required for all persons performing shop or field welds of any kind on the work, whether permanent or temporary. Ensure each welder provides a picture ID upon request or other form of positive identification as required by the Engineer.

(D) Qualification of Welds and Procedures

For shop employed welded construction, submit to the Department all welding procedures, prequalified or qualified by test 30 days in advance before performing any welding. All welding shall comply with the applicable AWS designed code of construction.

For field weld applications, submit prequalified Welding Procedure Specifications (WPS) for each joint configuration for approval at least 30 days before performing any welding. In lieu of the aforementioned,, use the WPS provided and preapproved by the Department. Field welding operations are limited to using SMAW welding process. These preapproved WPS are available from the Materials and Tests Unit. Use non-prequalified welding procedures that have been submitted and approved by the Engineer. At no cost to the Department, demonstrate their adequacy in accordance with the applicable AWS Welding Code.

On all welding, include in the welding procedure continuous visual inspection by welders, welding operator, tackers, welding supervisors and all personnel involved in preparation of the material for welding.

Approval by the Engineer of the procedure specifications does not relieve the Contractor of his responsibility to develop a welding procedure that produces weldments meeting the required quality and dimensions.

If non-prequalified joints procedures are previously found acceptable to the Engineer on another project, furnish the inspector with a copy of the joint details and procedure specification approved at the time of qualification. Such documentation is required from each fabricator employing a non-prequalified joint or procedure on the work. Failure to produce such documentation results in the fabricator being required to requalify the joint or procedure or to use prequalified joints, procedures, and procedure specifications.

On weldments where geometric shape prevents compliance with requirements to weld a particular position, alternate procedures are considered for approval. Previously qualified alternate procedures are considered for approval without further procedure qualification tests. No separate payment is made for developing, demonstrating and documenting for future use such alternate procedures, as such work is incidental to the work of welding.

(E) Requirements for Testing and Inspection

Require the fabricator to make provisions for convenient access to the work for inspection and cooperate with the inspector during the required inspection and testing.

Visual welding inspection shall be performed by an inspector qualified in accordance with AWS QC-1. Inspect welds in the presence of the Department’s inspector unless otherwise approved by the Department’s inspector, using visual inspection and the nondestructive

tests herein prescribed in addition to the test requirements of the Bridge Welding Code and the contract. Employ quality control inspectors and NDT technicians qualified in accordance with the Bridge Welding Code and preapproved by the Engineer before the start of any fabrication. Supply the appropriate certifications as required by the Bridge Welding Code to the Department's inspector for all inspectors. Individuals assigned to production welding activities or processes and their supervisors are not acceptable for performing quality control testing. Ensure a qualified quality control welding inspector (CWI) is present any time welding is in progress. No separate payment is made for inspection and testing.

Retest welds requiring repairs or replacement in the presence of the Department's inspector after the repairs or replacements are made. Approval of the Engineer is required for any repair exceeding three attempts to correct.

If the Engineer finds that acceptable repair to defective work is not feasible; the entire piece is rejected.

Payment at the contract prices for the various items in the contract which include the work of welding is full compensation for all costs resulting from the required nondestructive testing of welds and from the required inspection of welds.

(F) Nondestructive Test Required

Personnel performing Nondestructive Testing (NDT) other than visual examination shall be certified in conformance with the American Society for Nondestructive Testing's (ASNT) recommended practice number (SNT-TC-1A). The Employer's program shall meet all established guidelines of SNT-TC-1A for the qualification of NDT personnel. In addition, all personnel performing NDT for final weld acceptance shall be subject to the Department's practical proficiency test.

The extent of nondestructive testing required for main members is as prescribed in the Bridge Welding Code and by the contract except that all flange splices shall be radiographed for their full length. The term "main members" in this regard means girders, diaphragms for curved girders, beams, floor beams, stringers, truss members, high strength bolts, columns, bearing stiffeners, bearing shoes, high mount light standards and components of main member carrying stress, including the end connections for such members. Nondestructive testing of other complete welds or weld passes is required when so noted in the plans or deemed necessary by the Engineer. For bridge applications involving tubular structures that may be subject to the AWS D1.1 welding code, the extent of NDT shall be as specified above for main members. Tests other than those prescribed are also required when deemed necessary by the Engineer. Perform all radiographic testing in accordance with procedures established by the Engineer. Copies of these procedures are available from the State Materials Engineer.

High mount light standards shall be examined in accordance with Section 1401-2. Other nondestructive test methods are sometimes deemed necessary by the Engineer to determine the quality of the welds. No separate payment is made for inspection and testing.

Any NDT not identified above shall be examined as directed by the Engineer.

The entire cost of this work is included in the unit contract price for the structural steel items involved.

(G) Welded Structural Shapes

Produce butt welds of flanges and webs, and fillet welds of web to flanges of plate girders and haunched beams using the submerged arc process. Produce other structural shapes built up from plates and bars using the submerged arc process unless another process is qualified for these joints in accordance with the Bridge Welding Code and is subject to the approval of the Engineer.

After all shop welded splices in the flanges and webs for the full length of the field section are made, tested and approved, fit the flange plates tight and square against the web to leave no gap and to not bow the web. Brace one side of each flange against the web with gussets or struts and tack weld securely to the web at the stiffener locations. Upon removal of the welds, grind any nicks or gouges, preheat, weld and test or incorporate into the stiffener fillet weld.

Connect the flanges to the web by starting the fillet weld at one end of the girder and proceeding to the other ends.

As an option, make adjacent welds simultaneously.

The sequence for making the flange to web fillet welds is subject only to the provisions for control of shrinkage and distortion and to the position requirements of the Bridge Welding Code.

After flange to web welds are complete, shift bracing gussets or struts if necessary, then remove all temporary gussets or struts. Remove tack welds by grinding flush with parent metal.

Straighten any transverse warpage of the flanges if necessary by heating along the centerline of the outside face.

Fit tight, square and tack weld stiffeners securely to the web. With the girder in the flat position (web horizontal), weld the stiffeners to the web. Do not weld or tack weld stiffeners to the flanges except where noted in the plans. Stiffeners are not to be used to correct tilt of flange due to distortion associated to welding.

After all parts are welded into place, trim the girder to detail length with adjustments for slope and end rotation exceeding 1/4 inch net.

1072-19 SHOP ASSEMBLING

(A) General

Assemble the field connections of main members of continuous beam spans, plate girders and rigid frames in the shop with milled ends of compression members in full bearing, and then ream their sub-size holes to specified size while the connections are assembled. Assembly shall be either Full Girder Assembly or Progressive Girder Assembly unless Full Girder Assembly or Special Complete Structure Assembly is required by the contract.

Furnish a camber diagram to the Engineer showing the camber at each panel point of each continuous beam line, plate girder or rigid frame. When the shop assembly is Full Girder Assembly or Special Complete Structure Assembly, ensure the camber diagram shows the camber measured in assembly. When any of the other methods of shop assembly is used, show the calculated camber in the camber design.

Clean surfaces of metal in contact before assembling. Assemble the parts of a member, pin well and firmly draw together with bolts before reaming. Take assembled pieces apart, if necessary, for removal of burrs and shavings produced by the reaming operation. Ensure that the member is free from twists, bends and other deformation.

Drift during assembling only to bring the parts into position, and not sufficient to enlarge the holes or distort the metal. If any holes are enlarged to admit the fasteners, ream them.

Match-mark those connecting parts assembled in the shop for the purpose of reaming holes in field connections and provide a diagram showing marks furnished by the Engineer.

(B) Full Girder Assembly

Full Girder Assembly consists of assembling all members of each continuous beam line, plate girder or rigid frame at one time.

(C) Progressive Girder Assembly

Progressive Girder Assembly consists of assembling initially for each continuous beam line or plate girder at least two contiguous shop sections or all members in at least two contiguous shop panels but not less than the number of panels associated with three contiguous section lengths (i.e., length between field splices) and not less than 150 feet in the case of structures longer than 150 feet. Add at least one shop section at the advancing end of the assembly before removing any member from the rearward end, so the assembled portion of the structure is never less than the specified above.

(D) Special Complete Structure Assembly

Special Complete Structure Assembly consists of assembling the entire structure, including the floor system.

Ensure each assembly, including camber, alignment, accuracy of holes and fit of milled joints, is approved by the Engineer before reaming.

1072-20 PAINTING AND OTHER PROTECTIVE COATINGS

Shop paint in accordance with Section 442.

Repair galvanized surfaces that are abraded or damaged in accordance with Article 1076-7.

1072-21 MARKING AND SHIPPING

Paint or mark each member with an erection mark for identification and furnish an erection diagram with erection marks shown thereon. Notification of shipping shall be provided to the Department in writing as soon as practical but in no case less than 24 hours for in-state producers and 72 hours for out of state producers. Hours are as defined in Subarticle 1072-7(A).

Prior to loading, the Fabricator's quality control (QC) shall make certain (QC stamped approved) that all material meets the contract and has been presented to the Department for final inspection.

Furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer directs. Show the weights of the individual members on the statement. Mark the weights on members weighing more than 3 tons. Load structural members on trucks or cars in such a manner that they are transported, unloaded and stored at their destination without being excessively stressed, deformed or otherwise damaged.

Load and ship steel beams and girders in accordance with the Figures 1072-2 and 1072-3 and Table 1072-9 for all types of transportation. When the contractor wishes to place members on trucks not in accordance with these limits, to ship by rail, to attach shipping restraints to the members, to ship horizontally curved steel members, or to invert members, he shall submit a shipping plan before shipping. Refer to Article 1072-9.

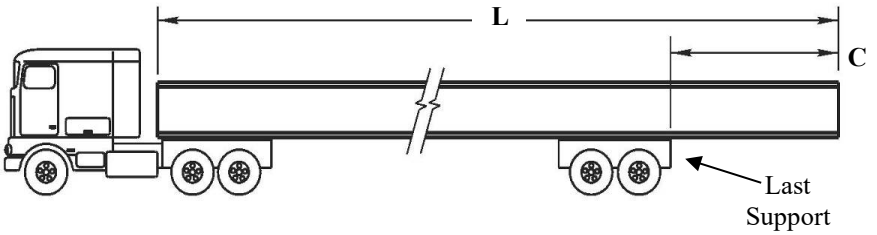


Figure 1072-2. Truck loading diagram for when the length past the last support, **C**, is 15 ft or less.

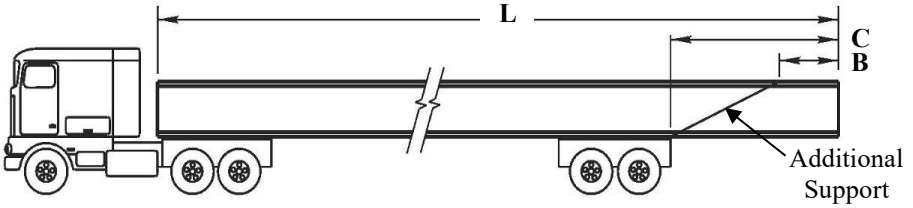


Figure 1072-3. Truck loading diagram for when the length past the last support, **C**, is between 15 feet and 30 feet.

For truck loading with the length of the last support between 15 feet and 30 feet in Figure 1072-3, use the following formulas to calculate truck loading limits or use the values given in Table 1072-9:

$$\mathbf{B} = 0.4C$$

$$\mathbf{C} = 0.2L \text{ to } 0.3L\text{, up to 30 ft}$$

Where **B** is the length of the member past a required additional restraint, **C** is the length of the member extending past the last support and **L** is the length of the member.

TABLE 1072-9 LIMITS FOR PLACEMENT OF STEEL BEAMS AND GIRDERS DURING SHIPMENT			
Length of Member, feet	**Minimum Length Past Last Support, feet**	**Maximum Length Past Last Support, feet**	**Maximum Length Past Additional Restraint, feet**
(L)	*(C)*	*(C)*	*(B)*
75	15	22.5	9
80	16	24	9.6
85	17	25.5	10.2
90	18	27	10.8
95	19	28.5	11.4
100	20	30	12
105	21	30	12
110	22	30	12
115	23	30	12
120	24	30	12
125	25	30	12
130	26	30	12
135	27	30	12

Restrain overhanging ends of beams or girders both vertically and horizontally to prevent excess movement. Chains are permitted to secure beams and girders during shipping only when adequate measures are taken to prevent damage to the material by the use of approved protective material. If necessary, use adequate bracing to prevent bending of the top flange.

Pack bolts of one length and diameter and loose nuts or washers of each size separately. Ship pins, small parts and packages of bolts, washers and nuts in boxes, crates, kegs or barrels, but do not allow the gross weight of any package to exceed 300 lbs. Plainly mark a list and description of the contained material on the outside of each shipping container.

Steel die stamped fabricator's identity, station number, girder number and span number of main members into an unpainted area (if available) near the end of the member. Die stamp members with painted ends outside the painted area but as close to the end as possible.

Ship anchor bolts, washers and other anchorage or grillage materials, in time to be incorporated into the masonry portion of the structure.

SECTION 1074
MISCELLANEOUS METALS AND HARDWARE

1074-1 WELDING

Any facility performing welding operations shall be approved by NCDOT Materials and Tests Unit. Weld other steel items not covered under the Bridge Welding Code in accordance with the applicable AWS Welding Code. Some examples may include but not limited to; Structural Welding Code-Steel (AWS D1.1), Structural Welding Code-Aluminum (AWS D1.2), Structural Welding Code-Sheet Steel (AWS D1.3), Structural Welding Code- Steel Reinforcing Bars (AWS D1.4) and Structural Welding Code-Stainless Steel (AWS D1.6). Certify all welders performing any welding on any metals in accordance with the applicable AWS welding code in the position and process required as approved by the Engineer.

1074-2 EXPANSION ANCHORS

Unless otherwise shown in the plans, provide expansion anchors consisting of two or more units with a minimum of two hard metal conical ring wedges and two expandable lead sleeves of an equally effective design that is approved by the Engineer. Use anchors providing a minimum safe holding power of 3,000 lbs. for 3/4 inch bolts and 2,000 lbs. for 5/8 inch bolts, based upon

1/4 of the actual holding power of the anchor in 3,000 psi concrete. Furnish satisfactory evidence, based upon actual tests performed by a commercial testing laboratory, which indicate that the anchors develop the minimum required safe holding power.

When it is proposed to use anchors that are previously accepted as meeting the above requirements, the anchors are accepted on the basis of a certified statement indicating the prior acceptance of the furnished anchors.

1074-3 PLAIN STEEL BARS WITH THREADED ENDS

Provide plain steel bars with threaded ends meeting ASTM A307, Grade A.

1074-4 HARDWARE FOR TIMBER STRUCTURES

Use machine bolts, drift-bolts and dowels that are either wrought iron or medium steel. Use washers that are cast iron ogee, malleable iron castings or cut from medium steel or wrought iron plate.

Use machine bolts with square heads and nuts. Use nails that are cut or round wire of standard form. Use spikes that are cut, wire spikes or boat spikes.

Use black or galvanized nails, spikes, bolts, dowels, washers and lag screws for untreated timber.

Galvanize or cadmium plate all hardware for treated timber bridges, except malleable iron connectors.

1074-5 METAL BRIDGE RAILING

(A) General

As an option, use either aluminum or galvanized steel metal rail, provided that the same material is used on all structures on the project.

Certified Mill Test Reports are required for rails and posts.

Place a permanent identifying mark that identifies the fabricator on each post. Use a method and location of the identifying mark such that it does not detract from the appearance of the post.

Where it is necessary for rails to be curved, form the curvature in the shop or in the field. Uniformly curve the rail without buckling or kinking. Perform all welding in accordance with AWS D1.1 for steel railing and AWS D1.2 for aluminum railing.

Provide an anchor unit of sufficient strength to ensure load anchoring capacity as specified for rail loading in the *AASHTO LRFD Bridge Design Specifications*.

(B) Aluminum Rail

Supply material for posts, post bases, rails, expansion bars and clamp bars meeting ASTM B221 for Alloy 6061 T6, materials will be mill finished.

Use material for rivets meeting ASTM B316 for Alloy 6061 T6. Use rivets that are standard button head and cone point cold driven.

Use material for nuts meeting ASTM B211 for Alloy 6061 T6.

Provide material for washers meeting ASTM B209 for Alloy Alclad 2024 T3.

Supply material for shims meeting ASTM B209 for Alloy 6061 T6.

Ensure that the handrails meet the dimensional tolerance requirements of ANSI H35.2.

(C) Galvanized Steel Rail

Use posts, post bases, rails, expansion bars and clamp bars meeting ASTM A36 and galvanize in accordance with ASTM A123. Grind the cut ends of rail smooth and give

them 2 coats of organic zinc repair paint. Galvanize the posts and post bases after they are riveted together.

Use rivets meeting ASTM A502 for Grade 1 rivets.

Use bolts meeting ASTM F593 Alloy 304.

Use nuts meeting ASTM F594 Alloy 304.

Use washers meeting ASTM F844 except made from Alloy 304 stainless steel.

Use materials for shims meeting ASTM A1011 for Grades 36, 40 or 45, or ASTM A1008 for Grade C, and galvanized in accordance with ASTM A123.

1074-6 STEEL PIPE

Steel pipe bent or welded in fabricating shall meet ASTM A53 for standard weight pipe. Use galvanized pipe unless otherwise shown in the plans.

1074-7 IRON CASTINGS

(A) General

Comply with the Department's Iron Casting QA/QC program. Producers and suppliers furnishing iron castings for Department projects shall comply with this program. The program details are available on the Materials and Tests website.

Boldly fillet castings at angles, and provide arises that are sharp and precise. No sharp, unfilleted angles or corners are permitted. Provide castings that are true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects affecting their strength and value for the service intended. Sand blast or otherwise effectively clean of scale and sand all castings to present a smooth, clean, and uniform surface. Welding is not allowed for the purpose of making a casting structurally sound. Welding for cosmetic or other purposes is not allowed without approval of the Engineer.

(B) Gray Iron Castings

Supply gray iron castings meeting all facets of AASHTO M 306 excluding proof load. Proof load testing will only be required for new casting designs during the design process, and conformance to AASHTO M 306 loading (40,000 lbs.) will be required only when noted on the design documents. Acceptance of production castings will be based on test bars. Cast test bars, of size "B", attached to an integral with the castings. Instead of this, cast test bars separate from the castings when approved in writing by the Engineer. The Engineer reserves the right to require that a test bar be machined from an actual casting if deemed necessary. Unless otherwise specified, do not coat gray iron castings. Do not perform any welding on castings for any reason without prior approval from the Engineer. Mark castings with the NCDOT Standard Number of the casting design, the fabricator's ID and the day, month and year of production.

1074-8 STEPS

Fabricate steps for minor drainage structures from deformed reinforcing bars, use gray iron castings meeting Subarticle 1074-7(B) or use composite plastic-steel construction as shown in the plans.

The use of steps differing in dimension, configuration or materials from those shown in the plans is allowed by furnishing the Engineer with details of the proposed steps and obtaining written approval for the use of such steps.

1074-9 FABRICATED STEEL GRATES

Use fabricated steel grates made from bars that meet ASTM A36. Galvanize the grates after fabrication in accordance with AASHTO M 111. Mark items with fabricators ID, month and year of production.

1074-10 PINS

Supply pins for bearing assemblies meeting either ASTM A36 or ASTM A108 for Grades 1016 through 1030, unless otherwise required by the plans or specifications.

1074-11 WASHERS

Provide washers for use with fasteners meeting ASTM F436. Provide washers for high strength bolts meeting Article 1072-5.

Ensure that the size and finish (plain, weathering or galvanized) of washers is compatible with the fastener.

1074-12 METAL STAY-IN-PLACE FORMS

Provide metal stay-in-place forms for concrete floor slabs of zinc-coated (galvanized) steel sheet conforming to ASTM A653, Structural Steel (SS) Grades 33 through 80 and Coating Class G165 meeting all requirements relevant to steel stay-in-place forms as noted on the contract plans. Do not use material thinner than 20 gauge.

1074-13 STEEL GRID FLOORING

Steel grid flooring shall conform to the requirements of *AASHTO LRFD Bridge Construction Specifications*, Section 12 and these *Standard Specifications*.

SECTION 1076
GALVANIZING

1076-1 GALVANIZING

Wherever galvanizing is required, perform the galvanizing in accordance with this section except where other requirements for galvanizing are included in other sections of these *Standard Specifications*.

Allow the Engineer to obtain samples of molten zinc directly from the galvanizing vat upon request.

1076-2 INSPECTION NOTIFICATION

Coordinate galvanizing inspection with the Materials and Tests Unit in accordance with Subarticle 1072-7(A). Before inspection, the galvanizer/supplier shall provide the Department's inspector with NCDOT approved drawing/purchase order, stating contract number, location of project, quantity/type of material being galvanized and Mill Test Report(s) for respective material.

1076-3 FABRICATED PRODUCTS

Galvanize products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips 1/8 inch thick and heavier in accordance with AASHTO M 111. Fabricate products into the largest unit that is practicable to galvanize before the galvanizing is done. Fabrication includes all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, welding and riveting. Galvanize components of bolted or riveted assemblies separately before assembly. When it is necessary to straighten any sections after galvanizing, perform such work without damage to the zinc coating.

Completely seal all edges of tightly contacting surfaces by welding and commercial blast clean to SSPC-SP 6 before galvanizing.

Commercial blast clean components with partial surface finishes in accordance with Subarticle 442-7(A) before pickling.

1076-4 HARDWARE

Galvanize iron and steel hardware in accordance with AASHTO M 232.

1076-5 ASSEMBLED PRODUCTS

Completely seal all edges of tightly contacting surfaces by welding before galvanizing. Galvanize assembled steel products in accordance with AASHTO M 111.

1076-6 SHEETS

Galvanize iron or steel sheets in accordance with ASTM A653.

1076-7 REPAIR OF GALVANIZING

Repair galvanized surfaces that are abraded or damaged at any time after the application of zinc coating. Surfaces to be repaired shall be clean, dry and free of oil, grease, pre-existing paint, corrosion and rust. Surface to be repaired shall be blast-cleaned to SSPC-SP 10 (Near-White Metal).

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 1080-7. 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 that is NCDOT approved as found on the Department's approved producer/supplier list. The Department will remove a manufacturer of precast concrete units from this producer/supplier list 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.

(A) Producer Qualification

Producers of precast concrete members are required to establish proof of their competency and responsibility in accordance with the National Precast Concrete Association (NPCA) or American Concrete Pipe Association (ACPA) Certification Programs to perform work for the NCDOT. Certification of the manufacturing plant under either NPCA or ACPA program and submission of proof of certification to the State Materials Engineer is required before beginning fabrication. Maintain certification at all times while work is being performed for the Department. Submit proof of certification following each NCPA or

ACPA audit to the State Materials Engineer for continued qualification. These same requirements apply to producers subcontracting work from the producer directly employed by the Contractor. All producers shall be listed as an approved producer/supplier before beginning any work for the Department.

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 a complete set 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, weight 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 Materials	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
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 15 business 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, electrical outlets and internet access.

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. Provide access to all surfaces of units so the plant inspector has the opportunity to properly inspect the units before approval. The provided access should allow room for inspection personnel to safely and freely move between and around units. Do not stack above 6 feet off the ground.

(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 will be indicated by the compliance with the Department's RFID tag/label tagging policy in accordance with Section 1030 and verified product approval as noted by an authorized Field Inspection Report (FIR) or NCDOT alternate ID.

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 5% ± 2%. Supply concrete with a maximum slump of 3.5 inches unless a high range water reducer (super plasticizer) is approved by the Engineer. Supply concrete with a maximum slump of 3.5 inches. A slump of 8 inches is permitted only when obtained with the use of an approved high range water reducer. As an option, reduce the cement content of the mix design by up to 30% and replace with fly ash at a rate of 1 lb. 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.

Submit proposed concrete mix designs in terms of saturated surface dry weights on *Materials and Tests Form 312U* at least 35 days before proposed use. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated surface dry mix proportions will not be permitted unless revised mix designs have been submitted to the Engineer and approved. Laboratory trial batches shall be created to confirm the proposed mix design meets the requirements of the plastic and hardened concrete.

Accompany *Materials and Tests Form 312U* with a listing of laboratory test results of aggregate gradation, air content, slump and compressive strength from a certified laboratory. List the compressive strength of at least three 6 inch x 12 inch or 4 inch x 8 inch cylinders at the age of 7 and 28 days.

Perform laboratory tests in accordance with the following test procedures:

Property	Test Method
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump	AASHTO T 119
Compressive Strength	AASHTO T 22 and R100

The Engineer will review the mix design for compliance with the Specifications and notify the Contractor as to its acceptability. Do not use a mix until written notice has been received. Acceptance of the mix design does not relieve the Contractor of his responsibility to furnish a product that meets the contract.

(B) Self-Consolidating Concrete (SCC) and Intermediate Flow Concrete

When a flowable concrete consistency is required, the use of an SCC or Intermediate Flow concrete is permitted with an approved concrete mix design.

SCC is a specialized concrete mix that utilizes various admixtures to obtain a fluid consistency without negatively impacting the strength or homogeneity of the mix. SCC is designed to flow under its own weight and completely fill the formwork completely, even in the presence of dense reinforcement and without the need for consolidation. SCC is characterized by a plastic concrete mixture with a flow that achieves a spread of 22-30 inches, when tested in accordance with ASTM C1611.

Intermediate Flow Concrete is a concrete mix that exceeds the slump of standard concrete but does not have the same high flow characteristics of an SCC concrete mix.. Intermediate Flow Concrete is characterized by a plastic concrete mixture with a flow that achieves a spread of 16-22 inches, when tested in accordance with ASTM C1611.

When submitting a proposed SCC or Intermediate Flow concrete mix design on a *Materials and Tests Form 312U*, include the test results obtained using the following test procedures:

Property	Test Method
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump Flow	ASTM C1611
Visual Stability Index (VSI)	ASTM C1611
Passing Ability	ASTMC1621 (Filling Procedure B)
Segregation	ASTM C1610
Compressive Strength	AASHTO T 22 and R100

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 5 ± 2%. SCC and Intermediate Flow mixes shall have a difference in slump flow and passing ability not to exceed 2 inches, a Visual Stability Index no greater than 1, and a static segregation limit of 15%.

TABLE 1077-1 PRECAST CONCRETE STRENGTH REQUIREMENTS AT AN AGE OF 28 DAYS		
Precast Units	**Requirement**	**Specification Reference**
BARRIER:		
Portable	4,500 psi	Section 854, 1090 and 1170
Permanent	4,500 psi	Section 854, 857 and 1090
CULVERTS:		
Circular Pipe	4,000 psi	Section 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	Section 310, 1032 and AASHTO M 170
Pipe Elbows	4,000 psi	Section 310, 1032 and AASHTO M 170
Cross & Parallel Special End Sections	3,500 psi	Section 310 and 1032
DRAINAGE STRUCTURES:		
Boxes (Solid & Waffle)	4,000 psi	Section 840 and ASTM C913
CIRCULAR MANHOLES:		
Base	4,000 psi	Section 1525 and AASHTO M 199
Riser Section	4,000 psi	Section 1525 and AASHTO M 199
Top Section	4,000 psi	Section 1525 and AASHTO M 199
Grade Ring	4,000 psi	Section 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	Section 455
Precast 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	Section 815, 816 and 825
Right-of-Way Markers	2,500 psi	Section 806 and 1054
Concrete Anchor For Cable Guardrail	3,000 psi	Section 1046
Picnic Tables	2,500 psi	Contract
Waste Containers	2,500 psi	Contract

Submit a proposed concrete mix design for the precast units to the Engineer. 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*.

(C) 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 incidental precast items listed in Table 1077-1, 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 AASHTO T 152, T196 or T121. If the air content does not meet the *Standard Specifications*, a second test on the same load is conducted using AASHTO T 152, T196 or T121. Acceptance or rejection of the load is based on the results of this test.

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

Determine slump in accordance with AASHTO T 119 and ensure that slump meets the specifications as stated on Materials and Tests Form 312U approved mix design.

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 R 100 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.

(D) 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.

(E) Use of Water Reducing Admixtures

Use water reducing admixtures in accordance with Subarticle 1000-3(G). Use high range water reducers (super plasticizers), if approved by the Engineer.

1077-6 FORMS

Use forms of sturdy construction and in good working order 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 and inspect for damage. Repair or replace damaged forms that will not allow for proper casting or cause defects in the finished product. 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. When using fibers manufactured from materials other than polyolefins, submit test results complying with ASTM D7508 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 5% ± 2% air content and a compressive strength of at least 4,000 psi in 28 days.

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.

Placing concrete for precast members in cold weather shall be in accordance with Article 1078-10.

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 1078-11(B). The temperature within the curing enclosure shall not exceed 160°F. Place recording thermometers within each enclosure. Calibrate recording thermometers at intervals not to exceed 6 months. Submit complete temperature records to the Engineer for all cures before final approval of the members.

(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) except as noted within Article 1077-16.

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 by the Engineer 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 3.5 feet or greater in height. Do not detail the lowest step more than 16 inches from the bottom.

1077-14 MARKING

Clearly mark 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

Clearly apply a Department approved self-adhesive RFID tag/label tagged in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F). When precast products have been inspected the Department will update the RFID tag/label record as found in the Field Inspection Report (FIR) or NCDOT alternate ID. RFID tag/labels are allowed but not required for incidental precast items.

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.

1077-17 SOUND AND NOISE WALL PANELS AND NOISE WALL POSTS

Wall panels will be required to be placed in a rack system for inspection. Double faced wall panels will require access to both faces for proper inspection. After sound wall panels have been inspected and approved they shall be stored in a manner that will not cause damage prior to delivery to the project.

Manufacture sound wall post within the tolerances indicated in Table 1078-2 and Figure 1078-1.

SECTION 1078
PRESTRESSED CONCRETE MEMBERS

1078-1 GENERAL

This section covers the materials for and the production of precast, prestressed concrete members produced in accordance with the contract.

Use prestressing of the pretensioning type in which steel prestressing strands are initially stressed and anchored; the concrete is then placed, vibrated and cured; and when the concrete reaches the required strength, the load is transferred from the anchorages to the concrete.

The intent of this section is to require the producer to provide prestressed concrete members that meet the *Standard Specifications* and exhibit characteristics that are not objectionable to the Department.

(A) Producer Qualification

Producers of precast, prestressed concrete members are required to establish proof of their competency and responsibility in accordance with the Precast/Prestressed Concrete Institute's (PCI) Plant Certification Program to perform work for the project. Certification of the manufacturing plant under the PCI program and submission of proof of certification to the State Materials Engineer is required before beginning fabrication. Maintain certification at all times while work is being performed for the Department. Submit proof of certification following each PCI audit to the State Materials Engineer for continued qualification. These same requirements apply to producers subcontracting work from the producer directly employed by the Contractor.

Employ producers PCI certified in Product Group B, Bridge Products and in one of the appropriate categories as listed below:

(1) B2 Prestressed Miscellaneous Bridge Products includes solid piles, sheet piles and bent caps;

(2) B3 Prestressed Straight-Strand Bridge Members includes all box beams, cored slabs, straight-strand girders and bulb-tees, bridge deck panels, hollow piles, prestressed culverts and straight strand segmental components; or

(3) B4 Prestressed Deflected-Strand Bridge Members includes deflected strand girders and bulb-tees, haunched girders, deflected strand segmental superstructure components and other post-tensioned elements.

Categories for elements not listed above will be as required by the project special provision or plans.

(B) Working Drawing Submittals

Before casting members, submit complete working drawings to the Engineer for approval. The working drawings shall detail the exact location and description of all casting holes, attachments and inserts cast in the member for both temporary and permanent applications. The casting holes, attachments and inserts are in association with, but not limited to: fall protection, overhang falsework, metal stay-in-place forms, solar platforms, temporary girder bracing, transit, erection, lifting and handling. If the plan notes indicate that the structure contains the necessary corrosion protection required for a corrosive site, epoxy coat, galvanize or metalize all metallic components except stainless steel and malleable iron components. Electroplating will not be allowed.

1078-2 MATERIALS

Refer to Division 10.

Item	Section
Air Entraining Agent	1024-3
Chemical Admixtures	1024-3
Coarse Aggregate	1014-2
Epoxy Protective Coating	1081-1
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Miscellaneous Metals	1074
Portland Cement	1024-1
Prestressing Strand	1070-5
Reinforcing Steel	1070
Blended Cement	1024-1
Silica Fume	1024-7
Structural Steel	1072
Water	1024-4

Do not make changes in the source of aggregates, cements or admixtures during the casting of members in any one span or substructure unit unless approved by the Engineer.

1078-3 INSPECTION

The Department reserves the right to place a duly authorized inspector in the plant at any or all times work related to the production of members for the Department is performed. Notify the Engineer at least 15 business days in advance when such work is scheduled. Provide an office area with an approximate floor space of 100 sf, a desk or drafting table, two chairs, telephone, separate dial-up or faster internet access, facilities for proper heating and cooling and adequate lighting at the plant for the exclusive use of the inspector. The Inspector has the authority to reject any or all members not manufactured in accordance with these specifications. Approval of any member by the inspector at the plant is in no way final, and further inspection is made at the structure site both before and after the member is placed in the final position. Any member found to be defective in any manner at any time is rejected and requires replacement by an acceptable member or repair in a manner approved by the Engineer.

Do not transport any member from the plant to the job site before approval of that member by the plant inspector. Provide access to all surfaces of the member so the plant inspector has the opportunity to properly inspect the member before approval. Such approval will be indicated by the compliance with the Department's RFID tag/label tagging policy in accordance with Section 1030 and verified product approval as noted by an authorized Field Inspection Report (FIR) or NCDOT alternate ID.

1078-4 PORTLAND CEMENT CONCRETE

(A) Composition and Design

Supply Portland cement concrete composed of Portland cement, coarse aggregate, fine aggregate, water and an approved air-entraining agent. Add other cementitious materials and/or chemical admixtures if approved by the Engineer. When admixtures are used, use them in the proper proportions to obtain the optimum effect. Do not use set accelerating admixtures, calcium chloride or admixtures containing calcium chloride. If approved by the Engineer, high range water reducer may be used at a rate not to exceed the manufacturer's recommended dosage.

Supply concrete with a minimum compressive strength of 5,000 psi at the age of 28 days, unless otherwise required by the plans or *Standard Specifications*. Ensure that all coarse aggregate used in prestressed concrete passes a 1 inch sieve. Maintain a cement content of at least 564 lbs. per cubic yard. Air entrain concrete to provide an air content of 5 ± 2%. Supply concrete with a maximum slump of 3.5 inches. A slump of 8 inches is permitted only when obtained with the use of an approved high range water reducer. As an option, reduce the cement content of the mix design and replace with fly ash or ground granulated blast furnace slag in accordance with Article 1024-1. For concrete with a 28 day design strength greater than 6,000 psi, if approved by the Engineer, substitute microsilica for cement, in conformance with Article 1024-1.

Submit to the Engineer proposed concrete mix designs for each strength of concrete used in the work. Determine quantities of fine and coarse aggregates necessary to provide concrete in accordance with the *Standard Specifications* by the method described in ACI 211 using the absolute volume basis.

Submit mix designs, stated in terms of saturated surface dry weights, on *Materials and Tests Form 312U* at least 35 days before using the proposed mix. Adjust batch proportions to compensate for surface moisture contained in the aggregates at the time of batching. Changes in the saturated dry mix proportions are not permitted unless revised mix designs are submitted to the Engineer and are determined to be acceptable for use. Create laboratory trial batches to confirm the proposed mix design meets the requirements of the plastic and hardened concrete.

Provide with *Materials and Tests Form 312U* a listing of laboratory test results of aggregate gradation, air content, slump and compressive strength. List the compressive strength of at least three 6 inches x 12 inches or 4 inches x 8 inches cylinders. Show the age of the cylinders at the time of testing and a detailed description of the curing procedure. Perform laboratory tests in accordance with the following test procedures:

Property	**Test Method**
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump	AASHTO T 119
Compressive Strength	AASHTO T 22 and R100

If the design 28 day compressive strength is greater than 6,000 psi, submit the compressive strength of at least six cylinders. Ensure that the average strength of the six cylinders is at least 1,500 psi above the minimum 28 day compressive strength required by the plans.

The Engineer will review the mix design for compliance with the specifications and notify the Contractor as to its acceptability. Do not use a mix until written notified has been received. Acceptance of the mix design does not relieve the Contractor of his responsibility to furnish a product that meets the contract.

(B) Self-Consolidating Concrete (SCC) and Intermediate Flow Concrete

When a flowable concrete consistency is required, the use of an SCC or Intermediate Flow concrete is permitted with an approved concrete mix design. SCC is a specialized concrete mix that utilizes various admixtures to obtain a fluid consistency without negatively impacting the strength or homogeneity of the mix. SCC is designed to flow under its own weight and fill the formwork completely, even in the presence of dense reinforcement and without the need for consolidation. SCC is characterized by a plastic concrete mixture with a flow that achieves a spread of 22-30 inches, when tested in accordance with ASTM C1611.

Intermediate Flow Concrete is a concrete mix that exceeds the slump of standard concrete but does not have the same high flow characteristics of an SCC concrete mix. Intermediate Flow Concrete is characterized by a plastic concrete mixture with a flow that achieves a spread of 16-22 inches, when tested in accordance with ASTM C1611.

When submitting a proposed SCC or Intermediate Flow concrete mix design on a Materials and Tests Form 312U, include the test results obtained using the following test procedures:

Property	Test Method
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump Flow	ASTM C1611
Visual Stability Index (VSI)	ASTM C1611
Passing Ability	ASTM C1621 (Filling Procedure B)
Segregation	ASTM C1610
Compressive Strength	AASHTO T 22 and R100

Supply concrete that develops a minimum compressive strength of 5,000 psi at the age of 28 days, unless otherwise required by the plans or *Standard Specifications*. SCC and Intermediate Flow mixes shall have a difference in slump flow and passing ability not to exceed 2 inches, a Visual Stability Index no greater than 1, and a static segregation limit of 15%.

(C) Testing

Employ a certified concrete technician to perform all testing required by this subarticle at the bed site in the presence of the plant inspector unless otherwise approved by the Engineer. Certification of technicians is awarded upon satisfactory completion of examinations prepared and administered by the Department or other approved agency.

(1) Air Content

Before allowing placement of the first load in a bed, determine the air content by AASHTO T 152, T196 or T121. During the placement of the first load, determine the air content by AASHTO T 152, T 196 or T 121. Determine the air content in each subsequent 10 cubic yards by AASHTO T 152, T196 or T121 before allowing placement. Determine the air content by AASHTO T 152, T196 or T121 from all loads from which cylinders are made. If the air content does not meet the *Standard Specifications*, a second test on the same load is conducted using AASHTO T 152, T196 or T121. Acceptance or rejection of the load is based on the results of this test.

(2) Slump

Determine slump in accordance with AASHTO T 119.

(3) Spread

Determine spread on SCC and intermediate flow concrete in accordance with ASTM C1611 or AASHTO T 347.

(4) Strength

For the purpose of testing for the required 28 day compressive strength and also for the required compressive strength for the transfer of load, furnish, at no cost to the Department, cylinders made from a sample of concrete placed near the live end of the bed and additional cylinders made from a sample of concrete placed near the dead end of the bed. Make cylinders in accordance with AASHTO R 100, except cure the cylinders in the same manner as the members represented until the strands are released. Place cylinders in clusters at random points along the casting bed. After the strands are released, air cure the cylinders in an approved common area near the testing apparatus for the remainder of the 28 day curing period. Test the cylinders in accordance with AASHTO T 22. Provide approved apparatus for testing the transfer strength of the cylinders. Maintain this apparatus to within 1.0% accuracy and calibrate at intervals not to exceed 12 months by an approved testing company at no cost to the Department. The Engineer reserves the right to require verification

immediately after a testing machine is relocated and whenever there is reason to doubt the accuracy of the indicated load, regardless of the time interval since the last verification.

The testing requirements for the 28 day compressive strength for all prestress members required by the plans are as follows:

(a) Release Strength

Test four cylinders, two sets of two cylinders from each end of the bed, for the purpose of determining whether the concrete has reached the required strength for transfer of load. The strengths from the dead end cylinders are averaged and the strengths from the live end cylinders are averaged. Ensure that both of these averages meet or exceed the required release strength and the lowest cylinder is not more than 200 psi below the required strength.

(b) Acceptance Strength

Test a set of three cylinders from each end to determine the 28 day compressive strength. The strengths from the dead end cylinders are averaged and the strengths from the live end cylinders are averaged. Ensure that both of these averages meet or exceed the 28 day compressive strength. Ensure that no cylinder indicates a compressive strength less than 400 psi less than the required 28 day compressive strength. Failure to meet the above requirements is cause for rejection of the members represented.

(D) Temperature Requirements

Maintain a concrete temperature at the time of placing in the forms between 50°F and 95°F.

Place concrete when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is a minimum of 35°F and rising.

Place concrete when the form temperature is between 35°F and 110°F.

(E) Elapsed Time for Placing Concrete

Ensure that the elapsed time for placing concrete is in accordance with Subarticle 1000-3(E). The requirements of Subarticle 1000-3(E) pertaining to Class AA concrete apply to prestressed concrete.

(F) Use of Set Retarding Admixtures

By permission of the Engineer, use an approved set retarding admixture if choosing to take advantage of the extended time interval between adding mixing water and placing the concrete.

Use a quantity of set retarding admixture per 100 lbs. of cement within the range recommended on the current list of approved set retarding admixtures issued by the Materials and Tests Unit.

(G) Use of Water Reducing Admixtures

Use water-reducing admixtures in accordance with Subarticle 1000-3(G).

(H) Use of Calcium Nitrite Corrosion Inhibitor

Add an approved calcium nitrite corrosion inhibitor (30% solids) to the concrete mix at the batch plant for the bridge elements identified by the plan notes. Clearly mark the prestressed concrete members that contain calcium nitrite.

Use the inhibitor at a minimum rate of 3.0 gal/cy. Ensure that the hardened concrete contains at least 5.8 lbs/cy Nitrite (NO_2) when tested in accordance with Materials and Tests Method Chem. C-20.0 with the exception of concrete used in prestressed members. Test prestressed members as follows:

The Department will perform the complete C-21.0 Field Test Procedure for the Nitrite Ion in Plastic Concrete on plastic concrete samples obtained randomly from a truck used to pour concrete near each end (live end and dead end) of a prestressed concrete casting. Powder samples will be taken from hardened cylinders made at the time C-21.0 is run for any concrete that fails the C-21.0 (plastic test) method. The Chemical Testing Laboratory will test the powder using method C-20.0 Determination of Nitrite in Hardened Concrete. Acceptance of the concrete is dependent in the results of method C-20.0 (hardened test) when any sample fails the C-21.0 (plastic test method).

The Department will perform a qualitative nitrite ion check by method C-22.0 (Field Spot Test) on each load of concrete batched for a prestressed concrete casting bed. Acceptance of the concrete is dependent on the results of method C-20.0 (hardened test) when any sample fails the C-22.0 (Field Spot Test). The producer may elect to not incorporate concrete that fails Method C-22.0 (Field Spot Test) instead of waiting for C-20.0 (hardened test) test results to determine the acceptability of the member. Once per each week's production of prestressed concrete with corrosion inhibitor, random samples of hardened concrete powder will be taken from cylinders used for method C-21.0 (plastic test). These samples will be submitted to the Chemical Testing Laboratory for analysis using method C-20.0 (hardened test).

Units with calcium nitrite in a quantity less than specified are subject to rejection. Furnish powder drilled from concrete cylinders to the Engineer, in a quantity to be specified, to verify the concentrations of calcium nitrite in hardened concrete. Concrete failing to contain calcium nitrite at the required concentrations as tested is subject to rejection.

Use only air-entraining, water-reducing and/or set-controlling admixtures in the production of concrete mixtures that are compatible with calcium nitrite solutions.

Strictly adhere to the manufacturer's written recommendations regarding the use of admixtures including storage, transportation and method of mixing. If preferred, use calcium nitrite, which acts as an accelerator, in conjunction with a retarder to control the set of concrete, as per the manufacturer's recommendation.

(I) Measuring Materials

Measure materials in accordance with Article 1000-9.

(J) Mixers and Agitators

Use mixers and agitators meeting Article 1000-11.

(K) Mixing and Delivery

(1) General

Mix and deliver concrete to the site of the work by one of the following methods, except where other methods are approved by the Engineer. The Engineer approves the mixing of concrete by methods other than those listed below provided the proposed method is capable of satisfying job requirements and there is adequate evidence that the proposed method produces concrete complying with the *Standard Specifications*. Assume responsibility for controlling the materials and operations so as to produce uniform concrete meeting the *Standard Specifications*.

Have present during all batching operations at the concrete plant a certified concrete technician employed by the Contractor, prestressed concrete producer or concrete supplier while concrete is batched and delivered to the site of the work. The sole duty of this employee is to have charge of and exercise close supervision of the production and control of the concrete. Ensure the technician performs moisture tests, adjusts mix proportions of aggregates for free moisture, completes batch tickets on *Materials and Tests Form 903* or approved delivery tickets, signs batch tickets or approved delivery tickets and assures quality control of the batching operations. Delivery tickets are

permitted instead of batch tickets on M&T *Form 903* provided they are reviewed and approved by the Materials and Tests Unit. Certification of technicians is awarded upon satisfactory completion of examinations prepared and administered by the Department or other approved agency.

(a) Central Mixed Concrete

Mix completely in a stationary mixer and transport the mixed concrete to the point of delivery in a truck agitator or in a truck mixer operating at agitating speed or in non-agitating equipment approved by the Engineer. Mix within the capacity and at the mixing speeds recommended by the equipment manufacturer.

(b) Transit Mixed Concrete

Mix completely in a truck mixer while at the batching plant, in transit or at the work site.

(2) Mixing Time for Central Mixed Concrete

The mixing time starts when all the solid materials are in the mixing compartment and ends when any part of the concrete begins to discharge. Charge the ingredients into the mixer such that some of the water enters in advance of cement and aggregate, and substantially all the water is in the drum before 1/3 of the specified mixing time elapses. Transfer time in multiple drum mixers is counted as part of the mixing time.

Establish the minimum mixing time by one of the following:

(a) Mixer performance tests as described herein,

(b) The manufacturer of the equipment, or

(c) The requirement of one minute for mixers of 1.0 cy capacity or less with an increase of 15 seconds for each cubic yard or fraction thereof in increased capacity.

The Engineer reserves the right to require a mixer performance test at any time. The minimum mixing time as determined by the mixer performance test is that which produces concrete in accordance with Table 1078-1.

Sample and test for mixer performance as provided below. Charge the mixer to its rated capacity with the materials and proportions used in the work and mix at the recommended mixing speed to the target time. Stop mixing then and begin discharging. Take two samples of sufficient size to make the required tests after discharge of approximately 15% and 85% of the load by an appropriate method of sampling which provides representative samples of the concrete.

Separately test each of the two samples of concrete for the properties listed in Subarticle 1078-4(A) or 1078-4(B). Conduct tests in accordance with the standard methods shown in Subarticle 1078-4(A) or 1078-4(B) or procedures established by the Materials and Tests Unit.

Perform the mixer performance test described above on at least two batches of concrete. For the performance test to be acceptable, ensure that all tests in each batch meet the requirements listed in Table 1078-1.

The Engineer rechecks mixer performance at any time when in his judgment acceptable mixing is not accomplished.

Where acceptable mixing cannot be accomplished in the established mixing time, the Engineer increases the mixing time or requires that the mixer be repaired or replaced before any further mixing.

TABLE 1078-1
REQUIREMENTS FOR UNIFORMITY OF CONCRETE WITHIN A BATCH

Property	Requirement	Test Method
Difference in Test Samples Air Content, Percent by Volume of Concrete	1.0%	AASHTO T 152
Slump	1.0"	AASHTO T 119
Coarse aggregate content, portion by weight of each sample retained on the No. 4 sieve	6.0%	-
Weight per Cubic Foot (Density)	1.0 lb/cf	AASHTO T 121
Average Compressive Strength at 7 days, Percent of Average	7.5%[A]	AASHTO T 22 and R100

A. Obtain tentative approval pending 7 day compressive strength tests.

(3) Truck Mixers and Truck Agitators

Use truck mixers and truck agitators meeting Subarticle 1000-11(C). For concrete with a design 28 day compressive strength greater than 6,000 psi, load trucks to within 1 cy of rated capacity and mix at a speed of 16 to 18 rpm.

(4) Delivery

For central mixed concrete delivered in truck agitators, truck mixers, or transit mixed concrete, use a ticket system for recording the transportation of batches from the proportioning plant to the site of the work. Fill out the tickets on *Materials and Tests Form 903* or approved delivery tickets in accordance with the instructions issued by the Engineer. Issue the tickets to the truck operator at the proportioning plant for each load and have them signed by the certified concrete technician, which signifies that the concrete in the truck is inspected before departure. Show on each ticket the time batching is complete and if transit mixed, the number of revolutions at mixing speed, if any, at the plant. Deliver the tickets to the inspector at the site of the work. For central mixed concrete delivered in non-agitating equipment, alternate methods of documenting batch proportions are considered by the Engineer. Loads that do not arrive in satisfactory condition within the time limits specified are not acceptable for use in the work.

(L) Ready Mixed Concrete Plant

Ensure ready mixed concrete plants are inspected and approved by the Department before they are used to produce concrete for the project. Ensure that plants meet all applicable requirements of the *Standard Specifications* and in addition have at least two acceptable concrete delivery vehicles that are in working condition. Plants approved by the Department are placed on a list of approved plants that is made available. All plants are subject to reinspection at intervals selected by the Engineer. Reapproval after each inspection is contingent on continuing compliance with the *Standard Specifications*.

1078-5 CASTING BED AND FORMS

Use metal forms, including headers or end forms, except where other materials are approved by the Engineer. Use forms of adequate thickness, braced, stiffened, anchored and aligned adequately to consistently produce members within the limits of dimensional tolerances. Design and align the forms so they do not restrict longitudinal movement of the casting when the prestressing force is transferred. Provide corners and angles that are chamfered or rounded. Provide joints in forms that are smooth and tight enough to prevent leakage of mortar. Plug holes and slots in forms, pallets, headers and bulkheads neatly to prevent leakage of mortar. Make the inside surfaces of forms accessible for cleaning. Thoroughly clean the beds and forms after each use. Before casting, clean the inside surfaces of the forms from rust, grease or other foreign matter. Remove all foreign substances from inside the forms, including any standing water. Do not allow coatings used for release of members to build up. Do not use forms that do not present a smooth surface.

When casting holes through the top flange of girders for overhang or interior bay falsework hanger rods, use rigid PVC conduits with a wall thickness of approximately 1/8 inch. Do not use thin wall material. Secure conduits in the forms so they do not migrate out of the proper location. Other methods of forming holes may be proposed but are subject to the Engineer's approval.

When casting dowel rod holes in cored slab or box beam members, use material that creates round, vertical holes of the specified diameter and in the correct location. Do not use material that deforms, collapses or shifts position during casting of the member.

Apply form release agents to the forms either before or after stringing of strands. If applied before stringing, provide a release agent of a type that dries to a degree so it cannot contaminate any strand that comes in contact with it. If the release agent is applied after stringing, exercise great care and provide a sheet metal or similar type shield for protection of the strands.

1078-6 TENSIONING DEVICES

Use tensioning devices adequate to produce and maintain the required tension in all strands until the concrete reaches the required transfer strength. Equip all jacks with accurate and calibrated gauges for registering jacking loads. Calibrate gauges with the jacks with which they are used. Calibrate all jacks and gauges by an approved testing company at no cost to the Department at intervals not to exceed 12 months. During progress of the work, if gauge readings and elongations indicate materially differing loads, recalibrate as required. Use gauges with a full load capacity of 1 1/2 to 2 times their normal working load, unless otherwise approved by the Engineer. Do not use loads less than one-fourth or more than 3/4 of the total graduated gauge capacity unless calibration data clearly establishes consistent accuracy over a wider range. Use gauges with indicating dials at least 6 inches in diameter and gauge pointers that do not fluctuate, preventing an accurate reading, but remain steady until the jacking load is released. Ensure that all gauges have an accuracy of reading within 2%. Provide means for measuring the elongation of strands within 1/4 inch.

1078-7 PLACING STRANDS, TIES AND REINFORCING STEEL

Position strands, ties, supports, reinforcing bars of the sizes shown in the plans and bearing plates in accordance with the detailed dimensions shown in the plans and effectively secure against displacement from their correct positions. The use of previously tensioned strands is not permitted. For prestressing strands, do not allow deflections or displacements of any kind between the end anchorages unless shown in the plans. Place the steel reinforcing in final position after tensioning of the strands. Bend all tie wires to the inside of the member so the ends are farther from the edge than the material tied. Support bottom strands spacings not to exceed 20 feet by supports meeting Article 1070-4 or by other approved means. Plastic supports may be used when approved by the Engineer.

Strands with kinks, bends, nicks, scale, excessive rust or other defects are not permitted. No more than one broken wire per casting bed is permitted. Slight rusting is not cause for rejection, provided it is not sufficient to cause visible pits. Take precautions to prevent contamination of strands and reinforcing steel. Clean the strands and reinforcing steel to an acceptable condition before pouring concrete. Do not place concrete in the forms until the strand and reinforcement condition and arrangement are inspected by the plant inspector.

Strand splices are only permitted at the end of a reel and when using a single strand jack. Ensure that the strand lengths to be spliced together have the same lay of wire to avoid unraveling and position the splice so it does not fall within a member. Do not torch cut the ends of the spliced strand lengths. Cut by shears, abrasive grinders or other means approved by the Engineer. No more than one strand splice per bed is allowed on an individual strand and the use of previously tensioned strands for splicing is not permitted.

Where debonding of strands is required, accomplish by encasing the strand in a tubular conduit capable of resisting the pressure exerted by the concrete. Do not use slit conduit. Use a conduit of HDPE or polypropylene with a minimum wall thickness of 0.025 inch. Ensure that the inside

diameter of the conduit is of sufficient size to allow free movement of the encased strand but not greater than the diameter of the strand plus 1/8 inch. Secure the conduit so longitudinal movement along the strand is prevented, and bonding of the strand is prevented at the required location ± 1 inch. When conduit is added after initial tensioning, prevent concrete from entering the conduit by taping all joints and cuts along the length of the conduit. Use tape manufactured from a non-corrosive material compatible with the concrete, conduit and steel.

1078-8 TENSIONING PROCEDURE

A producer quality control representative shall be present during strand tensioning. Tension each strand to the load shown in the plans before placing the concrete.

Measure the load induced in the prestressing strand both by jacking gauges and strand elongations on at least the first five strands and every third strand thereafter on each pour. Measure loads on all other strands by either jacking gauges or strand elongations. When both methods of measurement are used, if a discrepancy between gauge and elongation of more than 5% is apparent, carefully check the entire operation and determine the source of error before proceeding. Make appropriate allowances in the computed elongation and jacking loads for load losses due to friction and all possible slippage or relaxation of the anchorage. Establish references periodically at each strand anchorage to indicate any yielding or slippage that may occur between the time of initial tensioning and final release of the strands.

In determining the applied load by measuring the elongation of the strand, use a modulus of elasticity taken from the typical stress-strain curve for the brand, size and type of strand tensioned. Submit stress-strain curve data for the actual heats of material used in the strands to the plant inspector before using the strands. Identify each reel or strand by tagging in accordance with AASHTO M 203. Mark the outer layer of each reel pack of strand with a wide color band. In addition, attach a metal tag to each reel pack labeled in accordance with AASHTO M 203.

Tension strands in a group or individually. Before full tensioning, bring each strand to an initial tension of 2,000 lbs. for all beds under 150 feet in length, 3,000 lbs. for all beds 150 feet to 300 feet in length and 4,000 lbs. for all beds longer than 300 feet in length. Measure this initial tension by a calibrated gauge or other approved means, and then compute the elongation due to initial tensioning. Use the difference between the required final tension and the initial tension to compute the expected additional elongation.

For precast prestressed deck panels, use a final prestressing force of 14,000 lbs. per strand for Grade 250 strand and 16,100 lbs. per strand for Grade 270 strand.

After initial tensioning, tension the strands until the required elongation and jacking load are attained and reconciled within the limits specified above. Keep a permanent record of the initial jacking load, the final jacking load, and the elongation produced thereby.

In single strand tensioning, rotation of the jacking ram is not allowed.

When draped strands are used, submit the bed layout showing the method of draping and tensioning the draped strands and also calculations determining the loads required for tensioning the draped strands. Drape the strands for all members to be cast in any one tensioning operation before casting any beam. Have end templates or bulkheads at ends of beams remain vertical or as otherwise shown in the plans. Perform draping for all members either simultaneously or in single or incremental lifts beginning at the center of the bed and working outward toward each end of the bed. Complete tensioning in the fully draped position is not allowed unless approved in writing. Requests to tension in the draped position will only be considered if the producer has the ability to tension from both the live and dead end of the casting bed. When the tensioning of draped strands is approved in writing verification of the proper stresses in the draped strands will be required. The verification of the stresses in the draped strands shall be completed according to the Materials and Tests Standard Operating Procedures for Tensioning Draped Strands in the Final Position.

Use round steel rollers of a type and dimensions approved by the Engineer for deflecting the draped strands. Round the part in contact with the strand to a diameter of not less than 3/4 inch. Use support and hold-down devices of sufficient rigidity with adequate support so the final position of the strands is as shown in the plans. Ensure that all parts are in good working order and roll freely to ensure equal distribution of stress in the draped strands.

With strands tensioned in accordance with the above requirements and with other reinforcement in place, cast the concrete members so as to achieve the required lengths. Maintain strand load between anchorages until the concrete reaches the required compressive strength for transfer of load from the anchorages to the members.

For personnel engaged in the tensioning operation, provide protection by effective shields adequate to stop a flying strand. Provide shields produced from steel, reinforced concrete, heavy timbers and other approved material at both ends of the bed.

1078-9 PLACING CONCRETE

Place concrete in accordance with Article 1077-8 and the additional requirements of this article.

Upon completion of stressing strand, place concrete within a reasonable time to prevent contamination of the strands and reinforcing steel.

Place concrete for girders 54 inches or less in height, and concrete for all cored slabs and box beams, in two or more equal horizontal layers. Place concrete for girders over 54 inches in height in three horizontal layers. When placing concrete in three layers locate the top of the first layer approximately at the top of the bottom flange and locate the top of the second layer approximately at the top of the web. To prevent separation of surfaces between layers, do not allow the time between successive placements onto previously placed concrete to exceed 20 minutes, unless the previously placed concrete has not yet stiffened, as evidenced by the continuous effective use of vibration. Should shrinkage or settlement cracks occur, the Engineer reserves the right to require additional layers and/or vibration.

The requirement of the above paragraph may be waived with the permission of the Engineer if SCC or intermediate flow concrete is used.

Vibration may be required to produce uniformly dense concrete without honeycomb while maintaining the integrity of the concrete mix without causing segregation. Segregation of the concrete within a member may be cause for rejection by the Engineer.

Place concrete in cold weather in accordance with Article 1078-10.

Place concrete in daylight unless an adequate lighting system meeting the approval of the Engineer is provided.

Do not exceed a temperature of 95°F in the freshly mixed concrete when placed in the forms.

Place the concrete in the bed in one continuous operation, finishing each member before proceeding to the next one. If the pour stops before the concrete in all the members in the bed is placed, start curing immediately. Do not place concrete in any remaining members in that bed setup once curing at elevated temperatures has begun.

When cored slabs and box beams are cast, employ an approved internal hold-down system to prevent the voids from moving. At least 6 weeks before casting cored slabs or box beams, submit to the Engineer for review and comment, detailed drawings of the proposed void material and hold-down system. In addition to structural details, indicate the location and spacing of the holds-downs. Submit the proposed method of concrete placement and of consolidating the concrete under the void.

The use of an approved external hold-down system may be used in conjunction with an approved internal hold-down system with the understanding that the external hold-down system shall be removed while the concrete remains plastic. The areas where an external hold-down

system exits the surface of the member shall be consolidated and finished with the surrounding area as specified in Article 1078-16.

1078-10 PLACING PRESTRESSED CONCRETE IN COLD WEATHER

(A) General

Place concrete when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat, is 35°F and rising. When the temperature allows, uniformly heat the aggregates and or water to a temperature not higher than 150°F. Place the concrete when the temperature of the heated concrete is at least 55°F and not more than 95°F.

Use aggregates that are free of ice, frost and frozen particles. Do not place concrete on frozen foundation material and ensure that the forms are free of ice.

Follow the guidelines set forth in Article 1078-11 for proper curing methods when placing concrete in cold weather.

Protect all concrete with heated enclosures or by insulation when the concrete is placed when the air temperature, measured at the location of the concreting operation in the shade away from artificial heat is between 35°F and 50°F.

Provide and place, at directed locations, a sufficient number of maximum-minimum recording thermometers to provide an accurate record of the temperature surrounding the concrete during the entire protection /curing period. Place maximum-minimum recording thermometers within 50 feet of each end of the bed and at points not to exceed 100 feet between the end thermometers. Provide at least two thermometers for bed lengths of 100 feet or less.

Assume all risks connected with the placing of concrete under the cold weather conditions referred to herein.

(B) Heated Enclosures

Immediately enclose concrete that is placed when the air temperature is below 50°F. Enclose the concrete with a housing consisting of canvas or other approved material supported by an open framework which allows for the heat to be evenly circulated within the enclosure. Maintain the air surrounding the concrete at a temperature of at least 50°F and no more than 90°F when using dry heat. When using dry heat, provide means of preventing loss of moisture from the concrete.

1078-11 CURING CONCRETE

(A) General

Cure concrete by steam curing, radiant heat curing, portable heaters or water curing, as set forth below. As an option, cure concrete for prestressed piles with membrane curing compound as set forth below. Use a method or methods that prevent the concrete from losing moisture at any time before curing is complete. Use methods that do not deface or injure the concrete. Use curing procedures that prevent cracks from occurring in the members. Cure all members in any one bed by the same method.

Continue the curing period until the concrete reaches sufficient strength to permit transfer of load from the anchorage to the members. As soon as the concrete attains release strength, immediately release all forms in a continuous operation, without delay for other activities such as the cleaning of forms. As soon as the forms are removed, and after the Department's Inspector has had a reasonable opportunity to inspect the member, transfer the load from the anchorages to the members as quickly as possible in one continuous operation using the approved detensioning sequence.

(B) Curing at Elevated Temperatures

Perform radiant heat curing under a suitable enclosure that contains the heat and prevent moisture loss. Apply moisture by a cover of moist burlap, cotton matting, or similar approved material. Retain moisture by covering the member with an approved waterproof sheeting in combination with an insulating cover. Support the cover at a sufficient distance above the member being cured to allow circulation of the heat.

Provide steam curing enclosures essentially free of steam leakage to minimize moisture and heat losses. Do not allow the enclosure to come in contact with the members or forms for the members. Do not direct steam jets on the forms so as to cause localized high temperatures.

After placing and vibrating, allow the concrete to attain its initial set before the application of heat or steam. The concrete is considered to obtain its initial set when it has a penetration resistance of at least 500 psi when tested in accordance with AASHTO T 197. Take the sample of concrete tested for penetration resistance from the last load cast in the bed. Store the sample of concrete with the precast member and maintain in the same condition and environment as the member except for the periods of time necessary to prepare the test specimen and to perform the penetration resistance test. Conduct the penetration resistance test.

As an option, submit data indicating that an approved concrete mix attains its initial set after some particular time period. Different periods may be required for different weather conditions. If such data is submitted, consideration is given to permitting heat or steam introduced after the time indicated by such data instead of having to perform the penetration resistance test. Consideration is given to determining the time of initial set by methods other than AASHTO T 197 provided data supporting such other methods is submitted.

When the ambient air temperature is below 50°F, cover the forms after the placement of concrete and apply sufficient heat to maintain the temperature of the air surrounding the unit between 50° and 70°F.

When the ambient air temperature is above 70°F, start a water cure as set forth below or other approved method as soon as the concrete is able to receive the water without physical damage to its surface. Discontinuation of the cure is allowed upon introduction of steam, provided that a relative humidity of 100% is maintained.

The temperature within the curing enclosure shall not exceed 160°F.

Maintain a relatively uniform rate of increase of the temperature within the curing enclosure of approximately 40°F per hour, not to exceed 15°F per 15 minutes. Ensure that the temperature increase is relatively uniform throughout the length and on both sides and top of the concrete unit. Place recording thermometers within 50 feet of each end of the bed and at points not to exceed 100 feet between the end thermometers. Provide at least two thermometers for bed lengths of 100 feet or less. Calibrate recording thermometers at intervals not to exceed 6 months. Ensure that the temperature differential within the curing enclosure does not exceed 15°F. Submit complete temperature records for all cures before final approval of the members.

Continue steam curing until the concrete reaches the required transfer strength.

(C) Water Curing

Keep the concrete members damp by the application of water as soon as possible without damage to the concrete surface, and before the concrete obtains an initial set of 500 psi. Apply the water using soaker hoses and wet burlap or other approved means for the full length of each member. Apply water evenly along the entire length of the bed and as needed to maintain damp conditions.

When the ambient air temperature is below 50°F cover the forms after the placement of the concrete and apply sufficient heat in an approved manner to maintain the temperature of the air surrounding the member between 50°F and 70°F. After the concrete obtains an initial set of 500 psi, the air temperature surrounding the member is allowed to increase to 100°F while continually maintaining moisture on the surface of the concrete. Whenever heat is applied to the member, place temperature recording clocks on the bed as required when curing at elevated temperatures. The requirements for rate of temperature increase apply.

Maintain the application of heat (if used) and water until the concrete obtains release strength.

(D) Curing with Membrane Curing Compound

As an option, cure prestressed concrete piles with a membrane curing compound. Spray the entire surface of the concrete uniformly with a wax-free, resin-base curing compound conforming to Article 1026-2. Use clear curing compound to which a fugitive dye is added for color contrast.

Apply the membrane curing compound after the surface finishing is complete, and immediately after the free surface moisture disappears. In the event the application of curing compound is delayed, start another curing method immediately and continue until the application of the curing compound is started or resumed or until the concrete reaches the required detensioning strength.

Seal the surface with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer or as directed by the Engineer, but not less than one gallon per 150 sf of area.

At the time of use, thoroughly mix the compound in a condition with the pigment uniformly dispersed throughout the vehicle. If the application of the compound does not result in satisfactory coverage, stop the method and apply water curing, as set out above, until the cause of the defective work is corrected.

At locations where the coating shows discontinuities, pinholes, or other defects, or if rain falls on the newly coated surface before the film dries sufficiently to resist damage, apply an additional coat of the compound immediately after the rain stops at the same rate specified herein.

When the ambient air temperature is below 50°F, cover the forms after the application of the curing compound and apply sufficient heat in an approved manner to maintain the temperature of the air surrounding the member between 50°F and 70°F. Whenever heat is applied to the members, place recording thermometers on the bed as required when curing at elevated temperatures. The requirements for rate of temperature increase also apply.

Completely remove any curing compound adhering to a surface to which new concrete is bonded by sandblasting, steel wire brushes, bush hammers or other approved means.

Protect the concrete surfaces to which the compound is applied from abrasion or other damage that results in perforation of the membrane film until the concrete achieves design strength and the members are de-tensioned.

1078-12 TRANSFER OF LOAD

A producer quality control representative or equivalent qualified personnel shall be present during removal of forms and during transfer of load.

Transfer load from the anchorages to the members when the concrete reaches the required compressive strength shown in the plans. Loosen and remove all formwork in one continuous operation as quickly as possible as soon as release strength is obtained. As soon as the forms are removed, and after the Department's Inspector has had a reasonable opportunity to inspect

the member, transfer the load from the anchorages to the members as quickly as possible in one continuous operation using the approved detensioning sequence.

For any particular group of members cast in the same bed, do not transfer the load to any concrete until the test cylinder breaks indicate that the concrete in all these members has reached the required strength as outlined in Subarticle 1078-4(C)(3). If these conditions are not met, delay the transfer of the prestressing load to the concrete until tests of additional cylinders show that the required strength is reached.

When curing at elevated temperatures, begin the procedures for transferring prestressing load immediately after curing is discontinued and the forms are released, and while the concrete is still hot to prevent cooling shrinkage and cracking. If so directed by the Engineer, cover members or otherwise protect so as to cool the concrete slowly after release to prevent thermal shock and the evaporation of moisture in the members.

Transfer load to not cause cracks in members. Transfer load by gradual release of the strands as a group, by gradual release of part of the group, or by burning the fully tensioned strands at the ends of the members. If intending to release the strands by a method other than gradual release of the entire group, submit the proposed method and pattern of release, if not so shown in the plans, for approval by the Engineer. Rigidly follow the approved method and pattern of release. When the fully tensioned strands are burned, burn each strand or group of strands simultaneously at each end of the bed in its indicated order in the pattern and at each end of each member before proceeding to the strands in the next group in the pattern at any point. Because of the critical nature of the bond development length in prestressed concrete panel construction, if transferring of stress by burning the fully tensioned strands at the ends of the member, burn each strand first at the ends of the bed and then at each end of each member before proceeding to the next strand in the burning pattern.

When detensioning all girders, box beams, cored slabs, piles, and panels do not burn strands quickly but heat with a low oxygen flame played along the strand for at least 5 inches until the metal gradually loses its strength. Apply heat at such a rate that failure of the first wire in each strand does not occur until at least 5 seconds after heat is first applied. When detensioning other members, follow the above procedure unless an alternate procedure is approved by the Engineer. Detensioning by arc welder is not allowed.

Incorporate the following in the method for single strand detensioning of members having draped strands:

(A) Release the pair of straight strands located in the uppermost position in the lower flange first.

(B) Then release the tension in the draped strands at the ends and uplift points in accordance with an approved pattern.

(C) Disengage all hold-down devices for draped strands and release the hold-downs.

(D) Then release the pair of straight strands located in the upper flange.

(E) Release the remaining straight strands of the pattern in accordance with an approved sequence.

(F) Release all strands in a manner meeting the Engineer's approval that will cause a minimum shock and lateral eccentricity of loading.

Failure to follow the above procedures for transfer of load is ground for rejection of the members involved.

1078-13 VERTICAL CRACKS IN PRESTRESSED CONCRETE GIRDERS BEFORE DETENSIONING

This section addresses prestressed concrete members that have vertical casting cracks before strand detensioning. Certain types of these cracks have been determined by the Department to render the girders unacceptable.

Unacceptable cracked members are those with two or more vertical cracks spaced at a distance less than the member depth which extend into the bottom flange. Such members are not serviceable and will be rejected by the Engineer. Members with two or more vertical cracks spaced at a distance less than the member depth but do not extend into the bottom flange are subject to an engineering assessment. Such members may not be serviceable and may be rejected by the Engineer.

Members with one or more vertical cracks that extend into the bottom flange and are spaced at a distance greater than the member depth are subject to an engineering assessment to determine their acceptability. If this engineering assessment is required, submit, at no additional cost to the Department, a proposal for repairing the member and a structural evaluation of the member prepared by an engineer licensed by the State of North Carolina. In the structural evaluation, consider the stresses under full service loads had the member not cracked and the effects of localized loss of prestress at the crack as determined by methods acceptable to the Department.

All members, except those defined as unacceptable, which exhibit vertical cracks before detensioning, shall receive a 7 day water cure as directed by the Engineer. The water cure shall begin within 4 hours after detensioning the prestressing strands and shall be at least 3 feet beyond the region exhibiting vertical cracks.

The Department has the final determination regarding acceptability of any members in question.

1078-14 PRESTRESSED CONCRETE GIRDER WEB SPLITTING

After detensioning of certain girders with draped strands, cracks occasionally occur in the webs at the ends of the girders.

Repair all cracks located in the web of girders appearing after detensioning that are 0.010 inches (0.25 mm) or greater in width by means of epoxy injection in accordance with the Standard Specifications and as approved by the Engineer.

Repair any web cracks that are less than 0.010 inches (0.25 mm) and greater than 0.005 inches (0.15 mm) in width by coating them with an approved clear, water based alkylalkoxysilane (silane) penetrating sealant having 100% solids. Use a sealant that meets the requirement of NCHRP 244 and Federal AIM VOC emissions standards and has been approved by the Engineer. Coat web cracks between 0.005 inches (0.15 mm) and 0.010 inches (0.25 mm) in width with silane within 2 weeks after they appear or before shipment to the site whichever occurs soonest.

Cracks located in the web less than or equal to 0.005 (0.15 mm) in width need not be coated.

Do not repair or coat any cracks without prior approval of the Engineer. No separate payment will be made for the treatment of cracks, as payment is included in the contract unit price bid for prestressed concrete girders..

1078-15 HANDLING, TRANSPORTING AND STORING

Members damaged while being handled or transported are rejected or require repair in a manner approved by the Engineer. All members are allowed to be handled immediately after transfer of load from the anchorages to the members is complete.

Store all prestressed members on solid, unyielding, storage blocks in a manner to prevent torsion or objectionable bending. In handling prestressed concrete girders 54 inches or less in height, including cored slabs and box beams, maintain them in an upright position at all times and pick them up within 5 feet of the points of bearing and transport and store supported only

within 3 feet of points of bearing. In handling prestressed concrete girders greater than 54 inches in height, maintain them in an upright position at all times and submit for approval the proposed method of lifting, transporting, and storing the girders. When requested, provide calculations to confirm girders are not overstressed by such operations.

Prestressed concrete panels are weak in the direction perpendicular to the prestressing strands; therefore, they are subject to breakage during handling, storing or transporting. Provide adequate blocking during all of these construction phases.

In handling, transporting, and storing prestressed members, use the number and location of supports in accordance with the plan requirements for the sizes, lengths and types of members involved, or as approved by the Engineer.

When handling the prestressed concrete members, a temporary stress of $5\sqrt{f_{ci}}$ is permitted, where f_{ci} is the strength of concrete at release, in pounds per square inch.

Do not transport members away from the casting yard until the concrete reaches the minimum required 28 day compressive strength and a period of at least 5 days elapses since casting, unless otherwise permitted.

Do not transport any member from the plant to the job site before approval of that member by the plant inspector. Such approval will be indicated by the compliance with the Department's RFID tag/label tagging policy in accordance with Section 1030 and verified product approval as noted by an authorized Field Inspection Report (FIR) or NCDOT alternate ID.

1078-16 FINAL FINISH

Finish prestressed concrete members that are intended for composite action with subsequently placed concrete or asphalt with a roughened surface for bonding. Make sure that no laitance remains on the surfaces to be bonded.

Rough float the tops of girders with the exception of the centerline and outside 4 inches of each girder which shall receive a smooth finish. Broom finish the top surface of the cored slab and box beam sections receiving an asphalt overlay. Rake the top surface of cored slab and box beam sections receiving a concrete overlay to a depth of 1/4 inch. No surface finish is required for sides and bottom of the slab and beam sections except the exposed side of the exterior unit as noted below. Provide a resulting surface finish essentially the same color and surface finish as the surrounding concrete.

Provide a 3/4 inch chamfer along the bottom edges on ends and sides of all box beam and cored slab sections, top outside edges of exterior sections and acute corners of sections. Round the top edges on ends of all sections with a 1/4 inch finishing tool. Provide square corners along top edges on all sections along shear keys. Do not chamfer vertical edges at ends of sections.

Fill all voids in the diagonal/curved face of the bottom flange of prestressed concrete girders and the outside face of exterior cored slabs and box beams with a sand-cement or other approved grout. Fill all voids in piles greater than 1/2 inch in diameter or depth as above. Provide a resulting surface finish essentially the same color and surface finish as the surrounding concrete. Repair voids greater than 1/4 inch in diameter or depth in other faces of these and other members except piles in a like manner. Where an excessive number of smaller voids exist in any member, the Engineer requires a similar repair.

Repair honeycomb, excessively large fins, and other projections as directed by the Engineer. Submit, at no additional cost to the Department, a proposal for repairing members with honeycomb, cracks or spalls. Do not repair members containing honeycomb, cracks, or spalls until a repair procedure is approved and the member is inspected by the Engineer. Any appreciable impairment of structural adequacy that cannot be repaired to the satisfaction of the Engineer is cause for rejection.

Clean and fill holes caused by strand hold downs upon removal from the casting bed. Use an approved material for patching that is listed on the NCDOT APL. Ensure that members are clean and surfaces have a uniform appearance.

Give the top surface of prestressed concrete panels a raked finish or other approved finish to provide an adequate bond with the cast-in-place concrete. As soon as the condition of the concrete permits, rake the top surface of the concrete making depressions of approximately 1/4 inch. Take care when raking not to catch and pull the coarse aggregate.

Clean reinforcing bars exposed on the tops of girders and exterior cored slabs or box beams of mortar build up and excessive rust.

Apply epoxy protective coating to the ends of prestressed members as noted in the plans.

1078-17 ALIGNMENT AND DIMENSIONAL TOLERANCES

(A) Piles

Manufacture piles within the tolerances indicated in Table 1078-2 and Figure 1078-1.

(B) Cored Slabs

To ensure a good, neat field fit, assemble cored slab spans in the yard and have pieces matchmarked. Ensure that pieces fit together neatly and in a workmanlike manner.

Manufacture cored slabs within the tolerances indicated in Table 1078-3 and Figure 1078-2.

(C) Girders

Manufacture girders within the tolerances indicated in Table 1078-4 and Figure 1078-3.

(D) Prestressed Concrete Panels

Manufacture prestressed concrete panels within the tolerances indicated in Table 1078-5.

(E) Box Beams

To ensure a good, neat field fit, assemble box beam spans in the yard and have pieces match-marked. Ensure that pieces fit together neatly and in a competent manner.

Manufacture box beams within the tolerances indicated in Table 1078-6 and Figure 1078-4.

1078-18 IDENTIFICATION OF MEMBERS

Permanently identify each prestressed member by number and date of manufacture, and paint this information, or otherwise mark as approved by the Engineer, on at least one end of the member as soon as practical after manufacture. In the case of girders or cored slabs, paint other identification as to station, span and position within the span on at least one end of the member. All members shall additionally be identified by the use of an RFID tag/label embedded into the member in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F).

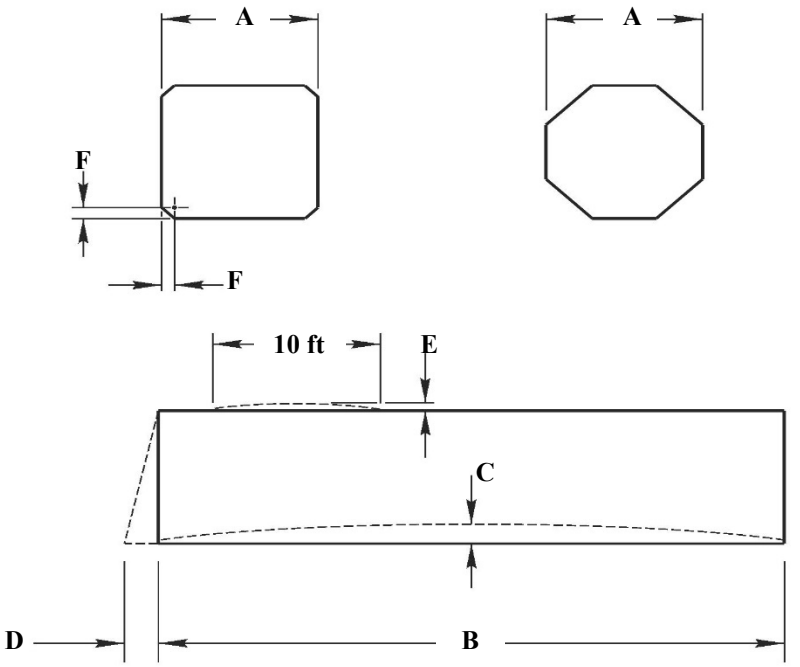
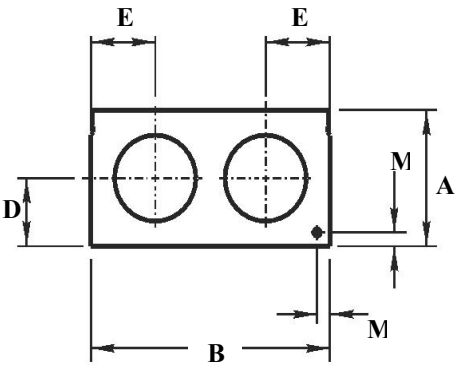
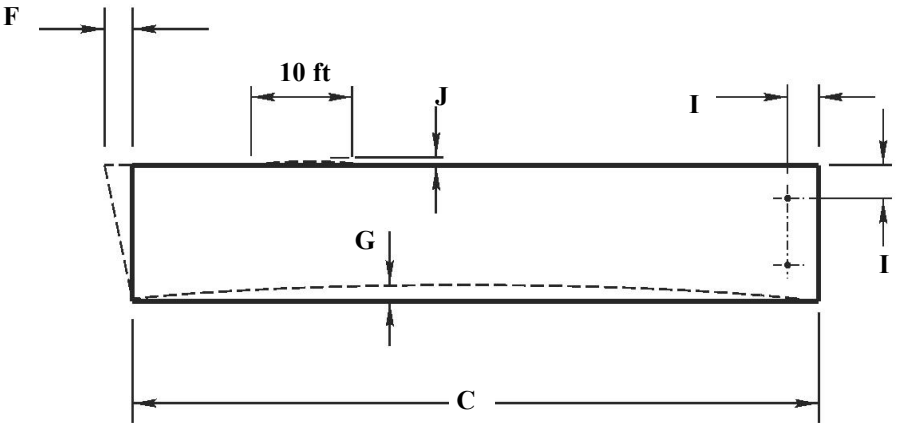


Figure 1078-1. Prestressed Piles. Dimensions shown are in Table 1078-2.

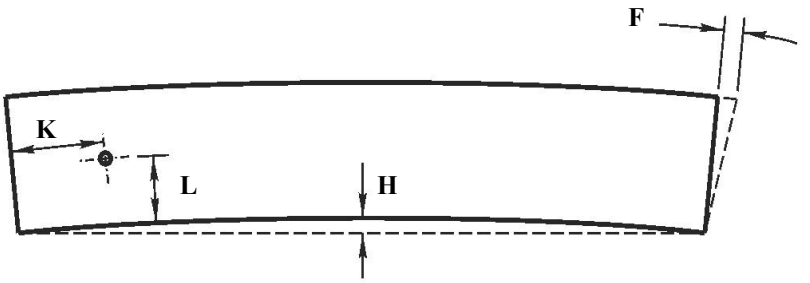
TABLE 1078-2 TOLERANCES FOR PRESTRESSED PILES (Refer to Figure 1078-1)	
Dimension	**Tolerance**
Width (A)	-1/4" to +3/8"
Length (B)	± 1 1/2"
Horizontal alignment Deviation from a straight line parallel to the centerline of pile (C)	1/8" per 10 ft
Squareness of ends (D)	1/8" per 12" of width, 3/16" max.
Local smoothness (E)	1/4" in 10 ft
Position of strands (F)	1/4"
Position of mild reinforcing steel, including spiral pitch	1/2"



SECTION



PLAN



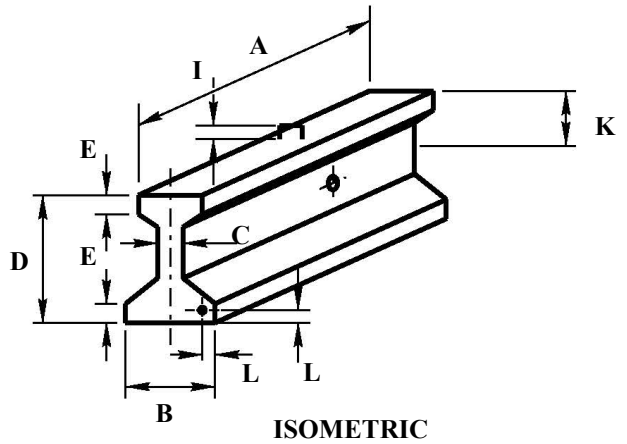
ELEVATION

1 **Figure 1078-2. Prestressed cored slabs.** Dimensions shown are in Table 1078-3.

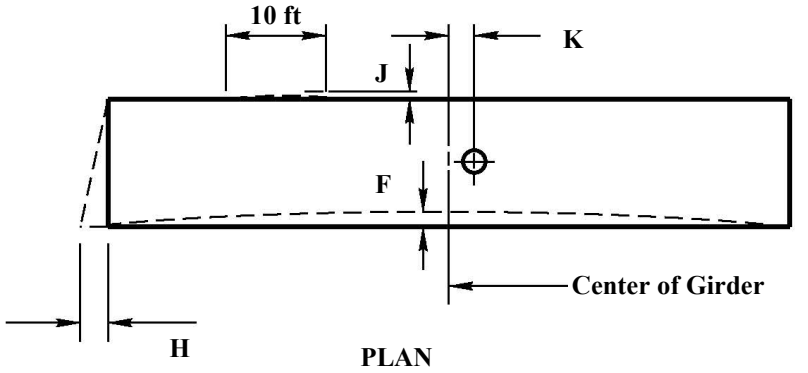
TABLE 1078-3 TOLERANCES FOR PRESTRESSED CORED SLABS (Refer to Figure 1078-2)	
Dimension	**Tolerance**
Depth (A)	+3/8" to -1/8"
Width (B)	± 1/4"
Length (C)	± 1/8" per 10 ft
Position of voids - Vertical (D)	± 3/8"
Position of voids - Horizontal (E)	± 3/8"
Position of void Ends – Longitudinal	+1", -3"
Square ends - Deviation from square (horizontal)or vertical) or designated skew (F)	±1/4"
Horizontal alignment - Deviation from a straight line parallel to the centerline of member (G)	0-30 ft long: 1/4" 30-50 ft long: 3/8" 50+ ft long: 1/2"
Camber - Differential between adjacent units (H)	1/4" per 10 ft, 3/4" max.
Camber - Differential between high and low members of same span (H)	3/4" max.
Position of dowel holes - Deviation from plan position (I)	1/4"
Width - Any one span	Plan width +1/8" per joint
Width - Differential of adjacent spans in the same structure	1/2"
Bearing area - Deviation from plane surface	1/16"
Local smoothness (J)	1/4" in 10 ft
Position of holes for transverse strands	Horizontal (K): ±1/2" Vertical (L): ±3/8"
Position of strands (M)	± 1/4"

1078-19 QUALITY CONTROL

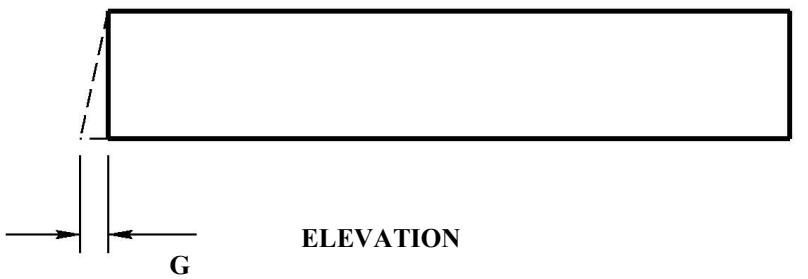
Maintain a daily quality control record form approved by the Engineer including pertinent information concerning tensioning, concrete quality and placement, curing and detensioning. Have this form signed and dated by a certified concrete technician. Furnish a copy of the completed or up-to-date form to the Materials and Tests Unit upon request and before any members are approved. A sample form, indicating the minimum required information, is available from the Materials and Tests Unit.



ISOMETRIC



PLAN



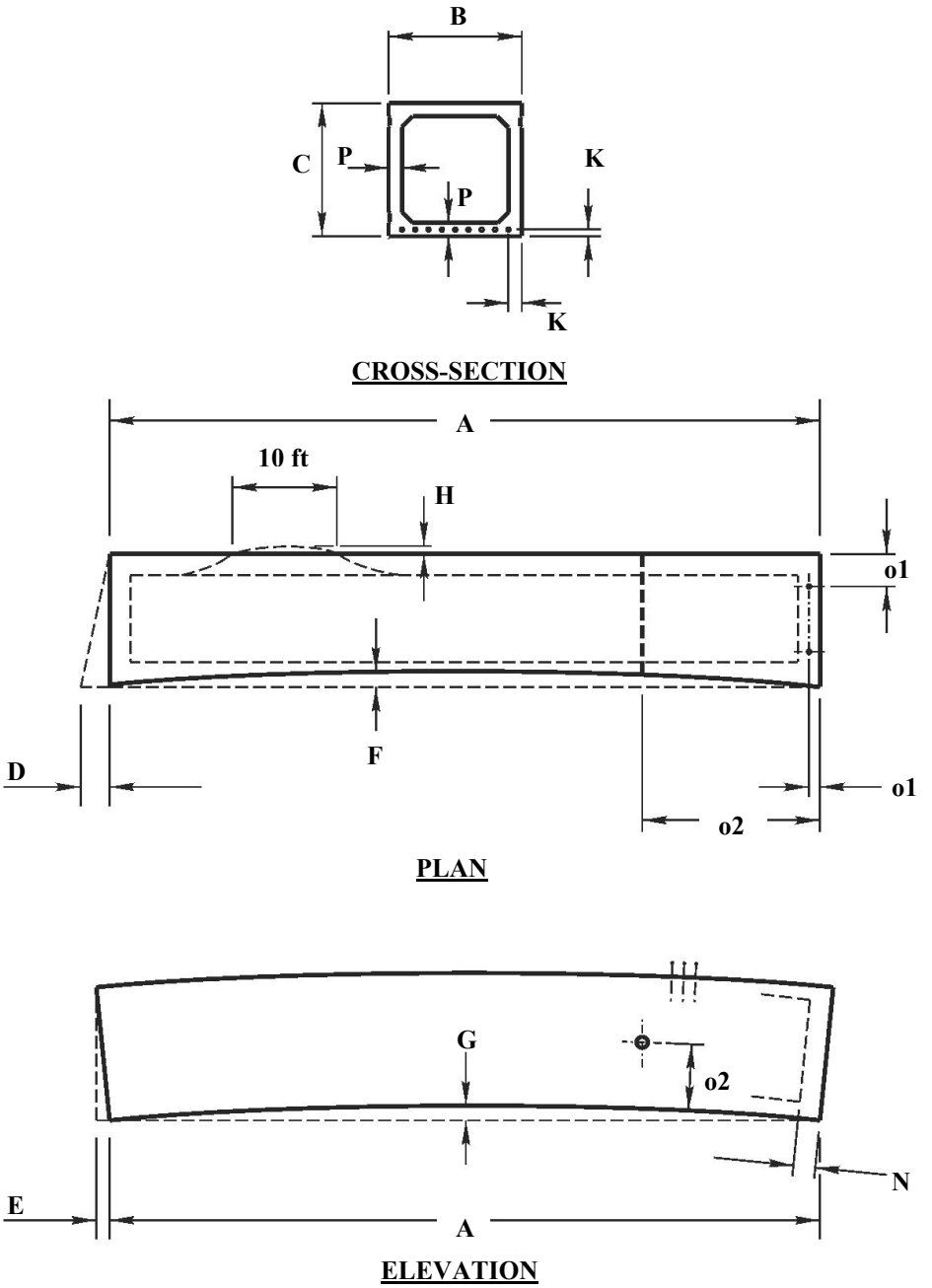
ELEVATION

1 **Figure 1078-3. Prestressed Girders.** Dimensions shown are in Table 1078-4.

TABLE 1078-4 TOLERANCES FOR PRESTRESSED GIRDERS (Refer to Figure 1078-3)	
Dimension	**Tolerance**
Length (A) Girders 80 ft. or shorter	± 1/8" per 10 ft
Length (A) Girders longer than 80 ft.	± 1/8" per 10 ft Not to exceed 1 1/2"
Width - Flanges(B)	+3/8" to -1/8"
Width - Web (C)	+3/8" to -1/8"
Depth - Overall (D)	+1/2" to -1/4"
Depth - Flanges (E)	± 1/4"
Horizontal alignment (top or bottom flange) Deviation from a straight line parallel to the centerline of beam (F)	± 1/8" per 10 ft Not to exceed 1.5"
Bearing plate Deviation from plane surface	1/16"
Girder ends Deviation from square or designated skew (G and H)	Vertical (G): ± 1/8" per 12" of girder height Horizontal (H): ± 1/2"
Position of stirrups - Projection above top of girder (I)	± 1/2"
Position of stirrups – Placement along girder length	± 1"
Local smoothness of any surface (J)	1/4" in 10 ft
Position of holes for diaphragm bolts (K)	± 1/4"
Position of strands (L)	± 1/4"

Dimensions followed by an alphabetical suffix are shown in Figure 1078-3. The length (A) is measured along the top of the top flange. The tolerances at girder ends (G and H) are increased to 1 inch if the girder end is to be encased in a full depth concrete diaphragm.

TABLE 1078-5 TOLERANCES FOR PRESTRESSED CONCRETE PANELS	
Dimension	**Tolerance**
Length (Transverse direction to girders)	-1/4" to +1/2"
Width (Longitudinal direction to girders)	-1/8" to +1/4"
Depth	0 to +3/8"
Position of Strand Horizontal Dimension Vertical Dimension	 ± 1/4" ± 1/4"



1 **Figure 1078-4. Prestressed Box Beams.** Dimensions shown are in Table 1078-6.

TABLE 1078-6 TOLERANCES FOR BOX BEAMS (Refer to Figure 1078-4)	
Dimension	**Tolerance**
Length (A)	± 1"
Width (overall) (B)	± 1/4"
Depth (overall) (C)	+ 1/4"
Variation from specified plan end squareness or skew (D)	± 1/8" per 12" width, ± 1/2" max
Variation from specified elevation end squareness or skew (E)	± 1/8" per 12", ± 1/2" max
Sweep, for member length (F) up to 40 ft	± 1/4"
Sweep, for member length (F) 40 to 60 ft	± 3/8"
Sweep, for member length (F) greater than 60 ft	± 1/2"
Differential camber between adjacent members (G):	1/4" per 10 ft., 3/4" max
Local smoothness of any surface (H)	1/4" in 10 ft
Position of strands (K)	± 1/4"
Longitudinal Position of blockout (N)	± 1"
Position of dowel holes (o1)	± 1/4"
Position of sleeves cast in beams, in both horizontal and vertical plane (o2)	± 1/2"
Position of void (P)	± 3/8"
Bearing area – deviation from plane surface	± 1/16"
Width - Any one span	Plan width + 1/8" per joint
Width – Differential of adjacent spans in the same structure	1/2"

SECTION 1079
BEARINGS AND BEARING MATERIALS

1079-1 PREFORMED BEARING PADS

Provide preformed bearing pads composed of multiple layers of 8 oz/sy cotton duck impregnated and bound with high quality natural rubber, or equally suitable materials approved by the Engineer, that are compressed into pads of uniform thickness. Ensure that the thickness of the preformed bearing pads is 3/16 inch with a tolerance of ± 1/16 inch. Use cotton duck that meets Military Specification MIL-C-882-E for 8 oz/sy cotton army duck or equivalent. Provide enough pads as to produce the required thickness after compressing and vulcanizing. Ensure that the finished pads withstand compressive loads perpendicular to the plane of the laminations of not less than 10,000 psi without detrimental extrusion or reduction in thickness.

Furnish a Type 3 certification in accordance with Article 106-3 certifying that the preformed bearing pads meet this specification.

1079-2 ELASTOMERIC BEARINGS

(A) General

Provide elastomeric bearings that meet the requirements of AASHTO M251, except as specified herein.

Use elastomeric bearings provided by a NCDOT approved as found on the Department's producer/supplier list. All producer/suppliers must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT producer/supplier list. Submit working drawings and manufacturing procedures for approval by the Engineer. Refer to Subarticles 1079-2(D). Furnish a Type 3 certification in accordance with Article 106-3 certifying that elastomeric bearings satisfy this *Standard*

Specification and all design criteria. Include the lot number, description and test results in the certification.

Internal holding pins are required for all shim plates when the contract plans indicate the structure contains the necessary corrosion protection for a corrosive site.

Repair laminated (reinforced) bearing pads utilizing external holding pins via vulcanization. Submit product data for repair material and a detailed application procedure to the Materials and Tests Unit for approval before use and annually thereafter.

(B) Elastomer Properties

The elastomer for all bearings shall be classified as Grade 3.

The shear modulus of the elastomer for laminated (reinforced) bearings shall be 160 psi, unless otherwise noted in the plans.

Provide Grade 50 or Grade 60 durometer hardness elastomer in all (unreinforced) bearings, unless otherwise noted in the plans.

(C) Testing

The optional test procedures of AASHTO M 251 are not required, except as specified herein.

Determine the shear modulus of the elastomer for laminated (reinforced) bearings in accordance with ASTM D4014.

At the Manufacturer's option, plain (unreinforced) bearings may be tested using the methods of Appendices X1 and X2 of AASHTO M 251.

Test at least two bearings per lot or as directed by the Engineer. Define a “lot” as a group of 100 or less bearings with or without holes or slots, which are:

(1) Manufactured in a reasonably continuous manner from the same batch of elastomer and cured under the same conditions, and

(2) Of the same type (plain or laminated) and of similar size (no dimensions shall vary by more than 40%).

A lot may include bearings from multiple projects and purchasers.

(D) Working Drawings

Submit a set of detailed fabrication drawings and procedures of laminated (reinforced) bearings to the Engineer for review, comments and acceptance. Show complete details and all material specifications. Clearly identify any proposed deviations from details shown in the plans or requirements of the *Standard Specifications*. Obtain drawing approval before manufacturing of the bearings.

SECTION 1080
PAINT AND PAINT MATERIALS

1080-1 GENERAL

All batches or lots of paint products shall be Department approved prior to use by the Materials and Tests Unit. Self-curing inorganic zinc paint shall also be pre-qualified as required in Article 1080-5. Deliver all Department approved paints to the point of application in sealed and original containers clearly marked with the type of paint and batch or lot numbers clearly labeled on the container. At the point of application all paints shall arrive ready to be mixed for use without additional oil or thinner. Mix all paints in accordance with the manufacturer’s printed instructions. All paints or paint components that harden or curdle in the container and will not break up with a paddle to form a smooth, uniform consistency will be rejected by the Engineer. Any thinning necessitated by weather conditions shall be approved in writing and

use only those thinners approved by the manufacturer. Thinning of any waterborne paints shall be prohibited. Upon receipt at the point of application, store all paint materials in a moisture free environment between 40°F and 110°F or at such temperatures within this range recommended by the manufacturer of which the more stringent shall apply. The storage areas shall be equipped with a device capable of recording daily high and low temperatures.

1080-2 PAINT VEHICLES, THINNERS AND DRYERS

Paint vehicles, thinners and dryers shall meet the requirements for these ingredients that are included in the *Standard Specifications* for the paint being used. Only ingredients recommended by the manufacturer which have a history of compatibility with each other and so recorded on the manufacturer product data sheet may be used.

1080-3 PACKING AND MARKING

Ship paint and paint materials in strong, substantial containers that are properly labeled and plainly marked with the weight, color and volume in gallons of the paint content; a true statement of the percentage composition of the pigment; the proportions of pigment to vehicle; and the name and address of the manufacturer. Any package or container not so marked as described above or exceeding 5 gallons total volume shall require prior approval by the Department.

1080-4 INSPECTION AND SAMPLING

All paint components shall be sampled and approved by the Department's Material and Tests Unit, either at the point of manufacture or at the point of application. Inspection and sampling will be performed at the point of manufacture wherever possible. The Contractor shall not begin painting until the analysis of the paint has been performed, and the paint has been accepted by the Department. When sampling paint products, use the Department sampling procedure. In order for materials to be evaluated and accepted by the Department, coating manufacturers shall submit completed performance test data from the AASHTO Product Evaluation & Audit Solutions or test results from ISO certified laboratories reporting requirements as required for each paint listed in Articles 1080-5 through 1080-10.

1080-5 SELF-CURING INORGANIC ZINC PAINT

Use only Department approved and qualified inorganic zinc paint. These products shall be requalified every five years unless the formulation of the product or manufacturing process is changed, in which case, the product shall be requalified before use. Samples for qualification shall be submitted to the State Materials Engineer six months in advance along with the following:

(A) A minimum one quart sample of each component of paint including the manufacturer's name, location, product name, mixing instructions, batch number and SDS.

(B) At least three panels prepared as specified in AASHTO M 300, Bullet Hole Immersion Test.

(C) At least six panels of 4 inch x 6 inch x 1/4 inch for the MEK Rub test, ASTM D4752 and the Adhesion Pull Test, ASTM D4541.

For new qualifications or where product formulation has changed provide the Department the following.

(A) A certified test report from an approved independent testing laboratory that the product has been tested for slip coefficient and meets AASHTO M 300, Class B.

(B) A certified test report from an approved independent test laboratory for the Salt Fog Resistance Test, Cyclic Weathering Resistance Test, and Bullet Hole Immersion Test as specified in AASHTO M 300.

Use the same batch of paint for all samples and panels. The independent test laboratory report may be for a typical batch of the same product. Submit samples and reports for qualification at least six months in advance of anticipated need. The Materials and Tests Unit will conduct all tests of paints in accordance with ASTM, Federal Test Method Standard No. 141 and various other methods in use.

Use a self-curing inorganic zinc paint meeting the Type I Inorganic Zinc Primer paint specified in AASHTO M 300 and the following:

(A) Use mixed paint with zinc content of not less than 72% by mass of the total solids.

(B) The slip coefficient meets AASHTO M 300, Class B.

(C) The adhesion shall be no less than 400 psi in accordance with ASTM D4541.

(D) Cure the paint to meet the solvent rub requirements in ASTM D4752.

(E) Formulate the paint to produce a distinct contrast in color with the blast cleaned metal surfaces and with the finish paint.

1080-6 COAL TAR EPOXY PAINT

Use coal tar epoxy paint meeting SSPC-Paint 16.

1080-7 ORGANIC-ZINC REPAIR PAINT

Use organic-zinc repair paint meeting SSPC-Paint 20 Type II or Federal Specification TT-P-641. Organic-zinc repair paint is not tinted and is applied 3 to 4 wet mils of paint per coat. Do not use zinc paint in aerosol spray cans. Use organic-zinc repair paint that is listed on the NCDOT APL.

1080-8 METALLIZATION SEALERS

Use low-viscosity, clear or colored and pigmented as approved by the Engineer. Sealer products are formulated to flow over and be absorbed into the natural pores of the thermal sprayed coating (TSC). The pigment particle size for colored sealer must be small enough to flow easily into the pore of the TSC, nominally a 5-fineness of grind per ASTM D1210.

1080-9 WATERBORNE PAINTS

Paint manufacturers must have a Department approved and qualified self-curing inorganic zinc product to submit a waterborne paint product for approval.

(A) Composition

Use ingredients and proportions as specified in Tables 1080-1 through 1080-3. Do not use Chrome Green.

Provide raw materials based on the specified ingredients that are uniform, stable in storage, and free from grit and coarse particles. Do not use rosin or rosin derivatives. Beneficial additives such as anti-skinning agents, suspending agents or wetting aids are allowed.

(B) Properties

(1) General

Use both Type I and II paints that meet Tables 1080-1 through 1080-3.

(2) Odor

Normal for the materials permitted in accordance with ASTM D1296.

(3) Color

The colors before and after weathering when compared with AMS-STD-595 are Brown #30045, Green #24108 and Gray #26622. There are no color requirements for white waterborne paint. The Engineer may approve the use of semi-gloss or gloss products for the above Department colors.

(4) Working Properties

Use a paint that is easily applied by brush, roller or spray when tested in accordance with Federal Test Method Standard No. 141, Methods 4321, 4331 and 4541. Ensure that the paint shows no streaking, running or sagging during application or while drying.

(5) Storage Conditions

Prior to application, ensure that the paint shows no thickening, curdling, gelling or hard caking when tested as specified in Federal Test Method Standard No. 141, Method 3011, after storage for 6 months from the date of delivery, in a full, tightly covered container, at a temperature of 50°F to 110°F.

(6) Skinning

No skinning is allowed in a 3-quarters filled closed container after 48 hours when tested in the standard manner specified in Federal Test Method Standard No. 141, Method 3021.

(7) Salt Contamination

Minimize the content of salt contamination by the incorporation of only high purity materials. Ensure that the specific resistance of the aqueous leachate of the composite of the pigments in required proportions is at least 5,000 ohm-cm when tested in accordance with ASTM D2448.

(8) Early Rust Resistance

Provide each type of paint that meets the early rust requirements specified in *Structural Steel Shop Coatings Program* Section 7.

(C) Inspection

All materials supplied under this Specification are subject to random inspection by the Department.

Supply samples of any or all ingredients used in the manufacture of this paint, along with the supplier's name and identification for the material when requested.

(D) Volatile Organic Compound (VOC) Content

Ensure that the VOC content after formulation, but before thinning, complies with the VOC limit for the applicable coatings category per Federal regulations. Notify the coating specifier if State or local regulations reduce the maximum VOC content permitted for coatings applied in a specific locality.

(E) Color Variation

A color variation of 5 Δe units from the specified color will be acceptable. After 3 months weathering, the color shall not vary more than 5 Δe units from the original color value.

Table 1080-1
Composition of Pigments for Waterborne Paints, % By Weight

Property	Brown		White		Gray		Test Method
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Pigment Content	20%	25%	35%	40%	13%	17%	ASTM D3723
Major Pigments							
Calcium Carbonate	-	-	30%	-	-	-	ASTM D1199
Magnesium Silicate	-	-	-	12%	-	-	ASTM D605
Titanium Dioxide	-	-	45%	-	70%	-	ASTM D476, Type II
Zinc Phosphate	10%	-	10%	-	10%	-	ASTM D6280
Iron Oxide	45%	-	-	-	-	-	ASTM D3721
Tinting Pigments							
Lamp Black	-	-	2%	-	-	-	ASTM D209
Phthalocyanine Pigments	-	-	-	2%	-	-	ASTM D1135 & D3256
Acid Soluble Pigments [A]	-	-	-	0	-	0	-
Lead	-	0.005%	-	0.005%	-	0.005%	-
Volatiles	-	2.0 lb/gal	-	2.0 lb/gal	-	2.0 lb/gal	ASTM D2369
Coarse Particles and Skins, as Retained on Std. 325 Mesh Screen	-	0.5%	-	0.5%	-	0.5%	ASTM D185
Rosin or Rosin Derivatives	-	0	-	0	-	0	-

A. Use a 5% acetic acid solution with a pH 4 + 2 to determine solubility.

Table 1080-2
Composition of Vehicle for Waterborne Paints, % By Weight

Property	Brown		White		Gray		Test Method
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
HG-56 [A] Solids	30%	-	30%	-	30%	-	
Water	-	55%	-	55%	-	58%	
Methyl Carbitol	5%	-	5%	-	5%	-	
Texanol	2%	-	2%	-	4%	-	

A. Or approved equivalent

Table 1080-3
Properties of Waterborne Paints, % By Weight

Property	Brown		White		Gray		Test Method
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Consistency [A] Sheer Rate 200 rpm, Ounces	255	350	255	350	255	350	ASTM D562
Consistency [A] Sheer Rate 200 rpm,	3.2	3.5	3.2	3.5	90	100	ASTM D562
Density, lb./US gallon	9.7	-	11.0	-	9.35	-	ASTM D1475
Fineness of Grind, Hegman Units	5.0	-	5.0	-	5.0	-	ASTM D1210
Drying Time, Hours, Tack Free	-	3	-	3	-	3	ASTM D1640
Drying Time, Hours, Dry Hard	-	24	-	24	-	24	ASTM D1640
Flash Point, F (degrees)	Report Value	Report Value	Report Value	Report Value	Report Value	Report Value	ASTM D3278
Early Rust	9	-	9	-	9	-	*Structural Steel Shop Coatings Program*
Leneta Sag Test	10+	-	10+	-	10+	-	ASTM D4400
Gloss, Specular @ 60 degrees	Report Value	Report Value	Report Value	Report Value	40	-	ASTM D523
pH	8.0	9.0	8.0	9.0	8.0	9.0	ASTM E70
Adhesion [B]	4B	-	4B	-	4B	-	ASTM D3359
Color, AMS-STD-595	30045	-	-	-	26622	-	ASTM D2244

A. Consistency 48 hours or more after manufacture.
B. Prepare the specimen for adhesion by applying 2 dry mils of coating to a 3 inch X 5 inch X 0.25 steel panel cleaned to a minimum SSPC-SP 6 finish with a 1.7 +0.5 mil profile.

1080-10 WATERPROOFING EPOXY

Waterproofing epoxy coating systems are intended for protecting concrete exposed to splash zones and tidal water. Use 100% solids epoxy coatings that adhere to concrete, wood, steel, and other structural materials. Multi-coat systems shall utilize a red primer coat with a gray topcoat to provide visual aid in ensuring adequate coverage during application. Use waterproofing epoxy systems found on the NCDOT APL. Waterproofing epoxy coating materials, which includes primer and topcoat, shall meet the following criteria in Table 1080-4.

TABLE 1080-4
WATERPROOFING EPOXY PROPERTIES

Property	Values	Test Method
Absorption, 24 hr, max. (%)	0.5%	ASTM D570
Bond Strength, 14 days, min.	1500 psi	ASTM C882
Tensile Strength, 7 days, min.	2000 psi	ASTM D638

1080-11 PAINT FOR VERTICAL MARKERS

For vertical markers, use a waterborne acrylic or alkyd type material meeting Table 1080-5. Apply sufficient paint to completely cover the color of the underlying substrate along with any surface imperfections.

TABLE 1080-5
PROPERTIES OF PAINT FOR VERTICAL MARKERS

Property	Requirement	Test Method
Color	# 27040 Black or # 13538	AMS-STD-595
Adhesion to Substrate	3A Min.	ASTM D3359

1080-12 EPOXY RESIN FOR REINFORCING STEEL

Submit epoxy resin powder products to the State Materials Engineer for approval. Epoxy resins shall meet ASTM A775 or ASTM A934 to qualify for use. A list of prequalified epoxy resin powder sources is available from the State Materials Engineer. Manufacturers of approved epoxy resin powder products shall submit a request for requalification every 5 years and any time a change is made in the manufacturing process, change is made to the chemical composition of the epoxy resin or a requalification is requested by the Engineer.

Use powdered resin of any color that provides contrast to the corroded or uncorroded surface of the steel. Provide material of the same quality as that used for prequalification tests and as represented by test reports forwarded to the State Materials Engineer.

Ensure the manufacturer of the epoxy resin supplies to the coating applier information on the resin that is essential to the proper use and performance of the resin as a coating. Ensure the manufacturer of the resin furnish the coating applier a written certification signed by a responsible officer of the company that the material furnished for coating the reinforced steel is the same formulation as that for which test reports were previously submitted to the State Materials Engineer.

With each batch of coating material, furnish a written certification by the coating applier to the Engineer which properly identifies the batch number, material, quantity represented, date of manufacture, name and address of manufacturer and includes a statement that the supplied coating material is the same composition as that prequalified.

1080-13 ABRASIVE MATERIALS FOR BLAST CLEANING STEEL

Select the gradation of the abrasive to impart the anchor profile specified.

(A) Mineral and Slag Abrasives

Use blasting abrasives with suitable steel or mineral abrasives containing no more than 100 ppm of any corrosive compound such as sulfate or chloride or 100 ppm of any EPA characteristic waste compound such as lead, chromium or arsenic. Mineral and slag abrasives as defined by SSPC AB-1 are not to be recycled without written permission from the Department. The end user of the abrasive (e.g. shop or contractor), shall provide the Department with the abrasive conformance testing certificate as required in SSPC AB-1 and perform field quality control testing immediately prior to use at the minimum frequency specified in SSPC AB-1.

(B) Ferrous Metallic Abrasives

Ferrous metallic abrasives are new and previously unused material. The end user (e.g. shop or contractor) of the abrasive shall provide the Department with the abrasive conformance testing certificate as required by SSPC AB-3 and perform the abrasive cleanliness testing and conductivity testing immediately prior to use when not recorded on the manufacturer's certification. The frequency for this testing is once per 55 gallon barrel of abrasive.

(C) Cleanliness of Recyclable Ferrous Metallic Abrasives

Shop facilities shall annually acquire a composite sample of their recycled abrasive (work mix) in the Department's Materials and Tests Unit presence. A composite sample is a mixture of individual samples taken from a minimum of three separate areas of the work mix. The composite sample is to be tested at an accredited laboratory and provide the Department with a TCLP analysis and sulfate and chloride testing. The shop shall provide annually, the Department with a notarized Type 3 certification certifying the plant location has not used their facilities or equipment for the removal of lead based coatings. Prior to starting work, field contractors recycled work mix used shall meet the requirements of SSPC AB-2 prior to first use for each Department project.

Shop and Field Contractors cleaned work mix shall meet the requirements of SSPC AB-2 and maintain the size and shape of the abrasive to impart the specified profile. The quality control inspector shall document and test the cleaned work mix prior to starting work once every 12 hours or once every work shift whichever period is shorter. Abrasive testing shall meet and be performed in accordance with SSPC AB-2, ASTM D4940, ASTM D7393, SSPC PA-17 and the contract.

Nonconforming work mix shall not be used, shall be removed from equipment and shall be disposed of in accordance with federal, state, and local regulations and project specification requirements. If non-compliant work mix is detected during continuous recycling following three failing testing attempts blasting and handling equipment shall be checked for residual contamination after removal of the contaminated media. Following cleaning, new compliant media should be fed through the equipment and shall be tested for compliance with requirements of SSPC-AB 2 before production work resumes.

1080-14 FIELD PERFORMANCE AND SERVICE

Do not use paint products inspected by the Engineer and found to exhibit poor performance in similar North Carolina environments. Poor performance is defined as any coating failing to meet ASTM D610, Grade 5, or having greater than 3% rusting or disbonding before attaining 5 years of service.

SECTION 1081
EPOXY AND ADHESIVES

1081-1 EPOXY RESIN ADHESIVE SYSTEMS

(A) General

This section addresses epoxy resin adhesive systems to be used for bonding hardened concrete, fresh concrete, or other materials to hardened concrete. The classification of these epoxy systems is consistent with ASTM C881, but is limited to epoxy Types I – V and Grades 1 – 3. Use epoxy resin adhesive systems found on the NCDOT APL.

(B) Classification

Epoxies are classified using a Type/Grade nomenclature (e.g. Type I, Gr. 1), where Type is defined by the application and determines performance requirements and Grade correlates to viscosity. Any combination of Type and Grade of epoxy listed below are permitted for evaluation and acceptance on the APL.

Types are defined as:

(1) Type I: Designed for non-load bearing applications as a neat epoxy or as a binder for epoxy mortar where hardened concrete or other materials are bonded to hardened concrete. This epoxy type is suitable for non-structural crack repairs where the epoxy is poured on the surface to penetrate cracks by gravity.

(2) Type II: Designed for non-load bearing applications as a neat epoxy to bond fresh concrete to hardened concrete.

(3) Type III: Designed for bonding aggregates to hardened concrete (e.g. for High Friction Surface Treatments (HFST)) or as a binder for mortar repairs of contact surfaces in traffic areas.

(4) Type IV: Designed for load bearing applications as a neat epoxy or as a binder for epoxy mortar where hardened concrete or other materials are bonded to hardened concrete. This application includes the installation of anchors, such as anchor bolts, dowel bars, threaded rods, rebar, and other fixtures in hardened concrete. This epoxy type also provides a high modulus that when combined with the desired viscosity, makes it suitable for pressure injection into concrete cracks.

(5) Type V: Designed for load bearing applications as a neat epoxy where fresh concrete is bonded to hardened concrete.

Grades are defined as:

(1) Grade 1: Low viscosity.

(2) Grade 2: Medium viscosity.

(3) Grade 3: Non-sagging gel.

Many epoxies meet the requirements of more than one Type classification due to the material satisfying the physical property and performance requirements of multiple type classes. When epoxies meet the requirements of more than one Type classification, the epoxy will be listed with each of the Types it qualifies for, such as Type I/II, Gr. 2.

(C) Requirements

Epoxies shall conform to the requirements shown in Table 1081-1 using the test methods described in Article 1081-3. Epoxy systems that appear on the NCDOT APL have been verified to meet the performance requirements shown in Table 1081-1. Further consideration of the installation requirements and environment is required when selecting an epoxy system for a particular application.

Type IV epoxy resin systems used for embedding anchors or other post-installed fixtures in hardened concrete shall be evaluated by the Contractor and verified by the manufacturer to ensure the pull-out strength of the anchor system in the proposed installed configuration provides a maximum of 125% of the yield load listed in the plans. "Anchor system" refers to the combined mechanical properties provided by the total assembly, which consists of the substrate material, the epoxy bonding material, and the anchor fixture, as a finished installation. Evaluation of the anchor system shall utilize a concrete compressive strength between 2,500 psi (minimum) and the design compressive strength of the concrete that the anchor will be installed in (maximum). The manufacturer of the selected Type IV epoxy system shall provide the Manufacturer's Printed Installation Instructions (MPII), as described in ASTM E488, including directions on hole preparation, sizing, spacing, minimum installation depth for the type of anchor to be installed and the pull-out strength obtained. The Manufacturer's MPII is accepted as certification that for the particular anchor grade, diameter and embedment depth specified, the anchor system will not fail by adhesive failure.

Field testing may be required for adhesively anchored fixtures.

List the properties of the adhesive on the container and include density, minimum and maximum temperature application, setting time, shelf life, pot life, shear strength and compressive strength.

(D) Properties of Epoxy Resin Systems

(1) All integral fillers, pigments and thixotropic agents shall be fine enough to not separate, settle or cause skinning during storage of the epoxy components. Do not use abrasive fillers such as alumina and silica flour. Do not use solvents. When mineral fillers are to be added during mixing, they shall be inert, readily dispersible and except for sand, have fineness such that 99% of the material will pass a No. 325 sieve.

(2) The coefficient of expansion of cured epoxy is 6 times greater than that of concrete. Therefore, to reduce spalling and peeling during temperature changes, avoid thick layers of pure epoxy. A 4:1 by weight sand-epoxy mortar has approximately the same coefficient of expansion as concrete.

(3) The shelf life of parts A and B shall be at least one year from the date of manufacture.

(4) Types I through V epoxy resin systems are moisture insensitive and can be applied on clean, dry or damp surfaces free of standing water.

TABLE 1081-1
PROPERTIES OF MIXED EPOXY RESIN SYSTEMS

Property	Epoxy Type				
	I	II	III	IV	IV
Viscosity (P)					
Grade 1, max	20	20	20	20	20
Grade 2, min	20	20	20	20	20
Grade 2, max	100	100	100	100	100
Consistency (in)					
Grade 3, max	1/4	1/4	1/4	1/4	1/4
Gel Time (min)	30[A]	30	15	30[A]	30
Bond Strength (psi)					
Hardened to Hardened Concrete:				1000	-
2 days (moist cure)	1000	-	-	1500	-
14 days (moist cure)	1500	-	1500[B]	-	1500
Fresh Concrete to Hardened Concrete:					
14 days	-	1500	-		
Absorption, 24 h, max, (%)	1	1	1	1	1
Thermal Compatibility	-	-	pass		
Compressive Yield Strength, min, 7 days (psi)	8000	5000	-	10000	8000
Tensile Strength, min, 7 days (psi)[C]	5000	2000	2500	7000	6000
Elongation, min, 7 days (%)[C]	1	1	30	1	1

A. Minimum gel time of 5 minutes is required when used with automated proportioning, mixing and dispensing equipment is used.

B. A bond strength minimum value of 250 psi, as determined by ASTM C1583, is acceptable in lieu of bond strength value obtained by ASTM C882.

C. Not required for Viscosity Grade 3 Systems.

(E) Test Methods for Epoxies

(1) Viscosity

Determine the viscosity of the mixture in accordance with ASTM D2556 and ASTM C881.

(2) Consistency

Determine the consistency of a Grade 3 epoxy in accordance with ASTM C881.

(3) Gel Time

Determine the gel time of the mixture in accordance with ASTM C881.

(4) Bond Strength

Determine the bond strength in accordance with ASTM C882.

(5) Absorption

Determine the absorption in accordance with ASTM D570.

(6) Thermal Compatibility

Determine the thermal compatibility in accordance with ASTM C884.

(7) Compressive Yield Strength and Compressive Modulus

Determine the compressive yield strength in accordance with ASTM D695.

(8) Tensile Strength and Tensile Elongation

Determine the tensile strength and tensile elongation of the mixture in accordance with ASTM D638. Tensile strength and tensile elongation are also required for Grade 3 consistency epoxies though not required by ASTM C881.

(F) Prequalification

All epoxy resin systems shall be on the NCDOT Approved Products List before use. Manufacturers choosing to supply material for Department jobs must submit an application through the Product Evaluation Program with the following information for each type and brand name:

(1) Contact information, including name, address and telephone number of the manufacturer,

(2) Brand/Trade name of the material,

(3) Type of the material in accordance with Article 1081-1 and 1081-4,

(4) Technical data sheet stating at a minimum product description, yield, technical information, mixing directions, finishing directions, curing, clean-up and precautions/limitations,

(5) Safety Data Sheets,

(6) Certified test data published through participation in the AASHTO Product Evaluation & Audit Solutions program showing the product meets the specifications of Table 1081-1.

Products will remain on the NCDOT APL as long as the formulation and manufacturing process remain unchanged, and the product performs as intended in the field.

(G) Acceptance

When materials on the NCDOT APL are furnished to a project, submit to the Engineer a Type 3 material certification in accordance with Article 106-3 for each lot or batch delivered.

When materials are furnished to the Bridge Maintenance Unit, the terms of acceptance will be listed in the bid solicitation. The Engineer reserves the right to reject any epoxy that does not perform adequately in the field.

(H) Supply

Supply epoxy resin in two components, labeled as “Component A - Contains Epoxy Resin” and “Component B - Contains Curing Agent”, for combining immediately before use in accordance with the manufacturer’s instructions. Mark each container with the manufacturer’s name, NCDOT type, lot or batch number, quantity, date of manufacture, shelf life or expiration date, color, mixing instructions, usable temperature range and hazards or safety precautions.

Furnish the two components in separate non-reactive containers. Provide containers of such size that the proportions of the final mix can be obtained by combining a single container of one component with one or more whole containers of the other component.

(I) Notes on Use of Epoxies

(1) Safety

Epoxies can irritate the eyes, skin and respiratory tract. Therefore, wear chemical splash goggles, chemically-resistant gloves and protective clothing and boots when

handling epoxies. Respiratory protection is usually not needed if epoxies are mixed and applied in well-ventilated areas, but avoid prolonged breathing of vapors. Follow all SDS instructions for proper use of these materials.

(2) Mixing

Stir parts A and B individually until each component is homogeneous. Use a separate stirrer for each component.

Combine parts A and B, either by weight or volume, as specified in the manufacturer's instructions. Stir the mixture vigorously, periodically scraping the sides and bottom of the container. Small quantities of epoxy usually require 2 to 3 minutes to mix homogeneously; 5-gallon quantities can take up to 10 minutes of mixing.

Temperature affects the viscosity and pot life of epoxies. Most laboratory tests are conducted at 77°F. Higher temperatures render epoxies thinner and faster setting; lower temperatures induce higher viscosities and longer pot lives.

Add sand or other fillers to liquid epoxies only after parts A and B have been thoroughly mixed. Stir in the sand or filler until all particles are completely coated.

(3) Storage and Substrate Temperature

Store epoxies at temperatures between 50°F and 90°F. Epoxy components exposed to the extremes of this range or outside this range should be conditioned to 77°F before mixing and blending. If heat is necessary, always use indirect methods such as hot water or a heated room to condition components.

The Epoxy Class, either A, B, or C as defined by ASTM C881, shall be used as a design basis when procuring epoxy for installation. Epoxy Classes define the epoxy performance across a range of substrate temperatures when the epoxy system is applied. For example, Class A epoxies, which are designed for applications below 40°F, will have viscosity and gel time values consistent with those shown in Table 1081-1 when applied to materials at temperatures below 40°F. Using the same material at 70°F could result in much shorter gel times and altered viscosity.

Seal previously opened containers to be airtight. Unsealed containers can absorb moisture from the atmosphere, which can alter the chemical reaction of the mixture.

1081-2 POLYESTER RESIN ADHESIVE

(A) General

Polyester resin is used specifically for embedding dowel bars, threaded rods, rebars and other fixtures in hardened concrete.

Polyester resin adhesive systems shall be evaluated by the Contractor and verified by the manufacturer to ensure the pull-out strength of the anchor system in the proposed installation configuration provides a minimum of 125% of the yield load listed in the Plan. "Anchor system" refers to the combined mechanical properties provided by the total assembly, which consists of the substrate material, the epoxy bonding material, and the anchor fixture, as a finished installation. Evaluation of the anchor system shall utilize a concrete compressive strength between 2,500 psi (minimum) and the design compressive strength of the concrete that the anchor will be installed in (maximum). The manufacturer of the selected Type IV epoxy system shall provide the Manufacturer's Printed Installation Instructions (MPII), as described in ASTM E488, including directions on hole preparation, sizing, spacing, minimum installation depth for the type of anchor to be installed and the pull-out strength obtained. The Manufacturer's MPII is accepted as certification that for the particular anchor grade, diameter and embedment depth specified, the anchor system will not fail by adhesive failure.

Field testing may be required for adhesively anchored fixtures.

(B) Materials

Package components of the adhesive in containers of such size that one whole container of each component is used in mixing one batch of adhesive. Use containers of such design that all of the contents may be readily removed, and are well sealed to prevent leakage. Furnish adhesive material that requires hand mixing in two separate containers designated as Component A and Component B. A self-contained cartridge or capsule will consist of two components which will be automatically mixed as they are dispensed, as in the case of a cartridge, or drilled into, as in the case of a capsule.

Clearly label each container with the manufacturer's name; date of manufacture; batch number; batch expiration date; all directions for use and such warning of precautions concerning the contents as may be required by Federal or State laws and regulations.

(C) Mixing of Adhesive

Mix adhesive in conformance with the manufacturer's instructions.

1081-3 HOT BITUMEN

Mix the adhesive asphaltic material with the filler homogeneously.

(A) Physical Requirements

Supply materials meeting Tables 1081-2 or 1081-3 and 1081-4.

TABLE 1081-2
ADHESIVE PROPERTIES OF ASPHALTIC MATERIAL WITH FILLER

Property	Min.	Max.	Test Method
Softening point,°F.	200	-	ASTM D36
Penetration, 100 g, 5 sec., 77°F	10	18	ASTM D5
Flow, inch, as modified in Subarticle 1081-3(B)	-	0.2	ASTM D5329
Viscosity, 400°F, poises or ASTM D4402 as modified in Subarticle 1081-3(B)	30	75	ASTM D2669
Flash Point, C.O.C.,°F.	550	-	ASTM D92

TABLE 1081-3
ASPHALT PROPERTIES OF ASPHALTIC MATERIAL WITHOUT FILLER

Property	Min.	Max.	Test Method
Penetration, 100 g, 5 sec., 77°F	25	-	ASTM D5
Viscosity, 275°F poises	12	100	ASTM D2171
Viscosity Ratio, 275°F	-	2.2	See Subarticle 1081-3(B)

TABLE 1081-4
FILLER PROPERTIES

Property	Min.	Max.	Test Method
Filler Content, % by Weight	65%	75%	See Subarticle 1081-3(B)
Filler Fineness, % Passing No. 325	75%	-	ASTM C430 as modified in Subarticle 1081-3(B)
Filler Fineness, % Passing No. 200	95%	-	
Filler Fineness, % Passing No. 100	100%	-	

(B) Test Methods

(1) Flow

Determine flow according to Section 6 of ASTM D5329 with the exception that the oven temperature shall be 158°F ± 2°F and sample preparation done according to Section 7.1 of ASTM D5.

(2) Viscosity

Viscosity is to be determined according to ASTM D2669 or ASTM D4402 using a spindle speed of 10 rpm. Heat the adhesive to approximately 410°F and allowed to cool. Determine viscosity at 400°F ± 1°F.

(3) Asphalt Properties

Properties of the base asphalt are to be determined on the material obtained from the following extraction and Abson recovery methods. Extract the asphalt by heating the adhesive just to the point where it will easily flow and then transfer 125 to 150 g into 400 ml of trichloroethylene with a temperature of 125°F to 150°F. Thoroughly stir this mixture to dissolve the asphalt. Decant the trichloroethylene-asphalt mixture decanted and the asphalt recovered using the Abson recovery method, ASTM D1856 as modified by the following. The extraction methods of ASTM D2172 do not apply and there will be no filtration of the solvent asphalt mixture. The extraction solution of trichloroethylene and asphalt shall be centrifuged for at least 30 minutes at 770 times gravity in a batch centrifuge. Decant this solution in the distillation flask, taking care not to include any filler sediment. Apply heat and bubble carbon dioxide solution slowly to bring the solution temperature to 300°F. At this point the carbon dioxide flow is increased to 800 ml to 900 ml per minute. The solution temperature is maintained at 320°F to 335°F with this carbon dioxide flow for at least 20 minutes and until the trichloroethylene vapors have been completely removed from the distillation flask. Repeat the above extraction-recovery method as necessary to obtain the desired quantity of asphalt. Use the asphalt recovered to determine penetration, 275°F viscosity, and 275°F viscosity ratio.

(4) Viscosity Ratio

Determine the 275°F viscosity ratio by comparing the 275°F viscosity on the base asphalt before and after the thin-film oven test. Perform the thin-film oven test in accordance with ASTM D1754. Determine the specific gravity by pycnometer as in ASTM D70 for use in the thin-film oven test. Calculate the 275°F viscosity ratio by dividing the viscosity after the thin-film oven test by the original 275°F viscosity.

(5) Filler Material

Separate the filler material from the asphalt to determine Filler Content and Filler Fineness. Determine the portion by weight of the adhesive insoluble in 1,1,1 trichloroethane by weighing 10.00 ± 0.01 grams of solid adhesive into a centrifuge flask with approximately 100 ml volume such as that specified in ASTM D1796. Add 50 ml of 1,1,1-trichloroethane to the adhesive, which should be broken up in small pieces to speed up the dissolution solids. Place the sample flask in a balanced centrifuge and spin using a minimum relative centrifugal force of 150 in accordance with ASTM D1796 for 10 minutes. Remove the sample flask and decant the solid, taking care not to lose any solids. Repeat the application of solvent and centrifuging until the solvent becomes clear and the filler is visually free of asphalt. Dry the filler at 160°F ± 5°F to remove solvent and weigh the resulting filler. Filtration of the decanted solvent may be performed to verify there is no loss of filler. Percent filler content is calculated as follows:

$$\text{Filter Content, \% by Weight} = \frac{\text{Filler Weight, grams} \times 100}{\text{Original Adhesive Weight, grams}}$$

Determine Filler Fineness according to ASTM C430 using number 325, 200 and 100 sieves. This method is to be modified by using a water soluble non-ionic wetting agent, such as Triton X-100, to aid the wetting action. Concentration of the surfactant solution shall be approximately 1% by weight. Thoroughly wet the one-gram dry sample in the surfactant solution and allowed to soak for 30 minutes. Transfer the filler completely into the sieve cup and apply water spray for 2 minutes. Surfactant solution may be added as needed and physical means used to disperse any clumped particles. Dry the sample and handle as described in ASTM C430.

(C) Prequalification

Interested parties shall submit a sample to a qualified independent testing laboratory for testing in accordance with Subarticle 1081-3(A) at no cost to the Department. Submit a Type 2 materials certification in accordance with Article 106-3 with the results and the name of the testing laboratory along with a qualification sample(s) of the same lot to the Department for evaluation.

(D) Packaging and Labeling

Pack the adhesive in self-releasing cardboard containers which will stack properly. Containers shall have a net weight of 50 lbs. to 60 lbs. and contain two to four subcompartments. Ensure the label shows the manufacturer, quantity and batch number. Print “Bituminous Adhesive for Pavement Markers” or similar wording on the label.

(E) Certification

A certification from the manufacturer showing the physical properties of the bituminous adhesive and conformance with the specifications shall be required before use.

(F) Application

Apply the adhesive according to the manufacturer’s requirements and the following requirements.

Apply the adhesive when the road surface, ambient air and pavement marker temperatures are in the range of 50°F to 160°F on dry pavement.

The composition of the adhesive shall be such that its properties will not deteriorate when heated to and applied at temperatures up to 425°F using either air or oil-jacketed melters.

Melt and heat the bituminous adhesive in either thermostatically controlled double boiler type units using heat transfer oil or thermostatically controlled electric heating pots. Do not use direct flame units.

Heat the adhesive to between 375°F and 425°F and applied directly to the pavement surface from the melter/applicator by either pumping or pouring. Maintain the application temperature between 375°F and 425°F as lower temperatures may result in decreased adhesion while higher temperatures may damage the adhesive.

Use sufficient adhesive to ensure total contact with the entire bottom of the pavement marker. Apply pavement markers to the adhesive immediately (within 5 seconds) to assure bonding. Place the pavement marker in position by applying downward pressure until the marker is firmly seated with the required adhesive thickness and squeeze-out. Remove excessive adhesive squeeze-out from the pavement and immediately remove adhesive on the exposed surfaces of pavement markers. Soft rags with mineral spirits or kerosene may be used if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent may be used.

Do not waste or spill any excess adhesive on Department right of way. Remove and properly dispose of any adhesive spilled or dumped at such location. The Contractor, at no cost to the Department, shall correct any damage incurred to the Department, highway or appurtenances as a result of misplaced adhesive.

The adhesive may be reheated and reused. However, the pot life at application temperatures shall not exceed the manufacturer's recommendations.

Clean out of equipment and tanks may be performed using petroleum solvents such as diesel fuel or similar materials. All solvents shall be removed from the equipment tanks and lines before the next use of the melter.

1081-4 EPOXY RESIN ADHESIVE FOR BONDING TRAFFIC MARKERS

(A) General

This section covers epoxy resin adhesive for bonding traffic markers to pavement surfaces.

(B) Classification

The types of epoxies and their uses are as shown below:

Type I

Rapid Setting, High Viscosity, Epoxy Adhesive. This type of adhesive provides rapid adherence to traffic markers to the surface of pavement.

Type II

Standard Setting, High Viscosity, Epoxy Adhesive. This type of adhesive is recommended for adherence of traffic markers to pavement surfaces when rapid set is not required.

Type III

Rapid Setting, Low Viscosity, Water Resistant, Epoxy Adhesive. This type of rapid setting adhesive, due to tis low viscosity, is appropriate only for use with embedded traffic markers.

Type IV

Standard Set Epoxy for Blade Deflecting-Type Plowable Markers.

(C) Requirements

Epoxies shall conform to the requirements set for in AASHTO M237.

(D) Prequalification

Refer to Subarticle 1081-1(E)

(E) Acceptance

Refer to Subarticle 1081-1(F)

SECTION 1082
STRUCTURAL TIMBER AND LUMBER

1082-1 GENERAL

Use Southern Pine timber and lumber graded in accordance with the current grading rules of the Southern Pine Inspection Bureau unless otherwise specified or approved by the Engineer. Use stress rated grades equal to or higher than the grades specified in this section or as otherwise specified in the contract. For temporary crossings, the use of stress rated lumber having stress ratings below those specified may be used if approved by the Engineer.

Have all wood products, including any preservative treatment, inspected and/or tested by an NCDOT approved commercial inspection company before it is delivered to the project. Provide industry standard commercial inspection reports and treatment test reports for each shipment of treated wood products before its use on the project. Perform inspections of preservative treated materials in accordance with American Wood Protection Association (AWPA) Standard M2. In addition, brand, hammer mark, ink stamp or tag each piece with the inspection company's

unique mark to indicate it has been inspected. All inspections shall be completed at no cost to the Department.

1082-2 UNTREATED TIMBER AND LUMBER

Lumber that is 2 inches to 4 inches thick and 2 inches to 4 inches wide shall conform to Structural Light Framing, Grade No. 1 Dense MC19. Lumber that is 2 inches to 4 inches thick and 6 inches wide or wider shall conform to Structural Joists and Planks, Grade No. 1 Dense MC19. Lumber that is 5 inches and thicker along the least dimension shall conform to Dense or Select Structural (Sel Str). Rough lumber will be acceptable except where surfacing is called for by the contract. Rough lumber may vary ± 1/4 inch from the dimensions shown on the contract or bill of material.

1082-3 TREATED TIMBER AND LUMBER

(A) General

Grade marked lumber will not be required. Brand or ink stamp each piece of treated lumber in accordance with the AWPA Standard M6. After treatment, handle the timber and lumber carefully to avoid breaking through the treated layer. This includes using rope slings, without sudden dropping, breaking of the fibers, bruising or penetrating the surface with tools or hooks. All drilled holes or cuts should be at least 1 foot above the earth to limit the potential for decay, with the exception of sign and guardrail end unit posts which are allowed.

(B) Bridges, Fender Systems and Piles

Lumber for bridges or fender systems that is 2 inches to 4 inches thick and 2 inches to 4 inches wide shall conform to Structural Light Framing, Grade No. 1 Dense. Lumber for bridges or fender systems that is 2 inches to 4 inches thick and 6 inches wide and wider shall conform to Structural Joists and Planks, Grade No. 1 Dense. Timbers for bridges or fender systems that are 5 inches and thicker along the least dimension shall conform to Structural Lumber, Dense or Select Structural (Sel Str). Lumber for fender systems shall conform to Dense or Select Structural (Sel Str).

Timber for piles shall meet ASTM D25 except that the timber shall be Southern Pine.

Rough lumber will be acceptable except where surfacing is called for by the contract or bills of material. Rough lumber may vary ± 1/4 inch from the dimensions shown in the plans or bill of material.

(C) Guardrail Posts, Blockouts and related components

Sawn timbers for guardrail posts, blockouts and related components shall be Southern Pine, conforming to Grade No. 1. Rough lumber will be acceptable. An allowable tolerance of 3/8 inch scant will be permitted from nominal dimensions.

(D) Fence Posts and Braces

Sawn fence posts and braces shall be Southern Pine, S4S, and conform to Grade No. 2 for posts up to 4 inches x 4 inches in cross section, and Grade No. 1 for posts larger than 4 inch x 4 inch in cross section.

Round posts and braces shall meet Subarticle 1050-2(A).

(E) Sign Posts and Battens

Lumber for sign posts no larger than 4 inches x 4 inches shall conform to Structural Light Framing, Grade No. 1. Lumber for sign posts larger than 4 inches x 4 inches and lumber for sign battens shall conform to Timbers, Grade No. 1. Use fully dressed S4S lumber for sign posts and battens.

A tolerance of 1/2 inch scant will be permitted from nominal dimensions of sign posts. A tolerance of 1 inch under and 3 inches over will be permitted in the length of the post.

(F) Poles

Timber for poles shall meet ANSI O5.1 except the timber shall be either treated Southern Pine or treated Coastal Douglas Fir. Use 40 feet Class 3 poles unless otherwise specified in the contract.

1082-4 PRESERVATIVE TREATMENT

(A) General

All timber and lumber is required to be treated with a preservative treatment in accordance with AASHTO M 133 or AWPA Standards, using a wood preservative registered by the US Environmental Protection Agency under the Federal Insecticide, Fungicide and Rodenticide Act.

Preservative treated wood products will not be accepted for use unless they have been inspected and found satisfactory, both before and after treatment as provided in Article 1082-1, and shall be delivered to the project site in a condition acceptable to the Engineer.

Use treating plants that have laboratory facilities at the plant site for use of the inspector in accordance with AWPA Standard T1.

In areas of frequent human contact, the use of chromated copper arsenate (CCA) treated wood is not permitted. Instead use material treated to the applicable AWPA Use Category with an appropriate preservative system permitted by EPA. "Frequent human contact" is defined as areas include decking, handrail and canopy posts, and rails of pedestrian bridges; other instances of human contact areas may include fencing, decorative borders, and other uses of treated wood at recreational facilities such as welcome centers, rest areas and weigh stations.

(B) Timber Preservatives

Use timber preservatives conforming to AASHTO M-133 or AWPA Standard U1, Section 4, Table 1.

(C) Bridges, Fender Systems and Piles

Treat timber and lumber for bridges and fender systems in accordance with AASHTO M-133 or AWPA Standard U1, Commodity Specification A: Sawn Products.

Treat piles in accordance to AWPA Standard U1, Commodity Specification E: Round Timber Piling.

(D) Guardrail Posts, Blockouts and Related Components

Treat guardrail posts, blockouts and related items in accordance to AASHTO M-133 or AWPA Standard U1, Commodity Specification A: Sawn Products, UC4B. The same type of preservative is to be used throughout the entire length of the project.

(E) Fence Posts and Braces

Treat sawn posts and braces in accordance with AASHTO M-133 or AWPA Standard U1, Commodity Specification A. Sawn Products, UC4B.

Treat round posts and braces in accordance with AASHTO M-133 or AWPA Standard U1, except require retention of preservative as below.

Before treatment, peel round posts and braces cleanly for their full length, remove all bark and cambium, and trim all knots and projections flush with the surface of the surrounding wood. Machine peeling will be permitted. Cut the ends to the proper length before treatment.

The same type of preservative shall be used throughout the entire length of the project.

(F) Sign Posts and Battens

Treat sign posts and battens in accordance with AASHTO M-133 or AWPA Standard U1, Commodity Specification A: Sawn Products UC4B.

The same type of preservative shall be used throughout the entire length of the project.

All timber shall have moisture content of not greater than 19% before treatment. Redry timber treated with chromated copper arsenate after treatment until it has moisture content of not greater than 25%.

(G) Poles

Treat poles in accordance with AASHTO M-133 or AWPA Standard U1, Commodity Specification D: Poles, UC4C.

The same type of preservative shall be used throughout the entire length of the project.

SECTION 1084
PILES

1084-1 PILES

(A) Treated Timber Piles

Timber for treated timber piles shall meet Article 1082-3. Give treated timber piles a preservative treatment in accordance with Article 1082-4.

(B) Steel Piles

Coat steel piles as required by the plans. Galvanize steel piles in accordance with Section 1076 or metallize steel piles in accordance with the *Thermal Sprayed Coatings (Metallization) Program*. Use Department approved supplier/producer as found on the NCDOT APL. Apply a barrier coat to any portion of the aluminum metallized steel piling encased in concrete. Use an approved waterborne barrier coating with a low-viscosity as found on the NCDOT APL which readily absorbs into the pores of the aluminum thermal sprayed coating. Apply waterborne coating at the spreading rate that results in a theoretical 1.5 mil dry film thickness. Provide a manufacturer certification in accordance with Article 106-3 Type 2 Certification that the resin chemistry of the waterborne coating is compatible with the 99.9% aluminum thermal sprayed alloy and suitable for tidal water applications. Before incorporating steel piles into the work, obtain all applicable certified Mill Test Reports clearly identifiable to the lot of material by heat numbers, submit these reports to the Engineer for review and analysis and receive approval of such test reports from the Engineer. Transfer the heat number of each painted pile to the newly painted surface with a permanent marker of a color contrasting to the paint once the paint has fully cured.

(1) Steel H-Piles

Steel H-piles shall meet ASTM A572 Grade 50 or ASTM A588.

(2) Steel Pipe Piles

Use uniform diameter steel pipe piles conforming to ASTM A252 Grade 3 modified (50,000 psi). Make all joints and seams in the pipe pile watertight. Unless otherwise indicated by the contract, the ends of pipe pile may be flame cut. Square flame cut ends with axis of the pile to provide a full uniform bearing over the entire end area when the pile is being driven. Welding procedure qualification for AWS D1.1 is required for pipe piles requiring splicing. The welding shall be performed by a Department certified welder.

(3) Steel Sheet Piles

For permanent applications, use hot rolled steel sheet piles and meet ASTM A572 or ASTM A690 unless otherwise required by the plans.

For temporary applications, use hot rolled steel sheet piles and meet ASTM A328.

(C) Prestressed Concrete Piles

Prestressed concrete piles shall meet Section 1078.

SECTION 1086
PAVEMENT MARKERS

1086-1 TEMPORARY RAISED PAVEMENT MARKERS

(A) General

Use raised pavement markers found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. .

Use raised pavement markers of the prismatic reflector type, or better as approved by the Engineer. The markers shall be constructed either of an injection molded plastic body and base or consist of a plastic shell filled with a mixture of inert thermosetting compound and filler material. Either construction type shall contain one or more integrated prismatic reflective lenses to provide the required color designation.

The minimum reflective area of the lens face is 2.0 sq.in.

The color of the reflective pavement marker housing shall match the pavement marking color, which it supplements.

All raised pavement marker reflective lenses shall be in close conformance with the AMS-STD-595 colors as listed below when viewed at night.

Crystal:	Color No. 17886 (White)
Yellow:	Color No. 13538
Red:	Color No. 11302

(B) Adhesives

(1) Epoxy

The epoxy shall meet Section 1081-4.

Review Subarticle 1081-4(B) for description of epoxy types suitable for markers to be installed. Use an epoxy adhesive type that is appropriate for the pavement and ambient temperature per the manufacture's recommendations. It is recommended that the ambient temperature during application of Types II and IV epoxy shall be at least 50°F and preferably higher than 60°F. These adhesives harden relatively slowly at 50°F, but the hardening rate rapidly accelerates as temperature increases.

(2) Hot Bitumen

The hot bitumen shall meet Article 1081-3.

(3) Pressure Sensitive

As supplied by the manufacturer.

(C) Material Certification

Furnish a Type 2 material certification in accordance with Article 106-3 for all raised pavement markers before use.

1086-2 PERMANENT RAISED PAVEMENT MARKERS

(A) General

Use raised pavement markers found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. The markers shall be constructed either of an injection molded plastic body and base or consist of a plastic shell filled with a mixture of inert thermosetting compound and filler material. Either construction type shall contain one or more integrated prismatic reflective lenses to provide the required color designation. Raised pavement markers (permanent) shall be of the glass or plastic face lens type and meet Subarticle 1086-1(A). Plastic lenses shall have an abrasion resistant coating.

(1) Potted Markers

Potted marker shells shall be made of molded methyl methacrylate conforming to Federal Specification L P 380C, Type I, Class 3. Filling material shall be an inert thermosetting compound selected for strength, resilience, and adhesion adequate to meet physical requirements of the specifications. Sand or other inert granulars shall be embedded in the surface of the inert thermosetting compound and filler material before its curing to provide a surface, which will readily bond to the adhesive.

(2) Injection-molded Markers

Injection-molded markers shall consist of polymer materials selected for strength and resilience adequate to meet the physical requirements of the specifications. The bottom surface of the marker shall contain grooves or nonsmooth structure designed to increase bonding with the adhesive.

(B) Optical Requirements

All optical performance for permanent raised pavement markers shall conform to ASTM D4280.

(C) Physical Properties

All physical properties for permanent raised pavement markers shall conform to ASTM D4280.

(D) Hot Bitumen Adhesives

Use hot bitumen adhesive for mounting the pavement markers to asphalt concrete roadways. The hot bitumen adhesive shall meet the requirements of Article 1081-3. Other adhesives such as epoxy or cold bituminous adhesive pads are not acceptable on asphalt concrete roadways for permanent applications.

(E) Epoxy Adhesives

Use epoxy adhesive for mounting the pavement markers to concrete roadways. The epoxy adhesive shall comply with Section 1081-4. Other adhesives such as hot and cold bituminous or adhesive pads are not acceptable on concrete roadways for permanent applications.

(F) Material Certification

Furnish a Type 2 material certification in accordance with Article 106-3 for all raised pavement markers before use.

1086-3 NON-CAST IRON SNOWPLOWABLE PAVEMENT MARKERS

(A) General

Use non-cast iron snowplowable pavement markers found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. The non-cast iron snowplowable pavement

marker shall consist of a housing with one or more glass or plastic face lens type reflective lenses to provide the required color designation. The marker shall be designed or installed in a manner that minimizes damage from snowplow blades. Plastic lens faces shall use an abrasion resistant coating.

(B) Housings

(1) Dimensions

The dimension, slope and minimum area of reflecting surface shall conform to dimensions as shown in the plans. The minimum area of each reflecting surface shall be 1.44 sq.in.

(2) Materials

Use non-cast iron snowplowable pavement markers that are on the NCDOT Approved Products List.

(3) Surface

The surface of the housing shall be free of scale, dirt, rust, oil, grease or any other contaminant which might reduce its bond to the epoxy adhesive.

(4) Identification

Mark the housing with the manufacturer's name and model number of marker.

(C) Reflectors

(1) General

Laminate the reflector to an elastomeric pad and attach with adhesive to the housing. The thickness of the elastomeric pad shall be 0.04 inch.

(2) Reflector Type

(a) One-direction, one color (crystal)

(b) Bidirectional, one color (yellow and yellow)

(c) Bidirectional, two colors (red and crystal)

(d) Bidirectional, two colors (red and yellow)

All pavement marker reflective lenses shall be in close conformance with the AMS-STD-595 colors as listed below when viewed during night situations.

Crystal:	Color No. 17886 (White)
Yellow:	Color No. 13538
Red:	Color No. 11302

(3) Reflector Optical Requirements

(a) Definitions

Define “horizontal entrance angle” as the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.

Define “observation angle” as the angle, at the reflector, between observer's line of sight and the direction of the light incident on the reflector.

Define “specific intensity (S.I.)” as candlepower of the returned light at the chosen observation and entrance angles for each footcandle of illumination at the reflector.

$$\textbf{S.I.} = RL \times (D \times D) \times IL$$

Where:

S.I. = Specific Intensity
RL = Reflected Light
IL = Incident Light
D = Test Distance

(b) Optical Performance

Test the reflector for specific intensity as described below:

Form a 1 inch diameter flat pad using #3 coarse steel wool per Federal Specification FF-W-1825. Place the steel wool pad on the reflector lens. Apply a load of 50 lbs. and rub the entire lens surface 100 times. Do not abrade the red lens of the Type 3 and Type 4 bi-directional units.

Locate the reflector to be tested with the center of the reflecting face at a distance of 5 feet from a uniformly bright light source having an effective diameter of 0.2 inch.

The photocell must be an angular ring 0.37 inch I.D. x 0.47 inch O.D. Shield it to eliminate stray light. The distance from light source center to the center of the photoactive area shall be 0.2 inch. If a test distance of other than 5 feet is used, modify the source and receiver in the same proportion as the test distance.

After abrading the lens surface using the above steel wool abrasion procedure, the specific intensity of each crystal reflecting surface at 0.2 degrees observation angle must not be less than the following when the incident light is parallel to the base of the reflector.

TABLE 1086-1
MINIMUM SPECIFIC INTENSITY
(candle/footcandle/unit marker)

Color	Horizontal Entrance Angle	
	0 Degrees	20 Degrees
Crystal	3.00	1.20
Yellow	1.80	0.72
Red	0.75	0.30

(D) Properties

All optical and physical properties for snowplowable pavement markers shall conform to ASTM D4383.

(E) Epoxy Adhesive

The epoxy adhesive shall meet the requirements of Section 1081-4. Mix the epoxy adhesive rapidly by a two component type automatic metering, mixing and extrusion apparatus.

(F) Material Certification

Furnish a Type 2 material certification in accordance with Article 106-3 for all raised snowplowable markers before use.

SECTION 1087
PAVEMENT MARKINGS

1087-1 GENERAL

Yellow and white pavement markings shall be retroreflective. Black pavement markings shall be matte, non-retroreflective.

The material manufacturer has the option of formulating the pavement marking material according to his own specifications; however, the manufacturer shall meet all the minimum requirements specified herein.

All pavement marking materials, pigments, beads, highly reflective media and resins shall be free from all skins, dirt and foreign objects.

Use pavement marking materials capable of being fabricated into pavement markings of specified dimensions and adhering to asphalt and Portland cement concrete pavements when applied in accordance with their manufacturer's recommendation.

Pavement marking materials upon heating shall not exude fumes, which are toxic, or injurious to persons or property.

Homogeneously mix all pavement marking materials.

1087-2 COMPOSITION

(A) Paint Composition

Pavement marking paint shall be a ready mixed type paint product conforming to Federal Specification TT--P-1952 with spraying consistency suitable for use as a retroreflective pavement marking. Glass beads are dropped by suitable pressurized means into the wet paint as it is applied to the pavement.

(B) Removable Tape Composition

Removable tape pavement marking shall be composed of materials as specified by their manufacturer.

Use removable tape markings capable of conforming to pavement contours, breaks, faults, etc. through the action of traffic at normal pavement temperatures. The tape shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking tape of the same composition under normal conditions of use. The removable tape markings shall be patchable.

Use removable tape markings capable of adhering to the pavement by a pressure-sensitive pre-coated adhesive or as directed by the manufacturer.

(C) Thermoplastic Composition

Use thermoplastic alkyd/maleic pavement markings composed of the materials in Table 1087-1.

TABLE 1087-1
PHYSICAL PROPERTIES
OF THERMOPLASTIC ALKYD/MALEIC PAVEMENT MARKINGS

Component	By Weight
Alkyd/Maleic Binder	18.0% Min
Glass Beads (Premixed)	30.0% Min
Titanium Dioxide Pigment (ASTM D476 Type 2)	10.0% Min.

Use white thermoplastic that does not contain anatase titanium dioxide pigment.

Calcium carbonate and inert fillers may be as opted by the manufacturer, providing all other qualifications are met.

The total silica content used in the formulation of the thermoplastic shall be the premixed reflective media. Uniformly disperse the pigment, beads, media and filler in the binder.

The alkyd/maleic binder shall consist of a mixture of synthetic resins (at least one synthetic resin shall be solid at room temperature) and a high boiling point plasticizers. At least 1/2 of the binder composition shall be 100% maleic-modified glycerol of resin and be no less

than 15% by weight of the entire material formulation. The binder shall contain no petroleum hydrocarbon resins. Use resins/rosins that are maleic-modified glycerol esters.

The thermoplastic material shall be free of contaminates and be homogeneously dry-blended or hot mixed from 100% virgin stock using no reprocessed materials, (excluding the requirement to use reprocessed glass).

The thermoplastic material shall not deteriorate or discolor when held at the application temperatures for at least 4 hours or upon repeated reheating (at least 4 times).

The color, viscosity and chemical properties versus temperature characteristics of the thermoplastic material shall remain constant for up to 4 hours at the application temperature and be the same from batch to batch.

The thermoplastic material shall be readily applicable at temperatures between 400°F and 440°F from the approved equipment to produce lines and symbols of the required above the pavement thickness.

(D) Cold Applied Plastic Composition

The cold applied plastic pavement marking shall consist of a mixture of high quality polymeric materials, pigments and reflective media distributed throughout its base cross-sectional area, with a reflective media bonded to the top surface.

The cold applied plastic markings shall adhere to the pavement by a pressure-sensitive pre-coated adhesive.

The cold applied plastic shall conform to pavement contours, breaks, faults, etc. through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking tape of the same composition under normal conditions of use. The cold applied plastic pavement marking shall be patchable.

1087-3 COLOR

All pavement markings, without reflective media, shall visually match the color chips that correspond to the AMS-STD-595 for the following colors:

Crystal: Color No. 17886 (White)
Yellow: Color No. 13538
Black: Color No. 37038

1087-4 GLASS BEADS

(A) Composition

The silica content of the glass beads shall be at least 60%.

Manufacture the beads from 100% recycled non-pigmented glass from a composition designed to be highly resistant to traffic wear and to the effects of weathering. All standard intermix and drop-on glass beads shall be manufactured using 100% North American recycled glass cullet.

All intermixed and drop-on glass beads shall not contain more than 75 ppm arsenic or 200 ppm lead.

(B) Physical Characteristics

Use glass beads that are colorless, clean, transparent and free from milkiness, excessive air bubbles, skins and foreign objects. Use glass beads with a minimum refractive index of 1.50 when tested by the liquid immersion method at 77°F ± 9°F in accordance with ASTM D1214 using the Becke Line Method or an equivalent method. Use glass beads that are spherical in shape and essentially free of sharp angular particles or particles showing surface scarring or scratching.

All intermixed and drop-on glass beads shall comply with NCGS § 136-30.2 and 23 USC § 109(r).

(C) Gradation & Roundness

Use drop-on and intermixed glass beads in all pavement markings with at least 80% true spheres when tested in accordance with ASTM D1155. Drop-on and intermixed glass beads used on any pavement markings shall meet Table 1087-2.

TABLE 1087-2
GLASS BEAD GRADATION REQUIREMENTS

Sieve Size	Gradation Requirements	
	Minimum	Maximum
Passing #20	100%	--
Retained on #30	5%	10%
Retained on #50	40%	80%
Retained on #80	15%	40%
Passing #80	0%	5%
Retained on #200	0%	5%

(D) Chemical Resistance

Conduct the following chemical resistance test on all glass beads:

Place 3 to 5 g portions of the same glass bead batch to be tested in three separate glass beakers or three porcelain dishes. Cover one sample with distilled water, cover the second sample with 3N solution of sulfuric acid and cover the third sample with 50% solution of sodium sulfides. After one hour of immersion, examine the glass bead samples microscopically for evidence of darkening or frosting. All three samples shall show no evidence of darkening or frosting.

(E) Moisture Resistance

Conduct the following moisture resistance test on drop-on glass beads:

Place a 2 lb. minimum sample of glass beads in a clean, washed cotton bag with a thread count of 50 warp, 50 woof. Immerse the bag containing the sample in a container of water for 30 seconds or until the water covers the spheres, whichever is longer. Remove the bag from water and force excess water from the sample by squeezing the bag. Suspend the bag and allow to drain for 2 hours at room temperature 70°F to 72°F. Then mix the sample in the bag by shaking thoroughly. Transfer the sample slowly to a clean dry glass funnel having a stem of 4 inches in length with 1/4 inch inside diameter. The entire sample shall flow freely through the funnel without stoppage. When first introduced in the funnel, if the spheres clog, it is permissible to lightly tap the funnel to start the flow.

1087-5 PACKAGING FOR SHIPMENT

Deliver all pavement marking and reflective media materials to the project in suitable containers packaged by the manufacturer. Clearly and adequately mark each material container to indicate the material, color, date of manufacture, process, batch or lot number, manufacturer's name and location, temperature application range, shelf life and include the SDS.

Thermoplastic pavement marking materials shall be in block or granular form packaged in either suitable corrugated containers or thermal degradable plastic bags to which it will not adhere during shipment or storage.

Package reflective media in moisture resistant packaging.

1087-6 STORAGE LIFE

All pavement marking materials shall meet these specifications for one year from the date of shipment from the manufacturer to the Contractor, or the project when stored properly by the

manufacturer's recommendation. Replace any pavement marking materials not meeting these specifications.

1087-7 TESTS TO BE PERFORMED

When independent test laboratory tests are required, perform them on samples taken by an agency certified by the Department from the same process, batch or lot number as the material shipped to the project. The test reports shall contain the lot number. Use Department approved independent test laboratories.

Perform the following tests on thermoplastic pavement marking materials, intermixed glass beads and drop-on glass beads unless prescribed otherwise by the Engineer:

(A) Intermixed and Drop-on Glass Beads

Use X-ray Fluorescence for the normal sampling procedure for intermixed and drop-on beads, without crushing, to check for any levels of arsenic and lead. If any arsenic or lead is detected, the sample shall be crushed and repeat the testing using X-ray Fluorescence. If the X-ray Fluorescence test shows more than LOD of 5 ppm, test the beads using United States Environmental Protection Agency Method 6010B, 6010C or 3052 for no more than 75 ppm arsenic or 200 ppm lead.

(B) Thermoplastic Pavement Marking Material Composition

(1) % Binder tested in accordance with ASTM D4797.

(2) % Titanium Dioxide Pigment tested in accordance with ASTM D3720 or D4764.

(3) % Glass Beads tested in accordance with ASTM D4797.

(C) Flash Point

The thermoplastic shall have a flashpoint of no less than 500°F when tested in accordance with ASTM D92 Cleveland Open Cup (COC).

(D) Requirements

The thermoplastic material after heating for 240 ± 5 minutes at 425 ± 3°F and cooled to 77 ± 3°F shall meet the following:

(1) Color

(a) White

Daylight reflectance 2° Standard observer and CIE illuminant

Using XYZ scale D65/10° - 80% minimum

ASTM E1349

Yellowness Index - The white thermoplastic shall not exceed a yellowness index of 12.0 per ASTM E313

(b) Yellow

Obtain Color Values Y,x,y per ASTM E1349 using C/2° illuminant/observer

Results shall be $Y \geq 45\%$, and x,y shall fall within PR#1 chart chromaticity limits.

(2) Bond Strength

The bond strength shall be 200 psi or greater in accordance with ASTM D4796.

(3) Cracking Resistance at Low Temperatures

After applying a 4 inch, 125 mil draw-down to concrete blocks and cooling to 15 ± 3°F, the material shall show no cracks at an observation distance of 12 inches.

(4) Specific Gravity

The specific gravity shall be 1.95-2.20 in accordance with ASTM D792.

(5) Softening Point

The softening point shall be 215 ± 15°F in accordance with ASTM D36.

(6) Drying Time

When applied at a thickness of 125 mils, the material shall set to bear traffic in no more than 2 minutes when air and substrate temperature is 50°F ± 3°F (and no more than 10 minutes when the air and substrate temperature is 90°F ± 3°F when applied at temperature of 412.5 ± 12.5°F in accordance with AASHTO T 250.

(7) Alkyd/Maleic Binder Determination

The thermoplastic material shall immediately dissolve in diacetone alcohol. Slow dissolution is evidence of the presence of hydrocarbon binder components.

(8) Indentation Resistance

The Shore Type A2 Durometer with a 4.41 lb. load applied shall be between 40 and 75 units after 15 seconds at 115°F in accordance with ASTM D2240.

1087-8 MATERIAL CERTIFICATION

Furnish the following pavement marking material certifications in accordance with Article 106-3.

When tested, the material shall meet the physical and chemical characteristics provided by the manufacturer. NCDOT reserves the right to compare these test results to baseline test results gathered by the NCDOT Materials and Tests Unit.

If not NCDOT standard glass beads, then must meet AASHTO M 247 Type 3 or 4 and a NCDOT Type 2 Material Certification must be provided.

Drop-on Reflective Media	Type 3 Material Certification and Type 4 Material Certification
Intermix Reflective Media	Type 2 Material Certification and Type 3 Material Certification
Paint	Type 3 Material Certification
Removable Tape	Type 3 Material Certification
Extruded Thermoplastic	Type 3 Material Certification and Type 4 Material Certification
Heated-In-Place Thermoplastic	Type 3 Material Certification
Cold Applied Plastic	Type 2 Material Certification and Type 3 Material Certification
Polyurea	Type 2 Material Certification and Type 3 Material Certification

SECTION 1088
DELINEATORS

1088-1 REFLECTIVE UNIT REQUIREMENTS FOR DELINEATORS

(A) Definition

Refer to ASTM D4956.

Define “entrance angle” as the angle at the reflector between direction of light incident on it and direction of reflector axis.

Define “observation angle” and “specific intensity” in accordance with Subarticle 1086-3(C)(3)(a).

(B) Reflective Elements

(1) Prismatic Plastic Type

(a) General

Use an acrylic plastic prismatic reflector hermetically sealed to an acrylic plastic back. The reflector shall consist of a clear and transparent face, herein referred to as a lens, with an acrylic plastic back fused to the lens under heat pressure around the entire perimeter of the lens. Where a central mounting hole is required, permanently seal the unit against dust, water and water vapor.

The lens shall consist of a smooth front surface free from projections or indentations except a central mounting hole and identification markings. Mold the manufacturer's trademark legibly into the face of the lens.

(b) Specific Intensity

Refer to ASTM D4956.

The specific intensity of each prismatic plastic type reflector shall meet Table 1088-1 measurements made with reflectors spinning. Failure to meet the specific intensity minimum will constitute failure of the lot.

TABLE 1088-1
OPTICAL PROPERTIES OF PRISMATIC PLASTIC TYPE REFLECTORS

Observation Angle (Degrees)	Entrance Angle (Degrees)	Minimum Specific Intensity (Candlepower per Footcandle)		
		Crystal	*Yellow*	*Red*
0.1°	0°	119	71	29
0.1°	15°	119	28	--
0.1°	20°	47	28	11
0.1°	35°	50	30	--

Locate the prismatic plastic type reflector to be tested at a distance of 100 feet from a single light source having an effective diameter of 2 inches operate the light source at approximately normal efficiency. Measure the return light from the reflector by a photoelectric photometer having a minimum sensitivity of 1 x 10 footcandles per mm scale division. The photometer shall have a receiver aperture of 0.5 inch diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 inches for 0.1 degree observation angle. During testing, spin the reflectors to average the orientation effect.

If a test distance other than 100 feet is used, modify the source and aperture dimensions, and the distance between source and aperture, in the same proportion as the test distance.

(c) Durability

(i) Seal Test

Use the following test to determine if a reflector is adequately sealed against dust and water:

Submerge 50 samples in water at room temperature. Subject the submerged samples to a vacuum of 5 inches gauge for 5 minutes. Restore atmospheric pressure and leave the samples submerged for 5 minutes, then examine the samples for water intake. Evidence of any water is a failure. Failure of more than 2% of the number tested will be cause for rejection.

(ii) Heat Resistance Test

Test three reflectors for 4 hours in a circulating air oven at 175°+5°F. Place the test specimens in a horizontal position on a grid or perforated shelf, permitting free air circulation. At the conclusion of the test, remove the samples from the oven and permit them to cool in air to room temperature. The samples, after exposure to heat, shall show no change in shape and general appearance when compared with unexposed control standards. Any failures will be cause for rejection.

(2) High Performance Sheeting Grade

The reflective sheeting shall be Grade C retroreflective sheeting that conforms to Article 1092-2.

1088-2 GUARDRAIL AND BARRIER DELINEATORS

(A) Brackets and Casings for Delineators

Make brackets for guardrail and barrier delineators out of 12 gauge galvanized steel, 0.063 inch thick aluminum alloy, or .080 inch thick polycarbonate. Use molded plastic type guardrail and barrier delineators that consist of a plastic casing and a reflective element.

(B) Reflective Element Requirements

The reflective element shall meet Article 1088-1. In addition, guardrail delineators and side mounted barrier delineators shall have a minimum reflective area of 7 sq.in. Top mounted barrier delineators shall have a minimum reflective area of 28 sq.in.

(C) Material Certification

Furnish a Type 2 material certification in accordance with Article 106-3 for all guardrail and barrier (permanent) delineators and a Type 7 material certification for all guardrail and barrier delineators (temporary) before use.

(D) Approval

All materials are subject to the approval of the Engineer.

1088-3 GUARDRAIL END DELINEATION

(A) General

Use guardrail end delineation that is adhesive coated yellow reflective sheeting applied with a pressure sensitive adhesive backing.

(B) Reflective Sheeting Requirements

Use Grade C yellow retroreflective sheeting which conforms to Article 1092-2 for all guardrail end delineation. In addition, guardrail end delineation shall have a minimum reflective area of 2 sf for curved end sections or cover the entire portion of square end sections. See *Roadway Standard Drawings*.

(C) Material Certification

Furnish a Type 2 material certification in accordance with Article 106-3 for all guardrail end delineation before use.

(D) Approval

All materials are subject to the approval of the Engineer.

1088-4 OBJECT MARKERS

(A) General

Use 7 feet galvanized steel U-shaped channel posts as supports for delineators that are fabricated from steel conforming to ASTM A36 or ASTM A409. Use 7 feet posts, which weigh at least 1.12 lbs/lf after fabrication and application of protective finish. Punch or drill all posts with 3/8 inch diameter holes on the centerline, spaced on 1 inch centers, starting 1 inch from the top and extending at least 24 inches down the posts. Make sure that the holes are clean and the posts are free of burrs. Hot dip galvanize the posts after fabrication for the full length and total area in accordance with ASTM A123.

(B) Reflectors

Use 3 inches diameter prismatic plastic reflectors on object markers that meet Subarticle 1088-1(B)(1).

(C) Reflective Sheeting Requirements

Use Grade C retroreflective sheeting on object markers that meet Article 1092-2.

(D) Panel Requirements

Use panels that meet Article 1092-1.

(E) Fasteners

Use fasteners that meet Article 1092-1.

(F) Material Certification

Furnish a Type 5 material certification in accordance with Article 106-3 for sheeting, a Type 2 material certification for delineators and a Type 1 material certification for U-channel posts before use.

(G) Approval

All materials are subject to the approval of the Engineer.

1088-5 TUBULAR MARKERS

(A) General

Provide tubular markers that are made of ultraviolet stabilized plastic impact resistant material found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL. Provide yellow, white or gray tubular markers as shown in the plans.

Provide tubular markers that are flexible or have a flexible joint at the base, such that it will return to its original shape and position if struck by a 5,000 lb vehicle at a velocity of 55 mph. When struck the tubular markers shall not permanently distort to a degree that would prevent reuse.

Use tubular markers that are circular in shape and have a minimum height of 36 inches with a broadened base. Use tubular markers that have a minimum height of 42 inches on roadways with posted speed limits greater than 50 mph.

Design tubular markers that have white retroreflective collars or as shown in the contract.

Where retroreflective collars are required, provide Grade C retroreflective sheeting or better that meets Article 1092-2. Use retroreflective sheeting bands with a minimum width of 4 inches with 6 inches between the bands. Apply a continuous strip of sheeting completely around the tubular marker to ensure 360° retroreflectivity.

(B) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new tubular markers and retroreflective collars and a Type 7 material certification for all used tubular markers and retroreflective collars before use.

(C) Approval

All materials are subject to the approval of the Engineer.

1088-6 FLEXIBLE DELINEATOR

(A) General

Provide flexible delineators found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL.

(B) Retroreflective Sheeting

Use retroreflective sheeting that is a minimum area of 16 sq.in., with a minimum width of 3 inches. The reflective sheeting shall be Grade C retroreflective sheeting or better and shall conform to Article 1092-2.

Use retroreflective sheeting which is yellow, red or white, as shown in the plans. Attach the retroreflective sheeting on the front and back of the delineator post as required by the contract.

(C) Post

Design a delineator post that is flexible and made of recycled material. Provide a delineator post that is resistant to impact, ultraviolet light, ozone, hydrocarbons and stiffening with age.

Provide a post that is not seriously affected by exhaust fumes, asphalt or road oils, dirt, vegetation, soil, deicing salts or any other types of air contamination or materials likely to be encountered. Upon weathering, the post shall not exhibit serious discoloration, checking or cracking, peeling or blistering, swelling, shrinking or distortion, or any other detrimental effects. Weathering shall not cause appreciable strength or flexibility loss.

Design a post with a smooth surface that is free from irregularities or defects. The surface of the post shall not soil excessively. If soiling does occur, it shall be easily cleaned using detergent and water, or solvent.

Use posts that have a convex shaped cross-section. The chord distance for the cross-section shall be from 3.5 inches to 4.5 inches in length.

Design a post such that it can maintain straightness throughout its entire life. Straight is defined as no point along its length any more than 1 inch away from a perfectly straight edge placed longitudinally along any side of the post.

Provide a post in which both sides of the top of the post accepts, and holds securely, retroreflectorized sheeting.

Design posts that are gray in color.

(D) Base Support

Provide a base support that is hot rolled rail steel or new billet steel meeting Article 1088-5, the physical requirements of ASTM A499 and the chemical requirements of ASTM A1.

Use a base support that is a uniform flanged U-channel post with a nominal weight of 3 lb./ft. before holes are punched. Use base support posts that are 18 inches in length and

have sufficient number of 3/8 inch diameter holes on 1 inch centers to facilitate attachment of the flexible post.

(E) Anchoring

Design a delineator post for a permanent installation to resist overturning, twisting and displacement from wind and impact forces.

(F) Temperature

Design flexible delineators that do not bend, warp or distort and remain straight, when stored or installed at temperatures up to + 120°F. Design all components of the flexible delineator, post and reflective sheeting to remain stable and remain fully functional within a temperature range of - 20°F to + 120°F.

(G) Impact Resistance, Wind Resistance

Design flexible delineators that meet the impact and wind resistance of the current evaluation criteria of the AASHTO Product Evaluation & Audit Solutions.

(H) Product Identification

Provide flexible delineator post that are permanently identified, on the rear side, with the manufacturer's name and the month and year of fabrication in order to provide a tracking method for ongoing outdoor evaluation, and specification quality control. The letters shall be at least 1/4 inch in height and permanently affixed to the rear of the marker.

(I) Material Certification

Furnish a Type 2 and Type 3 material certification in accordance with Article 106-3 for all flexible delineators before use.

(J) Approval

All materials are subject to the approval of the Engineer.

SECTION 1089
TRAFFIC CONTROL

1089-1 WORK ZONE SIGNS

(A) General

Use Grade B fluorescent orange retroreflective sheeting on rigid work zone sign substrates. All sheeting shall conform to Article 1092-2. Cover the entire sign face of the sign substrate with Department approved sheeting as found on the NCDOT APL. No bubbles or wrinkles will be permitted in the material. Products manufactured prior to December 31, 2019 shall meet NCHRP 350 or MASH crash requirements for Category II work zone devices.

(1) Work Zones Signs (Stationary)

Use approved composite or aluminum substrate for sign backing. For aluminum substrate sign thickness, refer to Table 901-2.

Use work zone signs (stationary) and sign supports as found on the NCDOT APL.

(2) Work Zones Signs (Barricade Mounted)

Use approved composite or roll-up signs for barricade mounted sign substrates. No other type of sign substrate is allowed on barricades. Approved composite barricade mounted warning signs (black on orange) shall be Grade B retroreflective sheeting that meets the requirements of Article 1092-2.

(3) Use work zone signs (barricade mounted) and barricade assemblies as found on the NCDOT APL. Work Zones Signs (Portable)

Use approved composite or roll-up sign substrates on portable sign stands. No other type of sign substrate is allowed on portable sign stands.

Use work zone signs (portable) and sign supports as found on the NCDOT.

(a) Composite

Use Grade B fluorescent orange retroreflective sheeting that meets the requirements of Article 1092-2.

(b) Roll-up Signs

Use Grade B fluorescent orange retroreflective sheeting for roll-up signs that meet the requirements of Article 1092-2.

Use roll up signs that have a minimum 3/16 inch x 1 1/4 inches horizontal rib and 3/8 inch x 1 1/4 inches vertical rib.

(B) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new reflective sheeting used on work zone signs meeting the retroreflective requirements of Article 1092-2. Furnish a Type 7 material certification for all used signs meeting the minimum retroreflective requirements of Article 1092-2.

(C) Approval

All materials are subject to the approval of the Engineer.

(D) Warranty

Refer to Subarticle 1092-2(B) for warranty requirements of rigid sign retroreflective sheeting.

Roll-up fluorescent orange retroreflective signs will maintain 80% of its retroreflectivity as described in Article 1092-2 for years 1 and 2 and 50% for year 3.

Rigid and rollup fluorescent orange signs shall maintain a fluorescence luminance factor of 13% for 3 years and conform to Article 1092-2.

Rigid and roll up fluorescent orange signs shall maintain a total luminance factor of 25 for 3 years and conform to Article 1092-2.

1089-2 WORK ZONE SIGNS SUPPORTS

(A) General

Products manufactured prior to December 31, 2019 shall meet NCHRP 350 or MASH crash requirements for Category II work zone devices.

(1) Work Zone Signs (Stationary)

Provide work zone sign supports for work zone signs (stationary) that are sturdy, durable and crashworthy. Use work zone signs (stationary) and sign supports as found on the NCDOT APL.

Use 3 lb U-channel steel posts, 4 inches x 4 inches wood posts or perforated square steel tubing posts for all work zone signs. Dual mount signs with surface areas greater than 10 sf on either 3 lb U-channel steel posts, 4 inches x 4 inches wood posts or perforated square steel tubing posts having the equivalent or greater strength of 3 lb U-Channel Steel posts. Perforated square steel tubing breakaway posts certified by the manufacturer for single mounting purposes may be used for the single mounting of stationary work zone signs for signs greater than 10 sf.

3 lb. steel U-channel posts shall comply with Subarticle 1094-1(B) and may be galvanized steel or painted green by the post manufacturer.

(2) Work Zone Signs (Portable)

Use work zone signs and portable work zone sign stands that are sturdy, durable and crashworthy. Use work zone signs (portable) and sign supports as found on the NCDOT APL.

(B) Material Certification

Provide portable work zone signs and stands that are listed on the NCDOT Approved Product List. Furnish a Type 3 material certification in accordance with Article 106-3 for all new work zone sign (stationary) posts and a Type 7 material certification for all used work zone sign (stationary) posts before use.

Furnish a Type 3 material certification in accordance with Article 106-3 for all new portable work zone sign stand assemblies and a Type 7 material certification for all used portable work zone sign stand assemblies before use.

(C) Approval

All materials are subject to the approval of the Engineer.

1089-3 BARRICADES

(A) General

Construct barricades out of perforated square steel tubing, angle iron or other Department approved materials.

Use barricade rails constructed of approved composite, hollow/corrugated extruded rigid polyolefin, HDPE or other Department approved material that have a smooth face and alternating orange and white retroreflective stripes that slope at an angle of 45°.

Use barricades as found on the NCDOT APL. Products manufactured prior to December 31, 2019 shall meet NCHRP 350 or MASH crash requirements for Category II work zone devices.

(B) Supports

Support barricade rails in a manner that shall be visible to the motorist and provide a stable support not easily blown over by wind or traffic.

(C) Retroreflective Sheeting

Use Grade B retroreflective sheeting that meets Article 1092-2. Flame treat rails before applying the sheeting if required by the sign sheeting manufacturer. Apply the reflective sheeting with a pressure sensitive adhesive to both sides of the rails.

Use the same color sheeting on each rail of any individual barricade.

(D) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new barricades and a Type 7 material certification for all used barricades before use.

(E) Approval

All materials are subject to the approval of the Engineer.

1089-4 SEQUENTIAL FLASHING WARNING LIGHTS

(A) General

Provide sequential flashing warning lights that meet all of the requirements for Type A warning lights in accordance with the MUTCD.

(B) Power System

Each light unit shall be capable of operating fully and continuously for a minimum of 200 hours when equipped with a standard battery set.

(C) Light Display

Each light in the sequence shall be yellow and flashed at a rate of not less than 55 times per minute and not more than 75 times per minute. The flash rate and flash duration shall be consistent throughout the sequence.

(D) Reliability

The lights shall be weather independent and visual obstructions shall not interfere with the operation of the lights.

(E) Material Certification

Furnish a Type 3 material certification in accordance with article 106-3 for all new Sequential Flashing Warning Lights and a Type 7 material certification for all used Sequential Flashing Warning Lights.

(F) Approval

Use sequential flashing warning lights listed on the NCDOT APL.

1089-5 CHANNELIZING DEVICES

(A) Drums

(1) General

Provide drums composed of a body, alternating orange and white 4-band pattern of Type III-High Intensity or higher prismatic retroreflective sheeting and ballasts.

(2) Body

Provide a drum made of orange, impact resistant, ultraviolet plastic material capable of maintaining its integrity upon impact throughout a temperature range of -20°F to 125°F. When struck, the drum shall not permanently distort to a degree that would prevent reuse, nor roll excessively after impact. Design the drum to prevent water from accumulating and freezing in the top or bottom.

Provide a drum that is cylindrical in shape with the following dimensions; a minimum height of 36 inches, a minimum top outer diameter of 18 inches, a bottom outer diameter of 21 inches to 24 inches, and a minimum weight of 7 lbs. The top outer diameter shall not exceed the bottom outside diameter. Provide closed tops on drums to prevent accumulation of debris.

(3) Retroreflective Stripes

Provide at least four retroreflective bands with two orange and two white alternating horizontal circumferential bands. The top band shall always be orange. Use a 6 inch to 8 inch wide band Type III–High Intensity or higher prismatic retroreflective sheeting meeting the requirements of Article 1092-2 for each band. Do not exceed 2 inches for any non-retroreflective spaces between orange and white stripes. Do not splice the retroreflective sheeting to create the 6 inch band. Apply the retroreflective sheeting directly to the drum surface. Do not apply the retroreflective sheeting over a pre-existing layer of retroreflective sheeting. Do not place bands over any protruding corrugations areas. No damage to the retroreflective sheeting should result from stacking and unstacking the drums, or vehicle impact.

(4) Ballast

Ballast drums using the sandbag ballast method, the tire sidewall ballast method or the preformed weighted base ballast method. When properly ballasted, the drums shall be wind resistant to the extent of withstanding wind created by traffic under normal roadway conditions, including high speed truck traffic in close proximity to the drums. Do not place ballast on top of the drum.

(a) Sandbag Ballast Method

Supply a sandbag with 50 lb. of sand with each drum. Place the sandbag inside the body on top of the detachable base. Upon impact the main body of the drum shall deform and become detached from the base, allowing vehicles to easily pass over the remaining base.

(b) Tire Sidewall Ballast Method

Design the base of the drums to accommodate no more than two tire sidewalls that when combined will have a weight of at least 30 lb and no more than 50 lb. Use the manufacturer's required tire sidewall ballast. Upon impact the main body of the drum shall deform and become detached from the tire sidewalls, allowing vehicles to easily pass over the tire sidewall ballasts.

(c) Preformed Weighted Base Ballast Method

Supply a preformed base specifically designed for the model drum. The weight of each drum's preformed base will be self-certified by the manufacturers. Each drum with preformed bases shall be approved by the Work Zone Traffic Control Unit. Upon impact, the main body of the drum shall deform and become detached from the base allowing vehicles to easily pass over the remaining base.

(5) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new drums and a Type 7 material certification for all used drums before use.

(6) Approval

All materials are subject to the approval of the Engineer.

(B) Skinny Drums

(1) General

Provide skinny drums composed of a body, alternating orange and white stripes of Type III-High Intensity or higher prismatic retroreflective sheeting and ballasts

(2) Body

Provide a skinny drum made of orange, impact resistant, ultraviolet plastic material capable of maintaining its integrity upon impact throughout a temperature range of - 20°F to 125°F. When struck, the skinny drum shall not permanently distort to a degree that would prevent reuse, nor roll excessively after impact. Design the skinny drum to prevent water from accumulating and freezing in the top or bottom.

Provide a skinny drum that is cylindrical in shape with the following dimensions; a minimum height of 42 inches, a minimum top outer diameter of 4 inches and a bottom outer diameter of 7.5 inches. The top outer diameter shall not exceed the bottom outside diameter. Provide closed tops on drums to prevent accumulation of debris.

(3) Retroreflective Stripes

Provide at least four retroreflective bands with two orange and two white alternating horizontal circumferential bands for each skinny drum. The top band shall always be

orange. Use a 6 inch to 8 inch wide band Type III–High Intensity or higher prismatic retroreflective sheeting that meets Article 1092-2 for each band. Do not exceed 2 inches for any non-retroreflective spaces between orange and white stripes. Do not splice the retroreflective sheeting to create the 6 inch band. Apply the retroreflective sheeting directly to the skinny drum surface. Do not apply the retroreflective sheeting over a pre-existing layer of retroreflective sheeting. Do not place bands over any protruding corrugation areas. No damage to the reflective sheeting should result from stacking and unstacking the skinny drums, or vehicle impact.

(4) Ballast

Ballast skinny drums using a preformed base specifically designed for the model skinny drum. Each base shall be at least 15 lb and circular or polygonal with equal sides. When properly ballasted, the skinny drums shall be wind resistant to the extent of withstanding wind created by traffic under normal roadway conditions, including high speed truck traffic in close proximity to the skinny drums. Do not place ballast on top of the drum. Upon impact, the main body of the drum shall deform and become detached from the base allowing vehicles to easily pass over the remaining base.

(5) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new skinny drums and a Type 7 material certification for all used skinny drums before use.

(6) Approval

All materials are subject to the approval of the Engineer.

(C) Cones

(1) General

Use cones made of ultraviolet stabilized plastic impact resistant material meeting MUTCD and this article. Orange will be the predominant color on cones.

Use cones conical in shape with a minimum height of 28 inches or 36 inches. The 28 inch cones shall have a minimum base dimension of 13.75 inches, and the 36 inch cones shall have a minimum base dimension of 14.5 inches as shown in the *Roadway Standard Drawings*. The 28 inch and 36 inch cones (excluding ballast) shall have a minimum weight of 7 lbs. and 10 lbs. respectively. When in an upright position, have the cones display the same dimensions regardless of their orientation to oncoming traffic.

(2) Ballasts

Provide wind resistant cones that do not blow over under normal roadway conditions, including high speed truck traffic in close proximity to the cones when properly ballasted. Provide cones that do not permanently distort to a degree that would prevent reuse when struck.

Achieve ballasting of the cones by using any of the following methods:

(a) Cones with bases that may be filled with ballast,

(b) Doubling the cones or using heavier weighted cones, or

(c) Cones with special weighted bases or weights such as rubber rings that can be dropped over the cones and onto the base to provide increased stability.

(3) Retroreflective Sheeting

Where retroreflective cones are required, provide a cone with flexible, prismatic cone sheeting having impact resistance and attached with precoated pressure sensitive adhesive. The retroreflective sheeting shall meet or exceed the retroreflectivity

requirements of Grade B sheeting in Article 1092-2. Use two retroreflective bands, the top one is 6 inches wide and the bottom one is 4 inches wide; see *Roadway Standard Drawings*.

(4) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new cones with or without retroreflective sheeting and a Type 7 material certification for all used cones with or without retroreflective sheeting before use.

(5) Approval

All materials are subject to the approval of the Engineer.

1089-6 FLASHING ARROW BOARDS

(A) General

Provide a trailer mounted arrow board that meets or exceeds the physical and operational requirements of the MUTCD and found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL.

The following specifications supplement those basic requirements. Provide a totally mobile complete unit capable of being located as traffic conditions demand.

The display housing shall meet the minimum size requirements of a Type C panel with a 15 or 25 lamp configuration.

The display housing shall have a hand-crank mechanism to allow raising and lowering the display with a locking device to ensure the display housing will remain secured in either position

The display housing will have a minimum height of 7 feet from the bottom of the sign to the ground when raised in the upright position.

The display housing assembly shall be of weather resistant construction.

The lamps shall be controlled to provide the following modes as a minimum: Flashing Right or Left Arrow, Flashing Double Arrow and Caution Mode (four outermost corner lamps).

(B) Power System

Provide a unit that is solar powered and supplemented with a battery backup system that includes a 110/120 VAC powered on-board charging system.

The unit shall also be capable of being powered by standard 110/120 VAC power source.

The batteries, when fully charged, shall be capable of powering the display for 20 continuous days with no solar power.

Store the battery bank and charging system in a lockable, weather and vandal resistant box.

(C) Controller

Provide automatic brightness/dimming of the display and a manual override dimming switch.

The controller shall provide a battery-charge status indicator.

Mobile radio or any other radio transmissions shall not affect the controller.

Store the controller in a lockable, weather and vandal resistant box.

(D) Trailer

Finish all exterior metal surfaces with Federal orange enamel per AMS-STD-595, color chip ID# 13538 or 12473 respectively. The trailer shall be able to support a 100 mph wind load with the display fully extended.

The trailer shall be equipped with leveling jacks capable of stabilizing the unit in a horizontal position when located on slopes 6:1 or flatter.

The trailer shall be properly equipped in compliance with North Carolina Law governing motor vehicles.

Provide a minimum 4 inch wide strip of fluorescent orange retroreflective sheeting to the frame of the trailer. Apply the sheeting to all sides of the trailer. The retroreflective sheeting shall be Grade C that conforms to Article 1092-2. Drums may be supplemented around the unit in place of the sheeting.

(E) Reliability

Provide a sign unit that all components are rated to operate at temperatures ranging from -30°F to 165°F.

The sign manufacturer shall notify the Work Zone Traffic Control Unit whenever modifications are made to a prequalified sign on the NCDOT APL.

The Work Zone Traffic Control Unit will review changes and per its discretion either make no change to the sign's status or remove it from the list until the sign can be reevaluated.

(F) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new flashing arrow boards, a Type 7 material certification for all used flashing arrow boards, and wind load certifications required in Subarticle 1089-6(D) for all new and used flashing arrow boards before use.

(G) Approval

The sign shall be on the NCDOT APL before use on construction projects in North Carolina. A sign may be removed from the NCDOT APL due to unsatisfactory field performance and shall not return to the list until the manufacturer identifies the reason for the failure and the problem has been corrected to the satisfaction of the Department.

The sign manufacturer shall notify the Department whenever modifications are made to their sign that was prequalified on the NCDOT APL. The Department will review changes and per its discretion, either make no change to the sign's status on the NCDOT APL or remove the sign from the list until the sign can be reevaluated.

1089-7 PORTABLE CHANGEABLE MESSAGE SIGNS

(A) General

Provide trailer or truck mounted portable changeable message signs that meet MUTCD and found on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL.

A trailer mounted portable changeable message sign shall be a totally mobile complete sign unit capable of being located as traffic conditions demand.

(B) Display Panel

Provide sign capable of sequentially displaying at least 2 phases of 3 lines of a programmable message with at least 8 characters per line and a character height of at least 18 inches.

The display characters will be composed of LED elements. The display panel may be of the following types- Full Matrix, Continuous Line Matrix, and Character Matrix.

Messages are to be automatically centered and proportionally spaced on each line of a Full Matrix and Continuous Line Matrix displays. Character Matrix displays shall display odd number character messages one character left of the centerline.

The display characters shall be protected with a polycarbonate lens that shall not decrease the daytime visibility of the sign.

The display panel shall have an electro-hydraulic system to allow raising and lowering the display with 360° rotation capability. The distance from the bottom of the sign to the ground shall be at least 7 feet. A locking device(s) shall be provided to ensure the display will remain secure in the raised, lowered and rotated positions. The sign shall have the capability to be raised and rotated to its operating position by one person.

A manual backup mechanism for the raising and lowering the display panel shall be provided in the event the electro-hydraulic system fails.

The display panel assembly shall be of weather resistant construction

(C) Power System

The unit shall be Solar powered and supplemented with a battery backup system which includes a 110/120 VAC powered on-board charging system.

The batteries, when fully charged, shall be capable of powering the display for 20 continuous days with no solar power. The unit shall be capable of being powered by standard 110/120 VAC power source.

Store the battery bank and charging system in a lockable, weather and vandal resistant box.

(D) Controller

The controller shall be capable of being equipped with the necessary hardware and software to allow wireless communication with other portable changeable message signs or other components of an intelligent transportation system. The controller shall also provide at a minimum; a keyboard, a display for message review and editing, a light source for nighttime operations, an event time clock and all other required controls for the operation of the display. Program each controller with password protection that will deter unauthorized programming of the controller. Change the controller password from the factory default and periodically change the controller password to deter unauthorized programming of the controller. The password system is recommended to include at least two levels of security such that operators at one level may only change message sequences displayed using preprogrammed sequences and operators at a higher level may create and store messages or message sequences.

The controller shall include the following capabilities; manually dimming the display, storing at least 99 user generated messages, adjusting the flash rate of display and display phasing and monitoring battery-charge status.

Mobile radio or any other radio transmissions shall not affect the controller.

The controller shall be stored in a locked, weather and vandal resistant box when not in use and after changes to the messages are made.

The controller shall be pre-programmed with messages shown below and stored in memory:

MAX SAFE SPEED 25 MPH	MAX SAFE SPEED 30 MPH
STOP AHEAD	YIELD AHEAD
MAX SAFE SPEED 35 MPH	MAX SAFE SPEED 40 MPH
MAX SAFE SPEED 45 MPH	MAX SAFE SPEED 50 MPH
ONE LANE BRIDGE	SURVEY CREW
MAX SAFE SPEED 55 MPH	DETOUR AHEAD
CAUTION DETOUR AHEAD	LANE CLOSED AHEAD
RIGHT LANE CLOSED	LEFT LANE CLOSED
CENTER LANE CLOSED	SINGLE LANE AHEAD
MERGE LEFT	MERGE RIGHT
KEEP LEFT	KEEP RIGHT
PASS LEFT	PASS RIGHT
USE LEFT LANE	USE RIGHT LANE
MERGE AHEAD	ROAD MACHINES AHEAD
ROAD WORK AHEAD	FLAGGER AHEAD
BUMP	DIP
STOP AHEAD	YIELD AHEAD
BE PREPARED TO STOP	SIGNAL AHEAD
SIGNAL NOT WORKING	DO NOT PASS
ONE LANE BRIDGE	SURVEY CREW
SHOULDER WORK	SOFT SHOULDER
PAVEMENT ENDS	LANE ENDS
ROAD CLOSED 1/4 MILE	ROAD CLOSED 1/2 MILE
ALL TRAFFIC EXIT LEFT	ALL TRAFFIC EXIT RIGHT
ROAD NARROWS	ROAD CLOSED AHEAD
RAMP CLOSED	REDUCE SPEED
ROAD PAVING AHEAD	ALL TRAFFIC MUST STOP
SLOW MOVING TRAFFIC	NIGHT WORK AHEAD
CAUTION FLAGGER AHEAD	RUNAWAY TRUCK RAMP
MEDIAN WORK AHEAD	
LEFT LANE NARROWS	RIGHT LANE NARROWS
TEST PATTERN A[A]	TEST PATTERN B[B]

A. Test Pattern A is 1/2 of the LEDs on at a time.

B. Test Pattern B is for the remaining 1/2 of the LEDs on at a time.

(E) Trailer

Finish all exterior metal surfaces with Federal orange enamel per AMS-STD-595; color chip ID# 13538 or 12473 respectively except for the sign face assembly that shall be flat black.

Provide a minimum 4 inches wide strip of fluorescent orange retroreflective sheeting to the frame of the trailer. Apply the sheeting to all sides of the trailer. The retroreflective sheeting shall be Grade C that conforms to Article 1092-2. Drums may be supplemented around the unit in place of the sheeting.

The trailer shall be able to support a 100 mph wind load with the display fully extended.

The trailer shall be equipped with leveling jacks capable of stabilizing the unit in a horizontal position when located on slopes 6:1 or flatter.

The trailer shall be properly equipped in compliance with North Carolina Law governing motor vehicles.

(F) Reliability

Provide a sign unit that all components are rated to operate at temperatures ranging from -30°F to 165°F.

(G) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new changeable message signs, a Type 7 material certification for all used changeable message signs and wind load certifications required in Subarticle 1089-7(E) for all new and used changeable message signs before use.

(H) Approval

The sign shall be listed on the NCDOT APL before use on construction projects in North Carolina. A sign may be removed from the NCDOT APL due to unsatisfactory field performance and shall not return to the list until the manufacturer identifies the reason for the failure and the problem has been corrected to the satisfaction of the NCDOT.

The sign manufacturer shall notify NCDOT whenever modifications are made to their sign that was prequalified on the NCDOT APL. The Department will review changes and per its discretion will either make no change to the sign's status on the NCDOT APL or remove the sign from the list until the sign can be reevaluated.

1089-8 TEMPORARY CRASH CUSHIONS

(A) General

Provide temporary crash cushions that meet Test Level II for work zones that have a posted speed limit of 45 mph or less. Provide temporary crash cushions that meet Test Level III devices for work zones that have a posted speed limit of 50 mph or greater.

Use temporary crash cushions as found on the NCDOT APL. Products manufactured prior to December 31, 2018 shall meet NCHRP 350 or MASH crash requirements for Category III work zone devices.

Provide redirective temporary crash cushions or non-directive temporary crash cushions that capture errant vehicles without complete penetration through the device.

The temporary crash cushion shall contain the debris resulting from impact within the structure of the temporary crash cushion.

Include in the temporary crash cushion package any required rear transition panels to connect the back of the temporary crash cushion to rigid or flexible barrier systems. Include any required portable base, as recommended by the manufacturer of the temporary crash cushion, to connect the bottom of the temporary crash cushion to a paved surface. Temporary crash cushion shall not be placed on an unpaved surface.

(B) Retroreflective End Treatments

Provide a yellow nose wrap that visually matches the color chip that corresponds to the AMS-STD-595 for Yellow (Color No. 13538) for all temporary crash cushions.

The retroreflective end treatment shall meet the requirement for retroreflectivity in Article 1088-1 and *Roadway Standard Drawings*.

(C) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new temporary crash cushions and a Type 7 material certification for all used temporary crash cushions before use.

(D) Approval

Use temporary crash cushions listed on the NCDOT APL.

1089-9 ATTENUATORS

(A) General

Provide truck mounted attenuators that meet Test Level II for work zones that have a posted speed limit of 45 mph or less. Provide truck mounted attenuators that meet Test Level III for work zones that have a posted speed limit of 50 mph or greater.

Use attenuators as found on the NCDOT APL. Products manufactured prior to December 31, 2018 shall meet NCHRP 350 or MASH crash requirements for Category III work zone devices.

Use trucks with gross vehicle tare weight as described in the NCHRP 350 crash test for the impact attenuator provided. Provide truck in accordance with the manufacturer's specifications. Ballasting methods are not permitted.

Use the attenuator in accordance with the manufacturer's specifications. Provide truck mounted attenuators with standard trailer lighting systems, including brake lights, tail lights and turn signals.

(B) Retroreflective End Treatment

The retroreflective end treatment shall meet Article 1088-1 and *Roadway Standard Drawings*.

(C) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new truck mounted attenuators and a Type 7 material certification for all used truck mounted attenuators before use.

(D) Approval

Use truck mounted attenuators listed on the NCDOT APL.

1089-10 FLAGGER

(A) 24 Inch Stop and Slow Paddle

(1) Retroreflective Sheeting

Use retroreflective sheeting with a smooth, sealed outer surface that will display the same color both day and night. Cover the entire sign face with Grade B retroreflective sheeting. Retroreflective sheeting shall meet Article 1092-2. The distance from the bottom of the sign to the ground shall be at least 6 feet.

(2) Material Certification

Furnish a Type 3 material certification in accordance with Article 106-3 for all new reflective sheeting used on flagger paddles and a Type 7 material certification for all used sheeting before use.

(3) Approval

All materials are subject to the approval of the Engineer.

(B) Vest

(1) Apparel Materials

Use highly-visibility safety apparel that meets the Performance Class 2 or higher requirements of the ANSI/ISEA 107-2010 or the equivalent revision. For nighttime flagging operations, Performance Class 3 safety apparel is required.

(2) Apparel Verification

All safety apparel shall have the original tag or label indicating that it meets the requirements of the ANSI/ISEA 107-2010 or the equivalent revision. Approval

All safety apparel is subject to the approval of the Engineer.

SECTION 1090
PORTABLE CONCRETE BARRIER

1090-1 PORTABLE CONCRETE BARRIER

(A) General

Use portable concrete barrier that meets Section 854, Section 1077 and the plans. The requirement for approved galvanized connectors will be waived if the barrier remains the property of the Contractor.

Use portable concrete barrier as found on the NCDOT APL. Products manufactured prior to December 31, 2019 shall meet NCHRP 350 or MASH crash requirements for Category III work zone devices.

(B) Material Certifications

All portable concrete barriers will have either a RFID tag/label tagged in accordance with Section 1030 applied in accordance with Subarticle 1030-2(F) or a certification. If the portable concrete barrier does not have an RFID tag/label, furnish a Type 3 material certification in accordance with Article 106-3 for all new portable concrete barrier and a Type 7 material certification for all used portable concrete barrier before use.

(C) Anchor Bolts

Use anchor bolts that meet ASTM F3125.

(D) Approval

All materials are subject to the approval of the Engineer.

SECTION 1091
ELECTRICAL MATERIALS

1091-1 GENERAL REQUIREMENTS

(A) New Materials

Furnish new equipment, materials and hardware unless otherwise specified.

(B) Electrical Industry Standards

Provide electrical materials in accordance with the appropriate UL standard when such standard is identified in the plans. All electrical materials shall be listed with a qualified testing laboratory that is approved by the North Carolina Department of Insurance, Office of State Fire Marshal such as UL, Intertek, ETL or CSA.

(C) Certification

Furnish a Type 3 material certification in accordance with Article 106-3.

1091-2 Wire and Cable

Use only stranded copper conductors, unless otherwise shown in the contract Provide wire and cable with identification labels or tags on either the wire or cable itself or on the coil, reel or smallest container in which the product is packaged when delivered to the project. Show the manufacturer's name, gauge, UL symbol and type of wire or cable on the identification label or tag. When requested by the Department, furnish samples of wire and cable to the Department at no additional cost.

Use wire and cable of the type and size shown in the contract meeting the following applicable UL standards at minimum: 44, 83, 493, 719, 854, 1063 and 1581.

Where required by the plans, use soft or annealed solid bare copper wire conforming to ASTM B3.

1091-3 CONDUIT

(A) Conduit Bodies, Boxes and Fittings

Use conduit bodies, boxes, and fittings that meet UL Standard 514A or 514B for electrical and communications installations.

(B) Rigid Metallic Conduit

Provide rigid hot dipped galvanized steel conduit that meets UL Standard 6 with rigid full weight sherardized or galvanized threaded fittings.

(C) PVC Conduit

Provide non-metallic conduit and duct including associated couplings, approved for above and below ground use with or without concrete encasement in accordance with UL Standard 651. Provide Schedule 40 conduit unless otherwise specified.

(D) Liquid-Tight Flexible Metal Conduit (LFMC)

Provide conduit that meets UL Standard 360. If used as an equipment grounding conductor, LFMC must meet the equipment grounding requirements of the NEC. Ensure conduit has insulated throat and malleable iron watertight fittings.

(E) Liquid-Tight Flexible Nonmetallic Conduit

Provide conduit that meets UL Standard 1660.

(F) Solid Wall HDPE Conduit

Use HDPE conduit that conforms to UL Standard 651A. Provide conduit meeting Table 1091-1 with minimum wall thickness ratios corresponding to EPEC-40 (Schedule 40), EPEC-80 (Schedule 80) or EPEC-B (SDR 13.5) as listed in UL Standard 651A and Table 1091-1.

TABLE 1091-1
HDPE CONDUIT SIZE

Conduit Trade Size	Furnish
1"	EPEC-40
1 1/4"	EPEC-40
1 1/2"	EPEC-B (SDR 13.5)
2"	EPEC-B (SDR 13.5)
2 1/2"	EPEC-B (SDR 13.5)
3"	EPEC-B (SDR 13.5)
4"	EPEC-B (SDR 13.5)
5"	EPEC-80
6"	EPEC-80

Ensure the polyethylene (PE) resin compounds used in manufacturing the conduit meet or exceed the cell classification PE 334480C (black with 2% minimum carbon black) or PE 334480E (colored conduit with UV inhibitors) in ASTM D3350 and Table 1091-2.

TABLE 1091-2 RESIN PROPERTIES		
Property	**Requirement**	**Test Method**
Density	0.940 - 0.947g/cm^3	ASTM D1505 ASTM D792 ASTM D4883
Melt Index (condition 190/2.16 is acceptable)	< 0.4 grams/10 minutes	ASTM D1238
Flexural Modulus	80,000 psi, min.	ASTM D790
Tensile Strength	Tensile Strength 3,000 psi, min.	ASTM D638
Elongation	Elongation 400%, min.	ASTM D638
Slow Crack Growth Resistance	An ESCR as per condition B, 10% IGEPAL requirement of F_{10}>96 hrs is allowable	ASTM D1693
Hydrostatic Design Basis	"0" for Non-Pressure Rated Pipe	ASTM D2837
UV Resistance (Outdoor Conduit Only)	Stabilize with at least 2% by weight carbon black or colored with UV Inhibitor	ASTM D4218

Furnish conduits in the colors for the applications shown in Table 1091-3. For conduits manufactured with stripes, ensure that a minimum of three stripes are uniformly spaced around the conduit with 120 degrees of separation. Do not use "Solid Yellow" or "Black with Yellow Stripes" conduit.

TABLE 1091-3 CONDUIT COLORS		
Conduit Contents	**Preferred Solid Color**	**Alternate**
Signal Cable	Black	None
Loop Lead-in Cable	White	Black with White Stripes
Communication Cable (Copper, Fiber-Optic, Coaxial)	Orange	Black with Orange Stripes
Electrical Power Cable	Red	Black with Red Stripes

Ensure the HDPE conduit is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil, gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate and transformer oil and is protected against degradation due to oxidation and general corrosion.

Furnish conduit with a coefficient of friction of 0.10 or less in accordance with Telcordia GR-356.

Ensure the supplied conduit is identified and certified as meeting, UL Standard 651A. Ensure the conduit is marked at least with the following information on 5 feet or less intervals:

(1) Material: HDPE

(2) Trade Size: i.e., 2 inches

(3) Conduit Type: SDR 13.5 or EPEC-B

(4) Manufacturer's name or trademark

(5) Manufacturer's production code to identify manufacturing date, facility, etc.

(6) NRTL symbol or listing number

Furnish coilable conduit that is supplied on reels in continuous lengths for transportation and storage outside. Ensure that the process of installing the coilable conduit on the reel does not alter the properties or performance of the conduit for its intended purpose.

(G) Conduit Plugs, Pull Line and Tracer Wire

Furnish conduit plugs that provide a watertight barrier when installed in conduit. Furnish conduit plugs sized in accordance with conduit. Ensure conduit plug provides a means to secure a pull line to the end of the plug. Provide removable and re-usable conduit plugs. Conduit plugs are not required to be listed electrical devices.

For all spare conduits, furnish woven polyester pull tape with a minimum rated tensile strength of 2,500 lbs. Pull lines are not required to be listed electrical devices.

Provide green insulated number 14 AWG, THWN, stranded copper wire to serve as tracer wire.

1091-4 DUCT AND CONDUIT SEALER

Use duct and conduit sealer or mastic which is a putty-like compound and:

(A) Is permanently non-hardening, non-oxidizing, and non-corrosive to metals, rubber, plastic, lacquer and paints;

(B) Is readily workable for thumbing into openings and forming into seals around wires inside conduits and openings around conduits;

(C) Has a service temperature range of minus 30°F to 200°F;

(D) Is clean, non-poisonous and non-injurious to human skin;

(E) Seals against water, dust and air and shall adhere to wood, glass, plastics, metal, rubber and painted surfaces; and

(F) Is non-conductive.

1091-5 ELECTRICAL JUNCTION BOXES

(A) General

Provide electrical junction boxes with covers of the type and size indicated by the contract or plans for the termination of conduits.

(B) Polymer Concrete (PC) Junction Boxes

Provide polymer concrete (PC) boxes which have bolted covers and open bottoms. Provide vertical extensions of 6 inches to 12 inches as required by project provisions.

Use polymer concrete material made of an aggregate consisting of sand and gravel bound together with a polymer and reinforced with glass strands to fabricate box and cover components which are exposed to sunlight. Other thermoplastic materials may be used for components which are not normally exposed to sunlight.

Provide certification that the polymer concrete boxes and covers meet Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are compliant with ANSI/SCTE 77.

Provide the required logo on the cover. Provide at least two size 3/8 inch diameter hex head stainless steel cover bolts to match inserts in the box. Provide pull slot(s) with stainless steel pin(s). Polymer concrete junction boxes are not required to be listed electrical devices.

(C) Cast Metal (BR/SW) Junction Boxes

Provide three-piece cast-metal barrier rail (BR) box with replaceable flange, or two-piece cast metal side walk (SW) box with non-replaceable flange, as shown in the plans. The

box shall be hot dipped galvanized with factory or field drilled conduit entrances. Provide a hot dipped galvanized cover with checkered imprint, pry bar slots, and reinforcing ribs for heavy loading, neoprene gasket, and brass or stainless steel bolts. Provide a blind tapped (1/4 inch NC thread minimum) boss on interior of box for grounding.

1091-6 GROUNDING ELECTRODES

Provide grounding electrodes of the following types as indicated in the specifications and plans.

(A) Ground Rods

Provide 5/8 inch diameter, 10 feet long, copper-clad steel ground rods with 10 mil thick copper cladding.

(B) Sectional Ground Rods

Provide sectional ground rods comprised of 5/8 inch diameter, 10 feet long, steel ground rods with 10 mil thick copper cladding, welded together in a butt configuration with an exothermic weld. As an alternative, provide UL listed bronze couplers designed to connect 5/8 inch diameter copper-clad steel rods. Do not use threaded ground rods or threaded couplers. Provide minimum lengths required by plans.

SECTION 1092
SIGNING MATERIALS

1092-1 SIGNS AND HARDWARE

Fabricate signs from aluminum alloy sheets. Use supporting frames and accessories made of aluminum. Use galvanized steel backing plates and mounting bolts. Use materials that conform to Tables 1092-1 and 1092-2.

Filler metal shall conform to AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, and the Interim Specifications as shown on the plans.

Aluminum sign studs, welded to the sign panels in accordance with Article 901-3, shall be capable of withstanding a direct pull-out load of 400 lb. Furnish a Type 3 material certification in accordance with Article 106-3 demonstrating conformance to this requirement. The Materials and Tests Unit will take samples of the studs and make random field tests of the welded studs to verify the statement of certification. Failure of more than 5% of the studs tested on any one sign or failure of 3 or more studs in a row will be sufficient evidence for rejection of stud welding on the entire sign. When tested in tension, the studs shall not fail in the weld area, but fail in the threaded portion of the stud. Corrective actions will be determined by the Engineer.

Drill bolt holes and slots to finished size or they may be punched to finished size, provided the diameter of the punched holes is at least twice the thickness of the metal being punched. Flame cutting of bolt holes and slots will not be permitted. No galvanizing of any steel part will be allowed until all welding, cutting, milling, punching, and drilling of the part has been completed.

TABLE 1092-1 ALUMINUM SIGN MATERIALS		
Aluminum Materials	**Alloy Specification**	**Test Method**
Extruded Bars	6061-T6	ASTM B221
Sheets and Plates	6061-T6,5052-H38 or 3004-H38	ASTM B209
Structural Shapes	6061-T6	ASTM B308
Standard Weight Pipe	6061-T6	ASTM B241
Castings	356-T7	ASTM B26
Bolts	6061-T6, 2024-T4[A]	ASTM B211
Nuts (1/4" Tap and under)	2024-T4[A], 6061-T6 or 6262-T9	ASTM B211
Nuts (5/16" Tap and over)	2024-T4[A], 6061-T6 or 6262-T9	ASTM B211
Nuts (3/8" Self-locking)	2017-T4, 6061-T6	ASTM B211
Washers (std. flat) Alclad	2024-T4[A] or 6061-T6	ASTM B209
Washers (std. lock)	7075-T6	ASTM B211
Welded Studs (1/4")	5356-H12 or 5356-H32	ASTM B211

A. The alloy shall have anodic coating of 0.0002 inch minimum thickness with dichromate or boiling water seal

TABLE 1092-2 STEEL SIGN MATERIALS		
Galvanized Steel Materials	**Test Method for Base Metal**	**Test Method for Galvanizing**
Structural Shapes and Plates	ASTM A36	ASTM A123
Standard Weight Black Pipe	ASTM A53	ASTM A123
Bolts and Nuts	ASTM A307	ASTM F2329
Washers (std. flat and lock)	ASTM A307	ASTM F2329
High Strength Bolts, Nuts and Washers	ASTM A325	ASTM B695 Class 55

1092-2 RETROREFLECTIVE SHEETING

Reflectorize all signs. Use colors and sheeting grades of the sign backgrounds and messages as shown in the contract. After preparation of the sign panels, in accordance with Subarticle 901-3(D), apply retroreflective sheeting as required herein. The retroreflective sheeting shall consist of white or colored sheeting having a smooth outer surface and the property of a retroreflector over its entire surface.

Retroreflective sheeting shall meet ASTM D4956 and be listed on the NCDOT APL. Products must be current with the applicable AASHTO Product Evaluation & Audit Solutions workplan to remain on the NCDOT APL.

The reflective material specified herein is intended for use on surfaces of various traffic control devices, including drums, barricades, traffic cones and highway signs, to assure their adequate visibility at all times upon exposure to a light source when totally dry or wet. Provide reflectorization that produces a wide-angle retroreflectivity, enhancing nighttime visibility. This retroreflective sheeting shall consist of encapsulated, enclosed lens or prismatic with a transparent plastic having a smooth, flat outer surface. Provide material that is flexible, of good appearance, free from ragged edges, cracks and extraneous materials, and exhibits good quality workmanship.

(A) Performance and Test Requirements

TABLE 1092-3 MINIMUM COEFFICIENT OF RETROREFLECTION FOR NC GRADE A (Candelas Per Lux Per Square Meter)								
Observation Angle, degrees	**Entrance Angle, degrees**	**White**	**Yellow**	**Green**	**Red**	**Blue**	**Fluorescent Yellow Green**	**Fluorescent Yellow**
0.2	-4.0	525	395	52	95	30	420	315
0.2	30.0	215	162	22	43	10	170	130
0.5	-4.0	310	230	31	56	18	245	185
0.5	30.0	135	100	14	27	6	110	81
1.0	-4.0	80	60	8	16	3.6	64	48
1.0	30.0	45	34	4.5	9	2	36	27

TABLE 1092-4 MINIMUM COEFFICIENT OF RETROREFLECTION FOR NC GRADE B (Candelas Per Lux Per Square Meter)									
Observation Angle, degrees	**Entrance Angle, degrees**	**White**	**Yellow**	**Green**	**Red**	**Blue**	**Fluorescent Yellow Green**	**Fluorescent Yellow**	**Fluorescent Orange**
0.2	-4.0	380	285	38	76	17	300	230	115
0.2	30.0	215	162	22	43	10	170	130	65
0.5	-4.0	240	180	24	48	11	190	145	60
0.5	30.0	135	100	14	27	6	110	81	30
1.0	-4.0	80	60	8	16	3.6	64	48	7.5
1.0	30.0	45	34	4.5	9	2	36	27	5.6

TABLE 1092-5 MINIMUM COEFFICIENT OF RETROREFLECTION FOR NC GRADE C (Candelas Per Lux Per Square Meter)							
Observation Angle, degrees	**Entrance Angle, degrees**	**White**	**Yellow**	**Green**	**Red**	**Blue**	**Brown**
0.2	-4.0	250	170	45	45	20	12
0.2	30.0	150	100	25	25	11	8.5
0.5	-4.0	95	62	15	15	7.5	5
0.5	30.0	65	45	10	10	5	3.5

For areas printed with transparent colors, the coefficient of retroreflection shall not be less than 70% of the values for the corresponding color.

(1) Adhesive

Meet ASTM D4956.

(2) Field Performance

The fabricator shall date all signs (month, year) at the completion of fabrication. That date constitutes the start of the field performance obligation period.

The installer shall date all signs (month, year) at the completion of installation.

(B) Manufacturer's Warranty and Obligations

(1) Warranty

The sheeting manufacturer warrants to the Department that all materials furnished under this Specification will be new, of good components and workmanship and agrees to the following conditions.

Retroreflective sheeting processed and applied to sign blank materials in accordance with the manufacturer's manuals shall be warranted by the manufacturer to perform effectively as stated in this section. The manufacturer's manuals shall contain a complete descriptive explanation of all the requirements necessary of the sign fabricator.

(2) Obligation Grades A, B and C

(a) Years 1 through 7 (Years 1 Through 2 for Fluorescent Orange)

Cover the cost of restoring the sign face in its field location to its original effectiveness at no cost to the Department for materials, labor and equipment. In addition to the reflective requirements for Grade B fluorescent orange, the sheeting shall at least maintain a total Luminance Factor (Y) of 25 in accordance with ASTM D4956 and a Fluorescence Luminance Factor (YF) of 13% in accordance with ASTM E2301 for 3 years. Maintain at least 80% of fluorescent orange sheeting reflectivity for years 1 and 2.

(b) Years 8 through 10 (Year 3 for Fluorescent Orange)

Replace the sheeting required to restore the sign face to its original effectiveness. Maintain 50% of fluorescent orange sheeting reflectivity for year 3.

(c) Years 11 through 12

Replace 50% of the sheeting required to restore the sign face to its original effectiveness.

1092-3 CERTIFICATION

Provide a Type 6 material certification in accordance with Article 106-3 for all retroreflective sheeting used in the manufacture of signs certifying that the sheeting meets Section 1092.

SECTION 1094
GROUND MOUNTED SIGNS

1094-1 GROUND-MOUNTED SIGN SUPPORTS

(A) Breakaway or Simple Steel Beam Sign Supports

Fabricators of breakaway or simple steel beam sign supports shall be AISC Category I certified.

Steel supports for Type A and B ground mounted signs shall be galvanized rolled steel sections, either breakaway or simple design, as required by the contract. Fabricate supports from plates, W shapes, and S shapes, as required by the contract, and they shall conform to ASTM A36. Splices in the supports will not be permitted. Perform galvanizing before assembly that conforms to ASTM A123. Cutting steel supports to length after they have been galvanized will not be permitted in new construction. The support(s) shall be

uniformly straight to within 1/8 inch tolerance for pieces less than 20 feet in length, and 1/4 inch tolerance for pieces over 20 feet in length.

Fabricate high strength bolts, nuts and washers required for breakaway supports from steel in accordance with ASTM F3125 and galvanize in accordance with ASTM B695, Class 55.

(B) 3 lb Steel U-Channel Supports

Make 3 lb steel U-channel supports out of rerolled rail steel or new billet steel, conforming to the mechanical requirements of ASTM A499, Grade 60, and the chemical requirements of ASTM A1, for rails having nominal weights of 91 lbs. per yard or greater. Proportion the cross section so a moment of 1,450 ft-lb, applied to the cross section normal to the flanges, will produce an extreme fiber stress no greater than 39,500 psi. Use posts that weight 3 lbs/lf. Punch or drill all posts with 3/8 inch diameter holes on the centerline, spaced 1 inch on centers, starting 1 inch from the top and extending to the bottom of the supports. Galvanize these posts after fabrication for the full length and total area in accordance with ASTM A123. The zinc coating inside of the 3/8 inch diameter holes shall not exceed specification requirements enough to prevent a 5/16 inch diameter bolt from freely passing through.

Use U-channel support sections of the same general configuration as that shown in the contract, however minor variations may be considered acceptable by the Engineer provided all other requirements are met.

(C) 2 lb Steel U-Channel Supports

Use 2 lb steel U-channel supports that are variable length galvanized steel, U-shaped channel supports.

Fabricate the U-channel supports from steel meeting ASTM A1008 or ASTM A499, or alternate approved by the Engineer. The posts shall weigh 2 lbs/lf, and be of the length necessary to meet the erection requirements of the contract. Before galvanizing, punch or drill 3/8 inch diameter holes on 1 inch centers, beginning 1 inch from the top of the post, for a minimum distance equal to the vertical dimension of the respective sign or mile marker. Galvanize these posts after fabrication in accordance with ASTM A123. The zinc coating inside of the 3/8 inch diameter holes shall not exceed Specification requirements enough to prevent a 5/16 inch diameter bolt from freely passing through.

U-channel support sections shall be of the same general configuration as that shown in the contract, however, minor variations may be considered acceptable by the Engineer, provided all other requirements are met.

(D) Steel Square Tube Supports

Use steel square tube supports of variable length galvanized steel. The support shall be a minimum 14 gauge steel square tube. Before galvanizing perforated square tubes punch or drill all posts with 7/16 inch diameter holes on the centerline, spaced 1 inch on centers on all four sides, starting 1 inch from the top and extending to the bottom of the posts.

Galvanize perforated supports after fabrication for the full length and total area in accordance with ASTM A653, Grade 50, meeting G90 galvanizing requirements. The zinc coating inside of the 7/16 inch diameter holes shall not exceed specification requirements enough to prevent a 3/8 inch diameter bolt from freely passing through.

Steel square tube support sections shall be of the same general configuration as that shown in the contract, however, minor variations may be considered acceptable by the Engineer, provided all other requirements are met.

(E) Wood Supports

Wood supports shall conform to Section 1082.

1094-2 RIVETS FOR SIGN OVERLAYS

Rivets for sign overlays shall be 1/8 inch diameter aluminum rivets of the pull through type, and be approved by the Engineer. Submit for approval several samples of rivets, along with adequate descriptive catalog literature.

SECTION 1096
OVERHEAD SIGN STRUCTURES

1096-1 ALUMINUM OVERHEAD SIGN STRUCTURES

Materials for aluminum overhead sign structures shall conform to Article 1092-1 and *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, and the Interim Specifications as shown on the plans. Where the Contractor proposes to use materials that are not covered by these references, such use will be contingent on the Engineer's approval of these materials.

1096-2 STEEL OVERHEAD SIGN STRUCTURES

Use Category I certified by the American Institute of Steel Construction Fabricators for steel overhead sign structures as required by Subarticle 1072-1(A). Use either structural carbon steel or structural low-alloy steel for steel overhead sign structures meeting *AASHTO LRFD Bridge Design Specifications*. Other steel may be used, subject to the approval of the Engineer. Structural steel that has been cold-rolled to increase the yield strength will be permitted. Mechanically galvanize all fasteners. Hot-dip galvanize all other components of the structural assembly after fabrication has been completed. The galvanizing shall meet ASTM B695, Class 55, for fasteners and ASTM A123 for other structural steel.

1096-3 WELDING

Perform all welding in the fabrication of the supports by AWS certified welders. Furnish a copy of the AWS certification for each welder used for fabrication. All welds shall be free of cracks, blow holes, slag, and other irregularities, and be wire brushed, sandblasted or otherwise cleaned. Refer to Article 1076-3 for additional requirements for galvanizing.

Aluminum welding processes and procedures, shielding gases, preparation, weld quality, inspection and correction of welds, and the qualification of welding procedures, welders and welding operators will be governed by the AWS Structural Welding Code, D1.2.

The welding of steel components, including structural details, filler metal, workmanship and technique, qualification and inspection will be based on the applicable requirements of the AWS Structural Welding Code, D1.1.

SECTION 1098
SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEM MATERIALS

1098-1 GENERAL REQUIREMENTS

(A) Qualified Products

Furnish new equipment, materials, and hardware unless otherwise required by the Engineer. Inscribe manufacturer's name, model number, serial number and any additional information needed for proper identification on each piece of equipment housed in a case or housing.

ITS and Signals Qualified Products List (QPL) is available on the Department's website.

Certain signal and communications equipment, material and hardware shall be pre-approved on the QPL by the date of installation. Equipment, material and hardware not pre-approved when required will not be allowed for use on the project. Consult the QPL website to obtain pre-approval procedures.

(B) Submittal Requirements

Furnish a Type 3 material certification in accordance with Article 106-3. When requested by the Department, provide additional certifications from independent testing laboratories and sufficient data to verify item meets applicable specifications. Ensure additional certification states the testing laboratory is independent of the material manufacturer and neither the laboratory nor the manufacturer has a vested interest in the other.

Identify all proprietary parts in Contractor-furnished material. The Department reserves the right to reject material that uses proprietary components not commercially available through electronic supply houses.

For Contractor-furnished material listed on the QPL, furnish submittals in the format defined by the QPL.

For Contractor-furnished material not on the QPL, furnish one electronic copy of the equipment list including three copies of catalog cuts. Identify proposed material on catalog cuts by a reproducible means (highlighter pen does not transfer to copies). Ensure material lists contain material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol and other appropriate ratings.

Submit for approval catalog cuts and/or shop drawings for materials proposed for use on the project. Allow 30 days for review of each submittal. Do not fabricate or order material until receipt of Engineer's approval.

Submit one electronic copy of each catalog cut and/or drawing and show for each component the material description, brand name, stock-number, size, rating, manufacturing specification and the intended use (identified by labeling all components with the corresponding contract line item number). Present the submittals neatly arranged in the same order as the contract bid items.

An electronic (PDF) copy of reviewed submittals will be returned to the Engineer from the ITS and Signals Unit.

(C) Observation Period

Warrant workmanship and Contractor-furnished equipment for a 30 day observation period under the payment and performance bond from date of acceptance.

If workmanship or equipment fails during the 30 day observation period, repair or replace with new equipment and begin a new 30 day observation period.

The observation period for this work is not part of the work to be completed by the project completion date.

(D) Warranties

Unless otherwise required herein, provide manufacturer's warranties on Contractor-furnished equipment for material and workmanship that are customarily issued by the equipment manufacturer and that are at least 2 years in length from successful completion of the 30 day observation period. Include unconditional coverage for all parts and labor necessary or incidental to repair of defective equipment or workmanship and malfunctions that arise during warranty period.

Ensure all contractor-furnished equipment, including pieces and components of equipment, hardware, firmware, software, middleware, internal components and subroutines, which perform any date or time data recognition function, calculation or sequencing will support a four digit year format for at least 50 years.

Upon successful completion of the 30 day observation period, transfer manufacturer's warranties with proper validation by the manufacturer to the Department or its designated maintaining agency.

(E) Firmware Licensing and Upgrades

Provide the Department with a license to duplicate all programmable devices in equipment for maintenance and software upgrades. Provide binary or hexadecimal format files for each device that may be programmed by the Department. Ensure files are provided on PC compatible approved media.

Ensure firmware performance upgrades that occur during the contract period are available to the Department at no additional cost.

Make firmware upgrades that are developed to correct operating characteristics available to the Department at no additional cost until the warranty period expires.

(F) Plan of Record Documentation

Before final acceptance, furnish plan of record documentation of all fieldwork. Plan of record documentation will be subject to approval before final acceptance. Store documentation in a manila envelope placed in a weatherproof holder mounted within each cabinet or housing for easy access.

Except for standard bound manuals, bind all 8 1/2 inches x 11 inches documentation, including 11 inches x 17 inches plans folded to 8 1/2 inches x 11 inches, in logical groupings in either 3-ring or plastic slide-ring loose-leaf binders. Permanently label each grouping of documentation.

Provide manual, electrical schematic diagram, and cabinet wiring diagram for each control equipment cabinet and piece of equipment in cabinet. Place manuals and prints in weatherproof holder. For wiring diagrams and electrical schematic diagrams not bound into printed manuals, provide copies at least 22 inches x 34 inches.

Provide Operator's Manuals containing detailed operating instructions for each different type or model of equipment. Ensure manuals contain instructions for possible modification to equipment.

Provide maintenance procedures manuals containing detailed preventive and corrective maintenance procedures for each different type or model of equipment.

Provide detailed wiring diagrams that include interconnection of equipment with pin-out configurations, pin functions, and cable part numbers. For communications systems, camera systems, video imaging loop emulator detection systems, intelligent transportation systems, closed loop signal systems and other computerized systems, provide one electronic copy of system connection diagrams showing system interconnection cables and associated terminations and place a hard copy in the cabinet.

(G) Wire and Cable

Furnish wire and cable on reels. When requested by the Department, furnish samples of wire and cable to the Department at no additional cost.

(H) Electrical Service for Traffic Signals

Furnish external electrical service disconnects with a single pole 50 A inverse time circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. For electrical service to an Advanced Transportation Controller (ATC) cabinet, provide a single pole 30 A inverse time circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating. Ensure service disconnects are listed as meeting UL Standard UL-489 and marked as being suitable for use as service equipment. Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils. Provide ground bus and neutral bus with at least 5 terminals with minimum wire capacity range of number 14 through number 4. Ensure each service has only one disconnecting

means in the enclosure. Place barriers in service equipment such that no uninsulated, ungrounded service busbar or service terminal is exposed.

Furnish NEMA 3R meter base rated 100 A minimum that meets the requirements of the local utility. Provide meter base with ampere rating of meter sockets based on sockets being wired with insulated wire rated at least 167°F.

Furnish four terminal, 600 volt, single phase, 3 wire meter base with the following:

(1) Line, Load and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire,

(2) Ringed or Ringless Type, with or without bypass,

(3) Made of galvanized steel,

(4) Listed as meeting UL Standard UL-414, and

(5) Overhead or underground service entrance as specified.

Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with minimum thickness of 2.4 mils.

Furnish 1 inch watertight hub for threaded rigid conduit with meter base.

If meter base and electrical service disconnect are supplied in the same enclosure, ensure assembly is marked as being suitable for use as service equipment. Ensure combination meter and disconnect mounted in a pedestal for underground service is listed as meeting UL Standard UL-231. Otherwise, ensure combination meter and disconnect is listed as meeting UL Standard UL-67.

(I) Painting

Where painting of signal equipment cabinets, signal heads, signal poles, and pedestals is required, apply paint at the factory. No field painting will be allowed except when paint has been scratched or marred. In such cases, apply two field coats of the same color and grade enamel as the original paint to the scratched or marred portions.

(J) Performance of Warranty Repair and Maintenance

Provide authorization to the Traffic Electronics Center of the NCDOT to perform all warranty repairs after project acceptance. The decision to perform warranty work at the Traffic Electronics Center by NCDOT electronics technicians or to have warranty work performed by the vendor shall be at the discretion of the State. Provide any training required by the manufacturer to authorize the Traffic Electronics Center to perform warranty work and ensure manufacturer will furnish parts to the Traffic Electronics Center for all warranty repairs at no cost to the State. In addition, ensure the manufacturer agrees to provide prompt technical support to the NCDOT electronics technicians for a period of one year after the end of the warranty period at no cost to the State. Defective parts replaced under warranty by the Traffic Electronics Center will be returned to the vendor at the vendor's request. Provide schematics, part lists, and other documentation to perform bench repair to the Traffic Electronics Center within 2 weeks upon request. The Department agrees not to divulge any proprietary information in the schematics, part lists and other documentation upon request from the vendor. After project acceptance and at the request of the State, manufacturer shall perform warranty repairs to equipment which fails during the warranty period at no cost to the State including freight costs to ship repaired equipment back to the Traffic Electronics Center. Ensure all equipment is repaired and returned to the Traffic Electronics Center within 21 calendar days of receipt by the manufacturer.

1098-2 SIGNAL CABLE

Furnish 16-4 and 16-7 signal cable that complies with IMSA specification 20-1 except provide the following conductor insulation colors:

(A) For 16-4 cable: white, yellow, red and green.

(B) For 16-7 cable: white, yellow, red, green, yellow with black stripe tracer, red with black stripe tracer, and green with black stripe tracer. Apply continuous stripe tracer on conductor insulation with a longitudinal or spiral pattern.

Provide a ripcord to allow the cable jacket to be opened without using a cutter. IMSA specification 19-1 will not be acceptable. Provide a cable jacket labeled with the IMSA specification number and provide conductors constructed of stranded copper.

1098-3 BACKPLATES

Comply with ITE standard *Vehicle Traffic Control Signal Heads*. Provide backplates specific to the manufacturer of the vehicle signal heads. Provide stainless steel fasteners and hardware for attachment to signal head. Provide backplates that extend at least 5 inches from the vehicle signal head outline. Ensure the backplate fills in the gaps between cluster-mounted vehicle signal sections (5-section vehicle signal heads). A 1/4 inch maximum gap between vehicle signal head and backplate, as viewed from the front, will be allowed.

Fabricate metallic backplates for vehicle signal heads from sheet aluminum at least 0.05 inch thick. Provide backplates painted an alkyd urea black synthetic baking enamel with minimum gloss reflectance that meets Federal Specification MIL-E-10169, Instrument Black.

Provide polycarbonate or vacuum formed ABS plastic or composite material backplates that are black on both the front and back sides with a consistent color throughout the entire piece for each backplate. Provide backplates that contain UV inhibitors and stabilizers for protection against UV degradation. Provide backplates that have a minimum tensile stress at yield of 5,300 psi at 73°F and meet UL Standard 94. Ensure polycarbonate backplates have a minimum thickness of 0.100 inch with one side dull black and the other side semi-gloss black. Ensure vacuum formed ABS plastic backplates have a minimum thickness of 0.125 inch with a hair cell finish on the front side and a smooth finish on the back side. Ensure composite material backplates have a polyethylene core with a minimum thickness of 0.074 inch surrounded by 2 aluminum sheets with each aluminum sheet at a minimum of 0.010 inch. Ensure the 2 aluminum sheets and the polyethylene core are bonded together with fluoropolymer or polyester coating on both outer sides for the composite material backplates.

Provide backplates with a florescent yellow retroreflective sheeting strip 2 inches wide, placed along the perimeter of the face of the signal backplate to reflect the profile of the signal head in low-light and darkness. Ensure connecting corner sections of the retroreflective sheeting strips are butt spliced with a minimum gap of 30 mil to a maximum gap of 45 mil. The sheeting strip shall meet the performance requirements of AASHTO M 268 Type D and ASTM D4956 Type X1 sheeting material. Ensure the retroreflective sheeting strip is applied in accordance with manufacturer's guidelines.

1098-4 MESSENGER CABLE

Comply with ASTM A475 for extra high strength grade wire strand, Class A zinc coating. Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

1098-5 RISER SEALING DEVICES

Furnish appropriately sized clamp-on aluminum weatherheads for electrical control and power cables.

Furnish heat shrink tubing for the installation of fiber-optic or coaxial cable in a new riser. Ensure the heat shrink tubing is made of modified polyolefin and includes a hot-melt adhesive. Provide tubing that has a length of at least 5 inches before heating. Ensure the heat shrink tubing will provide a watertight fit around individual cables and outer wall of the riser after heat is applied in accordance with the manufacturer's instructions.

Furnish heat shrink tubing retrofit kits for the installation of fiber-optic cable or coaxial cables to an existing riser with existing cables. Ensure the heat shrink material is made of modified polyolefin and is supplied in a flat sheet design. Ensure the kit contains an apparatus to secure

both ends of the flat sheet together to form a tube shaped cylinder. Ensure the securing apparatus is flexible to the point that it will allow the heat shrink material to conform to the shape and dimensions of the riser and cables once heat is applied and will not separate during the heating process. Provide heat shrink tubing retrofit kits with a hot-melt adhesive. Provide the flat sheet heat shrink material that has a minimum length of 5 inches prior to heating. Ensure the heat shrink tubing retrofit kit provides a watertight fit around individual cables and outer wall of the riser after heat is applied in accordance with the manufacturer's instructions.

1098-6 JUNCTION BOXES

(A) General

Comply with Article 1091-5.

(B) Standard Size Junction Boxes

Provide standard size junction boxes and covers with minimum inside dimensions of 16" (l) x 10" (w) x 10" (d).

(C) Oversized Junction Boxes

Provide oversized junction boxes and covers with minimum inside dimensions of 28" (l) x 15" (w) x 22" (d).

1098-7 POLE LINE HARDWARE

Provide universal grade strandvises used for extra high strength steel messenger cable.

Provide other pole line hardware constructed of hot-dipped galvanized steel conforming to ASTM A153.

Provide machine bolts, eyebolts and thimble eye bolts with minimum tensile strength of 12,400 lb. Provide hot-dipped galvanized nuts, 3 inches x 3 inches curved square washers and thimble eyelets.

Provide suspension clamp fabricated from hot-dipped galvanized steel with minimum length of 5 3/4 inches. Ensure clamp has a groove rated for the messenger cable size it is intended to secure. Provide J-hook fabricated from 3/8 inch thick hot-dipped galvanized steel flat or oval stock with sufficient hook radius to cradle 11/16 inch diameter cable. Provide two 1/2 inch diameter hot-dipped galvanized bolts and nuts to tighten the clamp around the messenger cable. Provide one 5/8 inch diameter hot-dipped galvanized bolt of sufficient length to attach J-hook and clamp to the wood pole with a 3 inch x 3 inch curved square washer and double nuts.

Provide 3-bolt clamp fabricated from hot-dipped galvanized steel with minimum length of 5 3/4 inches. Ensure clamp has two parallel grooves rated for the messenger cable size it is intended to secure. Provide three 5/8 inch diameter hot-dipped galvanized bolts and nuts to tighten the clamp around the messenger cable.

Provide parallel groove clamp consisting of high strength, high conductivity non-copper bearing aluminum alloy clamp halves with interlocking fingers to prevent mismatch. Ensure clamp halves have molded grooves to secure #8-1/0 AWG stranded copper wires. Provide clamps with grooves prefilled with antioxidant joint compound. Provide 3/8 inch hex head, square shank, galvanized steel bolt with galvanized steel lock washer and nut.

Provide 1/2 inch and 3/4 inch wide, .030 inch thick Type 316 stainless steel straps with Type 316 stainless steel buckles.

Provide either 0.05 inch x 0.30 inch aluminum wrapping tape or 0.06 inch diameter Type 316 stainless steel lashing wire for lashing cables to messenger cable. Ensure aluminum wrapping tape is 1350 alloy, O-temper, with 12,800 psi tensile strength. Use 0.045 inch diameter Type 316 stainless steel lashing wire to lash fiber-optic communications cable to messenger cable.

Provide hot-dipped galvanized steel clamp with groove sized for 1/4 inch to 3/8 inch messenger cable for securing lashing wire(s) to messenger cables at ends of each spiraled run. Ensure clamp hardware is hot-dipped galvanized steel.

1098-8 GUY ASSEMBLIES

Furnish guy assemblies with anchor assemblies, guy cable and guy cable guard.

Provide anchor assemblies with all miscellaneous hardware consisting of either expanding anchor with rod and triple-eye attachment, screw anchor with extension rod and triple-eye attachment, or expanding rock anchor with triple-eye attachment. Ensure anchor assembly size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel sized according to the soil bearing conditions in the area. Provide triple-eye guy attachments constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may be used instead of those with the triple-eye feature when only one guy cable is to be attached. Ensure anchor assemblies are 7 feet minimum in length.

For type of anchor assembly furnished, ensure the following:

(A) Expanding Anchor

Provide steel construction with protective paint or heat shrink of 6 mil plastic to protect metal during shipping and storage.

(B) Screw Anchor

Provide hot-dipped galvanized steel construction.

(C) Expanding Rock Anchors

Provide malleable iron and rust-resisting paint construction.

Provide 3-bolt clamp to match messenger cable size.

Provide full round guy cable guards that are 8 feet in length and constructed of UV stabilized, high impact, bright yellow HDPE.

Provide guy cables consisting of messenger cable of the same size as the largest sized messenger cable to be guyed. Comply with Article 1098-4.

1098-9 INDUCTIVE DETECTION LOOPS

(A) Loop Sealant

Provide loop slot sealant that completely encapsulates loop wire when installed according to manufacturer's instructions. Provide loop sealant that does not generate temperatures greater than 220°F. Ensure sealant bonds with asphalt and concrete pavement saw slots so sealant and encapsulated loop wire do not come out of slot. Ensure sealant is self-leveling, but with sufficient viscosity to prevent exit from saw slot when installed along a 10% grade.

Provide sealant that protects loop wire by preventing the entrance of dirt, water, rocks, sticks, and other debris into saw slot, and is resistant to traffic, water, gasoline, chemical and chemical fumes, mild alkalis, oils and mild acids. Ensure sealant will not be affected by water and sealant does not chemically interact with pavement and loop wire insulation.

Ensure loop sealant has sufficient flexibility to permit expected pavement expansion and contraction due to weather and to permit pavement movement due to traffic without cracking for a temperature range of -40 to 160°F.

Provide sealant with a usable life of at least ten minutes once mixed, when the ambient temperature is 75°F. Ensure sealant dries to tack free state in less than 2 hours, and does not flow within or out of saw slot after exposed surface has become tack free. Tack free

time will be determined by testing with a cotton ball until no sealant adheres to cotton ball and no cotton adheres to sealant.

Ensure 2 part sealant cures within 48 hours to attain 95% of published properties for the cured material.

Ensure one part sealant cures within 30 days to attain 95% of published properties for the cured material.

(B) Loop Wire

Provide loop wire composed of 19-strand conductor insulated by a cross-linked polyethylene compound. Ensure insulated conductors are completely encased in tubes of low density polyethylene compound. Print manufacturer's name, manufacture year and any applicable part number on encasing tube at intervals of 2 feet or less.

Provide number 14 AWG copper conductors fabricated from 19 strands that comply with ASTM B3 before insulating. Ensure stranded conductors use either concentric or bunch stranding and comply with circular mil area and physical requirements of ASTM B8 or ASTM B174 for bunch stranding.

Provide insulating compound that is cross-linked thermosetting black polyethylene in accordance with ASTM D2655. Ensure insulation is applied concentrically about conductor. Provide insulation thickness not less than 0.026 inch at any point and minimum average thickness of 0.030 inch as measured by UL Standard 62.

Ensure insulation of finished conductor will withstand application of a 60 Hertz or 3,000 Hertz, 7,500 volt (RMS) essentially sinusoidal spark test potential as specified in UL Standard 83.

Provide insulated conductors that are factory-installed in a protective encasing tube that complies with the following:

Encasing tube fabricated of polyethylene compound conforming to ASTM D1248 for Type I, Class C, Grade E5. Provide a minimum inside diameter of 0.150 inch. Provide a wall thickness of 0.040 inch ± 0.010 inch. Provide an outside diameter of 0.240 inch ± 0.010 inch.

(C) Conduit

Comply with Subarticle 1091-3(C) for PVC conduit.

1098-10 LEAD-IN CABLE

Furnish lead-in cable with two conductors of number 14 AWG fabricated from stranded tinned copper that complies with IMSA Specification 50-2 except as follows:

(A) Ensure conductor is twisted with a maximum lay of 2.0 inches resulting in at least six turns per foot.

(B) Provide a ripcord to allow cable jacket to be opened without using a cutter.

Provide length markings in a contrasting color showing sequential feet and within 1% of actual cable length. Ensure character height of the markings is approximately 0.10 inch.

1098-11 FIBER-OPTIC CABLE

(A) SMFO Communications Cable

Furnish single mode fiber-optic cable manufactured into a loose buffer tube design, installed around a central strength member where the cable complies with RUS CFR 1755.900 and ICEA 640 requirements. Ensure the Manufacture is ISO 9001 and TL9000 registered and that the manufacturer's cable is RUS listed. The operating temperature range of the cable shall be -40°F to +158°F.

Furnish individual fibers manufactured from silica and dopant materials with each fiber having a color coated finish that is compatible with local injection detection (LID) devices. Distinguish each fiber from others by color coding that meets EIA/TIA-598. Furnish single mode fiber that does not exceed attenuation ratings of 0.25 dB/km at 1550 nm and 0.35 dB/km at 1310 nm and complies with ITU G.652D and IEC 60793-2-50 Type B.1.3 industry standards for low water peak, single mode fiber. Provide fibers that are useable and with a surface, sufficiently free of imperfections and inclusions to meet optical, mechanical and environmental requirements.

Ensure the core central strength member is a dielectric glass reinforced rod and that the completed cable assembly has a maximum pulling rating of 600 lbf during installation (short term) and 180 lbf long term installed.

Construct buffer tubes (nominal size of 2.5 mm) manufactured from a polypropylene copolymer material to provide good kink resistance and allows the buffer tube to maintain flexibility in cold temperature over the expected lifetime of the cable. Ensure that buffers tubes contain no more than 12 fibers per buffer tube unless specified otherwise, and that all buffer tubes are filled with a water blocking gel or water swellable material. Construct the cable such that the buffer tubes are stranded around the central strength member in a reverse oscillating arrangement to allow for mid-span entry. Distinguish each buffer tube from others by color coding that meets EIA/TIA-598. Use filler tubes to maintain a circular cross-section of the cable. Ensure the filler tubes are the same nominal size as the buffer tubes of 2.5 mm. Apply binders (water swellable yarn, kevlar, etc.) with sufficient tension to secure buffer tubes and filler tubes to the central member without crushing the buffer tubes. Ensure that binding material is non-hygroscopic, non-wicking and dielectric with low shrinkage. Ensure the binders are of a high tensile strength that is helically stranded evenly around cable core.

Ensure the cable core is protected from the ingress of moisture by a water swellable material or that is filled with a water blocking compound that is non-conductive. Ensure the water swellable material (when activated) or the water blocking compound is free from dirt and foreign matter and is removable with conventional nontoxic solvents. Furnish at least one ripcord to aid in the process of removing the outer jacket. Furnish the outer jacket constructed of a medium-density polyethylene material to provide reduced friction and enhanced durability. Ensure the polyethylene material contains carbon black to provide UV protection and does not promote the growth of fungus. Ensure the cable jacket is free of slits, holes or blisters and the nominal outer jacket thickness is $\geq 0.050''$.

Ensure the completed cable assembly contains identification markings printed along the outside cover of the jacket every 2 feet. Ensure the character height of the markings is approximately 0.10 inch. Provide length markings in sequential feet and within 1% of actual cable length.

Mark each cable with the following:

(1) Sequential length marks in feet as specified
(2) The name of the manufacturer
(3) “OPTICAL CABLE”
(4) Month/year of manufacture
(5) Number(s) of and type(s) of fibers
(6) Cable ID Number for product traceability

(B) Drop Cable

Furnish drop cable meeting the material requirements listed in Subarticle 1098-11(A) with the exceptions herein to provide communications links between splice enclosures and through interconnect centers. Furnish drop cable containing at least 6 individual fibers.

Furnish drop cable that complies with RUS-CFR 1755.900 and is RUS listed. Ensure each drop cables has the same operating characteristics as the SMFO cable it is to be coupled with.

On one end of cable furnish six approved connectors for termination on connector panel in equipment cabinet. Provide either factory assembled drop cables with the approved connectors or field installed connectors. No connectors are required for drop cables running from one splice enclosure directly to another splice enclosure.

Ensure attenuation of drop cable at 1310 nm does not exceed 0.4 dB/km and the attenuation at 1550 nm does not exceed 0.3 dB/km. Ensure attenuation loss for complete drop cable assembly does not exceed a mean value of 1.5 dB.

(C) Communications Cable Identification Markers

Furnish yellow communications cable identification markers that are resistant to fading when exposed to UV sources and changes in weather. Use markers designed to coil around fiber-optic cable that do not slide or move along the surface of the cable once installed. Ensure exposure to UV light and weather does not affect the markers natural coiling effect or deteriorate performance. Provide communications cable wraps that permit writing with an indelible marking pen and contain the following text in black:

WARNING

NCDOT FIBER-OPTIC CABLE

CONTACT TELEPHONE NUMBER:

_____

WARNING

NCDOT FIBER-OPTIC CABLE

Figure 1098-1. Communication Cable Identification Marker.

Overall Marker Dimensions: 7 inches (l) x 4 inches (w)

Lettering Height: 3/8 inch for WARNING, 1/4 inch for all other lettering

Submit a sample of proposed communications cable identification markers to the Engineer for approval before installation.

(D) Fiber-Optic Cable Storage Racks

Furnish fiber-optic storage racks (snowshoes) that are non-conductive and resistant to fading when exposed to UV sources and changes in weather. Ensure snowshoes have a captive design such that fiber-optic cable will be supported when installed in the rack and the minimum bending radius will not be violated. Provide stainless steel attachment hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for securing fiber-optic cable to snowshoe. Ensure snowshoes are stackable so multiple cable configurations are possible.

1098-12 FIBER-OPTIC SPLICE CENTERS

(A) Interconnect Center

Furnish compact, modular interconnect centers designed to mount inside equipment cabinets. Design and size interconnect centers to accommodate all fibers entering cabinets.

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Design and size splice trays to be dielectric, to accommodate all fibers entering splice tray, and to provide sufficient space to prevent microbending of optical fibers. Provide connector panels with approved connectors.

Furnish SMFO pigtails with each interconnect center. Provide pigtails containing connector panels that are no more than 6 feet in length with approved factory assembled connector on one end. Ensure SMFO pigtails meet the operating characteristics of the SMFO cable with which it is to be coupled.

Furnish SMFO jumpers that are at least 3 feet in length with approved factory assembled connectors on each end. Ensure SMFO jumpers meet the operating characteristics of the SMFO cable with which it is to be coupled.

(B) Splice Enclosure

Furnish splice enclosures that are re-enterable using a mechanical dome-to-base seal with a flash test valve, and are impervious to the entry of foreign material (water, dust, etc.). Ensure enclosures are manufactured so as to be suitable for aerial, pedestal, buried, junction box and manhole installation.

Provide enclosures with at least one over-sized oval port that will accept two cables and with at least four round ports (for single cables) that will accommodate all cables entering enclosure. Provide heat shrink cable shields with enclosure to ensure weather tight seal where each cable enters enclosure.

Within enclosures, provide enough hinged mountable splice trays to store the number of splices required, plus the capacity to house six additional splices. Provide a fiber containment basket for storage of loose buffer tubes expressed through the enclosure. Ensure enclosures allow sufficient space to prevent microbending of buffer tubes when coiled.

Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside splice tray. Provide splice trays that are dielectric.

1098-13 FIBER-OPTIC TRANSCEIVERS

Furnish shelf-mounted, modular, single mode fiber-optic transceivers that transmit and receive optical signals over a fiber-optic communications medium of two fibers and interface with equipment cabinets (signal controller, dynamic message signs, etc.). Ensure transceivers are asynchronous in operation. Ensure transceivers are capable of operating up to 5 miles without boosting signal and without distortion. Ensure transceivers are switch selectable for either local or master operation.

Do not provide transceivers internal to system equipment. Provide identical transceivers at all locations capable of being interchanged throughout system.

Provide LEDs on the front panel of transceivers for power, and transmitting and receiving indications. Comply with the following:

TABLE 1098-1
PROPERTIES OF FIBER-OPTIC TRANSCEIVER

Property	Requirement
Input Power	115 VAC
Minimum Loss Budget	12 dB with corresponding receiver
Operating Wavelength	1310 or 1550 nm
Optical Connector	ST
Signal Connector	Female Plug Type DB9 or DB25
Temperature Range	0 to 150°F

Ensure modems operate in one of the following topologies:

Drop and Repeat Transceivers: Furnish transceivers that transmit and receive data in drop-and-repeat poll-response data network mode with EIA/TIA-232, EIA/TIA-422 and EIA/TIA-485 protocols.

Self-Healing Ring Transceivers: Furnish transceivers that transmit and receive data in a drop-and-insert poll-response data network mode with EIA/TIA-232, EIA/TIA-422 and EIA/TIA-485 protocols. Ensure transceiver operates in a Self-Healing Ring Network Architecture.

1098-14 DELINEATOR MARKERS

Furnish tubular delineator markers, approximately 6 feet long, and constructed of Type III HDPE material. Provide delineator assemblies that are ultraviolet stabilized to help prevent components from color fading, warping, absorbing water, and deterioration with prolonged exposure to the elements. Provide delineators designed to self-erect after being knocked down or pushed over. Provide orange delineator posts.

Provide text, including division contact number, hot stamped in black on a yellow reflective background material that will not fade or deteriorate over time. Provide delineator markers with nominal message height of 15 inches that contain the text in Figure 1098-2 visible from all directions approaching the assembly.

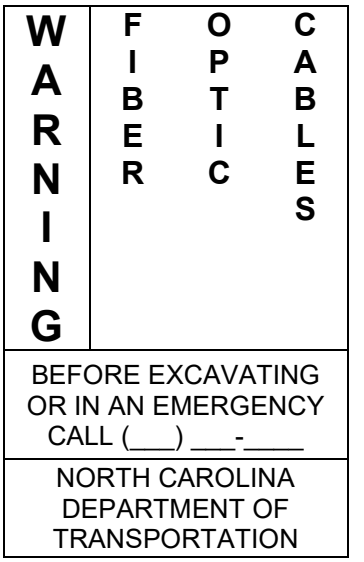


Figure 1098-2. Delineator Marker.

1098-15 PEDESTALS

Furnish pedestal assemblies with foundations that conform to the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, and the Interim Specifications as shown on the plans. Refer to *Roadway Standard Drawings* No. 1743 for structural design specifications for each type of pedestal.

(A) Pedestal Shaft

Furnish one piece pedestal shafts fabricated from either aluminum or galvanized steel pipe with a uniform pipe outer diameter of 4.5 inches and of the lengths specified for the type of pedestal shown on *Roadway Standard Drawing No.* 1743. Refer to Article 1743-2 for pedestal type descriptions.

For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals), furnish shafts constructed from schedule 40 extruded aluminum pipe that conforms to Aluminum Association Alloy 6061-T6 with a tensile strength of 30 KSI and a minimum wall thickness of 0.237 inch. Aluminum conduit will not develop the necessary strength required and is not allowed. Thread and deburr in accordance with American National Standard Pipe Threads, NPT (ANSI B2.1). Finish the exterior with a rough surface texture consisting of a uniform grain pattern that is perpendicular to the axis of the pipe along the full pipe

length. Unless otherwise specified, do not use galvanized steel pipe for Type I and Type II pedestal shafts.

For Type III (heavy-duty pedestals), furnish schedule 120 galvanized steel pipe that conforms to ASTM A53. Provide an 11 inches square by 1 inch thick steel base plate with minimum yield strength of 36 ksi that conforms to ASTM A36. Fabricate the base plate with four equally spaced bolt holes on an 11 inches bolt circle. Orient the bolt holes in the corners of the plate. Size the holes to accommodate 1 inch diameter machine bolts. Weld the pedestal shaft to the center of the base plate using a socket connection. Provide circumferential fillet welds at the top and bottom of the base plate. Perform all welding in accordance with AWS Code on the plans. Hot-dip galvanize the pedestal shaft and base plate assembly after fabrication in accordance with ASTM A123. Unless otherwise specified, do not use aluminum pipe for Type III pedestal shafts.

(B) Transformer Bases

Furnish transformer bases for each type of pedestal shown on *Roadway Standard Drawings* No. 1743 fabricated from aluminum that meets Aluminum Association Alloy 356 or equivalent, and that are designed to break upon impact in accordance with AASHTO requirements. For each type of transformer base use products as found on the ITS and Signals QPL. For use in grounding and bonding, provide a 0.5 inch minimum diameter, coarse thread hole cast into transformer base located inside base and oriented for easy access.

Provide a minimum access opening for all transformer bases of 8 inches x 8 inches with an access door that is attached with a 1/4 inch x 3/4 inch long stainless steel vandal proof screw to secure access door.

For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals), provide overall base dimensions of 15" (l) x 13 3/4" (w) x 13 3/4" (d) for square bases and 14" (l) x 16 1/2" (w) x 16 1/2" (d) for octagonal bases. Provide a threaded opening at the top of the base to receive a 4 inch NPT pipe shaft. Include a set screw prep and 3/8 inch-16 x 1 inch stainless steel set screw to secure the pedestal post to the pedestal base. Fabricate the bottom of the transformer base with four equally spaced holes or slots for a 12 inches bolt circle to secure the entire assembly to the concrete foundation.

For Type III (heavy-duty pedestals), provide square bases with overall dimensions of 17" (l) x 13" (w) x 13" (d). Fabricate the top of the transformer base with four equally spaced holes or slots for an 11 inches bolt circle to attach the pedestal shaft. Size the holes or slots to accommodate 1 inch diameter machine bolts. Fabricate the bottom of the transformer base with four equally spaced holes or slots for a 12 inch bolt circle to secure the entire assembly to the concrete foundation. Size the holes or slots to accommodate 1 inch diameter anchor bolts. Provide the following mounting hardware for heavy-duty pedestals:

(1) Four 1 inch diameter by 3 1/2 inches long machine bolts (ASTM F593), with heavy hex nuts (ASTM A563 Grade DH, or A 194 Grade 2H), and thick flat washers, and lock washers (ASTM F436) per pedestal assembly. Galvanize in accordance with ASTM A153.

(2) Three heavy hex nuts (ASTM A563 Grade DH, or A194 Grade 2H), 2 thick flat washers, and one lock washer (ASTM F436) for each anchor bolt. Galvanize in accordance with ASTM A153.

(3) Six minimum slotted stainless steel shims of necessary thickness for leveling per pedestal assembly.

(C) Anchor Bolts

For each pedestal, provide four anchor bolts in accordance with ASTM F1554, Grade 55, of the size and length specified in *Roadway Standard Drawings* No. 1743. Provide anchor

bolts with coarse threads meeting the bolt/thread criteria specified by AISC. Provide threads for a minimum length of 4 inches on each end of the bolt. All thread anchor rods may be used. Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A153.

For each anchor bolt:

(1) Provide three heavy hex nuts; one at the top, and two at the bottom (embedded end) of the anchor bolt. Provide hex nuts with coarse threads that match the anchor bolt thread requirements above. Provide hex nuts that meet the requirements of ASTM A563 Grade DH, ASTM A194, Grade 2H or equivalent. Galvanize all heavy hex nuts in accordance with ASTM A153.

(2) Provide one standard size washer that meets the requirements of ASTM F436 for use between the two heavy hex nuts on the embedded end of the anchor bolt. Galvanize in accordance with ASTM A153.

(3) Provide one extra thick, oversized washer for use over the slotted opening of the pedestal base. Fabricate washer to meet the chemical, physical, and heat treating requirements of ASTM F436. Fabricate the washer to the diameter and thickness needed. Galvanize fabricated washer in accordance with ASTM A153. Heat treat to the same requirements as F436 (i.e. 26 to 45 HRC).

For a 3/4 inch diameter anchor bolt mounted in a 1 1/2 inch slotted opening, the dimensional requirements for an extra thick, oversized washer are as follows:

(a) The minimum Outside Diameter (OD) required is 2 3/4 inch.
(b) The hole Inside Diameter (ID) = Nominal Bolt Diameter + 1/16 inch = 0.812 inch.
(c) The minimum washer thickness required is 3/8 inch.

If anchor bolts less than 3/4 inch in diameter are proposed for use to anchor pedestal bases, provide a washer calculation to ensure the washer thickness is adequate. To account for any pedestal manufacturing differences, verify the actual slotted opening width of the pedestal base anchoring points, and include it in the calculation. Anchor bolts that are less than 1/2 inch in diameter may not be used as they are not structurally adequate to support the pedestal and may inhibit the performance of the breakaway base.

The fabrication process for thick washers makes the washer slightly tapered (i.e. the top OD and the bottom OD are not the same). Install thick washers with the larger diameter face down against the pedestal base casting.

Do not use standard washers over the slotted opening of the pedestal base. Do not substitute or stack thin washers to achieve the required thickness specified or required.

In addition to the submittal requirements of Section 1098-1(B), provide Mill Certifications, Galvanization Certifications, and Heat Treating Certifications for all anchor bolts, fabricated washers, and structural hardware

(D) Pedestal Cap

Furnish a 4 1/2 inch outside diameter slip fit domed pedestal top cap for each pedestal assembly designed to fit over the outside of the pedestal shaft. Fabricate the cap from aluminum that meets Aluminum Association Alloy 356. Ensure the cap provides 3 equally spaced stainless steel set screw fasteners to secure the cap to the pedestal shaft.

(E) Pole Flange Base for 4 1/2 Inches Pipe

Furnish a flange base with cover for use with Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals) only. Flange bases are non-breakaway supports that are to be used with a breakaway bolt system for AASHTO compliance for breakaway

structures. Provide aluminum or steel flange bases with a minimum 7.5 inches diameter bolt circle. Ensure bases are either continuously welded to shafts or threaded to receive shafts. Each base should be designed to accommodate either three or four 1/2 inch bolts equally spaced on the bolt circle to receive breakaway anchors. Provide NPT threads on the internal opening of the flange base through the full length of the flange base with locking set screws at the top of the base to receive a 4 inch NPT pipe shaft.

Fabricate aluminum flange bases that meet Aluminum Association Alloy 356 requirements for architectural bases. Fabricate steel flange bases that meet ASTM A36.

Do not use flange bases for Type III pedestals.

(F) Breakaway Anchors

Furnish single or double neck omni-directional breakaway anchor bolt coupling systems for use with Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals) only. Use breakaway anchors as an alternative to transformer bases as approved by the Engineer. Use with non-breakaway pole flange bases. Use 1/2 inch diameter bolts for pushbutton posts and 3/4 inch bolts for normal-duty pedestals. Fabricate from steel with a minimum yield strength of 55 KSI. Galvanize in accordance with ASTM A153. Do not use breakaway anchors with Type III pedestals, or in conjunction with breakaway transformer bases.

(G) Foundation

Install pedestal foundations of the type and size shown on *Roadway Standard Drawings* No. 1743.04 Furnish Class A minimum concrete that conforms to Article 1000-4.

Provide reinforcing steel that conforms to the applicable parts of Section 1070.

(H) Screw-In Helical Foundation Anchor Assembly

Furnish and install screw-in helical foundation as an alternative to the standard reinforced concrete foundation specified in Section 1743, for supporting Type I and Type II Pedestals. Do not use for Type III Pedestals.

(1) Type I – Pedestrian Pushbutton Post:

Fabricate pipe assembly consisting of a 4 inch diameter x 56 inch long pipe, single helical blade and square fixed attachment plate. Furnish pipe in accordance with ASTM A53 ERW Grade B and include a 2 inch x 3 inch cable opening in the pipe at 18 inches below the attachment plate. Furnish steel attachment plate and helical blade in accordance with ASTM A36. Include four slotted mounting holes in the attachment plate to fit bolt circles ranging from 7 3/4 inches to 14 3/4 inches diameter. Furnish additional 3/4 inch keyholes at slotted holes to permit anchor bolt installation and replacement from top surface. Include combination bolt-head retainer and dirt scrapers at the attachment plate underside to allow for a level or flush-mount plate installation with respect to the finished grade. Galvanize pipe assembly components in accordance with AASHTO M 111 or an approved equivalent.

Furnish four 3/4 inch 10NC x 3 inch square head anchor bolts to meet the requirements of ASTM F3125. Provide four 3/4 inch plain flat galvanized washers, four 3/16 inch thick galvanized plate washers and four 3/4 inch galvanized hex nuts. Galvanize in accordance with AASHTO M 111 or an approved equivalent.

(2) Type II – Normal-Duty Pedestal:

Fabricate pipe assembly consisting of a 6 inch diameter x 60 inch long, single helical blade, 1 1/4 inch diameter stinger rod and square fixed attachment plate. Furnish pipe in accordance with ASTM A53 ERW Grade B using schedule 40 wall thickness and include a 2 inch x 3 inch cable opening in the pipe at 18 inches below the attachment plate. Furnish steel attachment plate, helical blade and stinger rod in accordance with

ASTM A36. Include four slotted mounting holes in the attachment plate to fit bolt circles ranging from 10 inches to 15 inches in diameter. Furnish additional 1 1/4 inch keyholes at slotted holes to permit anchor bolt installation and replacement from top surface. Include combination bolt-head retainer and dirt scrapers at the attachment plate underside to allow for a level or flush-mount plate installation with respect to the finished grade. Galvanize pipe assembly components in accordance with AASHTO M 111 or an approved equivalent.

Furnish four 1 inch 8NC x 4 inch galvanized Grade 5 square head anchor bolts. Provide four 1 inch plain flat galvanized washers and four 1 inch galvanized hex nuts. Galvanize in accordance with AASHTO M 111 or an approved equivalent.

1098-16 SIGNAL CABINET FOUNDATIONS

Provide foundations with a minimum pad area that extends 24 inches from front and back of cabinet and 3 inches from sides of cabinet.

Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

Provide preformed cabinet pad foundations with 7" (l) x 18" (w) minimum opening for the entrance of conduits. For precast signal cabinet foundations, include steel reinforcement to ensure structural integrity during shipment and placing of item. Include four 3/4 inch coil thread inserts for lifting. Comply with Article 1077-16.

1098-17 CABINET BASE ADAPTER/EXTENDER

Fabricate base adapters and extenders from the same materials and with the same finish as cabinet housing. Fabricate base adapter and extender in the same manner as controller cabinets, meeting all applicable specifications called for in Section 6.8 of CALTRANS TEES. Provide base adapters and extenders a height of at least 12 inches.

1098-18 BEACON CONTROLLER ASSEMBLIES

(A) General

Furnish all cabinets with a solid state flasher that meets NEMA TS-2-2003. Encapsulate flasher components as necessary. Connect flasher to provide beacon operation as specified.

Submit drawings showing dimensions, location of required equipment and mechanisms, cabinet electrical diagrams, part numbers and descriptions of required equipment and accessories to the Engineer. Provide certification to the Engineer that materials used in cabinet construction meet these specifications.

Furnish unpainted, natural, aluminum cabinet shells that comply with Section 7 of NEMA TS-2-2003. Ensure all non-aluminum hardware on cabinet is stainless steel or Department approved non-corrosive alternate. Provide roof with slope from front to back at a minimum ratio of 1 inch drop per 2 feet. Ensure each exterior cabinet plane surface is constructed of a single sheet of seamless aluminum. Ensure all components are arranged for easy access during servicing. When modular in construction, provide guides and positive connection devices to ensure proper pin alignment and connection.

Provide 20 mm diameter radial lead UL-recognized metal oxide varisters (MOV) between each field terminal and ground bus. Electrical performance is outlined in Table 1098-2.

TABLE 1098-2 PROPERTIES OF SURGE PROTECTOR	
Property	**Requirement**
Maximum Continuous Applied Voltage at 85°C	150 VAC (RMS) 200 VDC
Maximum Peak 8x20µs Current at 85°C	6500 A
Maximum Energy Rating at 85°C	80 J
Voltage Range 1 mA DC Test at 25°C	212 - 268 V
Max. Clamping Voltage 8x20µs, 100A at 25°C	395 V
Typical Capacitance (1 MHz) at 25°C	1,600 pF

Provide beacon controller assemblies equipped with terminal blocks (strips) for termination of all field conductors and all internal wires and harness conductors. Terminate all wires at terminals. Ensure all field terminals are readily accessible without removing equipment and located conveniently to wires, cables, and harnesses to be connected. Ensure terminals are not located on underside of shelves or at other places where they are not readily visible or where they may present a hazard to personnel who might inadvertently touch them. Provide terminal blocks made of electrical grade thermoplastic or thermosetting plastic. Ensure each terminal block is of closed back design and has recessed-screw terminals with molded barriers between terminals. Ensure each terminal consists of two terminal screws with removable shorting bar between them. Ensure each terminal block is labeled with a block designation and each terminal is labeled with a number. Ensure all terminal functions are labeled on terminal blocks. Provide labels that are visible when terminal block is fully wired. Show labels on cabinet wiring diagrams. Ensure terminals serving similar functions are grouped together.

Connect each conductor, including unused conductors, within or entering cabinet to a terminal using crimped spade lugs. Place no more than two conductors on any single terminal screw. Terminations to back panel may be soldered. Do not use quick connectors or barrel connectors. Make all connections at terminals. Do not make in-line splices.

Ensure outgoing circuits have same polarity as line side of power supply. Ensure common return has same polarity as grounded conductor (neutral) of power supply.

Neatly package all wiring. Dress harnesses by lacing, braiding, or tying with nylon tie wraps at closely spaced intervals. Attach wires, cables, or harnesses to cabinet walls for support or to prevent undue wear or flexing. Use nylon tie straps or metal clamps with rubber or neoprene insulators. Screw these attachment devices to cabinet. Do not use stick-on clamps or straps.

Tag AC+, AC-, chassis ground, and flasher circuit conductors with non-fading, permanent sleeve labels at conductor ends at terminals or use color-coded wire. Ensure sleeve labels tightly grip conductors. Alternatively, use hot stamped labels on internal conductor insulation at intervals of no greater than 4 inches. Ensure label legends are permanent.

Ensure all jumpers are wire conductors or metal plates. Do not use printed circuit back panels or back panels using wire tracks as jumpers.

Lay out all equipment and components for ease of use and servicing. Ensure equipment controls can be viewed and operated without moving or removing any equipment. Ensure there is access to equipment or components for servicing without removing any other equipment or components. Removal of equipment is acceptable to access fan or thermostat. Ensure equipment can be removed using only simple hand tools. Ensure layout of equipment and terminals within the various cabinets furnished is identical from cabinet to cabinet, unless otherwise approved by the Engineer.

Mount equipment using harnesses with suitable multipin (or similar) connectors. Design or key all equipment to make it physically impossible to connect unit to wrong connector.

Ensure that functionally equivalent equipment is electrically and mechanically interchangeable.

Equip vents with standard-size, replaceable filters or, if located where they can easily be cleaned, permanent filters.

(B) Type F1 Cabinet

Provide dual-circuit flasher and 20-amp inverse time circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating. Install one insect-resistant vent on bottom and one on top on opposite wall to facilitate airflow.

(C) Type F2 Cabinet

Provide 20 inches high x 16 inches wide x 12 inches deep cabinet, dual-circuit flasher, 20-amp inverse time circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating, and solid state time switch. Provide filtered power to time switch. Install one insect-resistant vent on each side of cabinet at the bottom to facilitate airflow.

(D) Type F2 and F3 Cabinet – Surge Protection and Documentation

Furnish and install a power line surge protector in the service power. Provide a 2-stage power line surge protector that allows connection of the radio frequency interference filter between stages of the device. Ensure device has a maximum continuous current rating of at least 10 A at 120 V. Ensure device can withstand at least 20 peak surge current occurrences at 20,000 A for an 8x20 microsecond waveform. Provide maximum clamp voltage of 395 V at 20,000 A with a nominal series inductance of 200 µh. Ensure voltage does not exceed 395 V. Provide devices that comply with Table 1098-3.

TABLE 1098-3
INSERTION LOSS OF SURGE PROTECTOR

Frequency (Hz)	Minimum Insertion Loss (dB)
60	0
10,000	30
50,000	55
100,000	50
500,000	50
2,000,000	60
5,000,000	40
10,000,000	20
20,000,000	25

Install surge protector in circuit breaker enclosure in a manner that will permit easy servicing. Ground and electrically bond surge protector to cabinet within 2 inches of surge protector.

Furnish and install a suitably sized plastic envelope or container in cabinet for holding cabinet wiring diagrams and equipment manuals. Locate envelope or container so it is convenient for service personnel. Furnish two sets of non-fading cabinet wiring diagrams in a paper envelope or container and place them in the plastic envelope or container.

(E) Type F3 Cabinet

Provide 25 inches high x 22 inches wide x 15 inches deep cabinet, dual-circuit flasher, fan, thermostat and switch-controlled cabinet light (15 watt minimum, incandescent).

Install a vent or vents at or near the cabinet bottom to permit the intake of air sized for the rated flow of air from the fan, but no smaller than 20 square inches. Install fan with a minimum 100 CFM rating.

Equip cabinet with two inverse time circuit breakers (20A & 15A) with at least 10,000 RMS symmetrical amperes short circuit current rating installed to ensure personnel

servicing the cabinet, including rear of back panel, cannot inadvertently be exposed to a hazard. Install a terminal block that will accommodate service wire as large as number 4 AWG, and connect it to the circuit breaker. Install circuit breakers in addition to any fuses that are a part of the individual control equipment components. Wire switch-controlled cabinet light and thermostatically-controlled fan to the 15A circuit breaker. Provide thermostat with a minimum range of 90° F to 130° F and with a rating sufficient for fan load.

Equip cabinet with a duplex receptacle that is connected to the AC out and neutral out terminals of the surge protector.

1098-19 SPREAD SPECTRUM RADIO

(A) General

Furnish 900 MHz Serial and 900 MHz Serial/Ethernet spread spectrum radio systems with field set-up software and all necessary hardware and signage in accordance with the plans and specifications to provide a data link between field devices (i.e. Traffic Signal Controllers, Dynamic Message Signs, etc.).

Provide a radio system with license free 902 – 928 MHz Serial Spread Spectrum transceivers that are capable of Bi-Directional, Full Duplex communications. Furnish material conforming to the National Electrical Code (NEC), the National Electrical Safety Code (NESC), Underwriter's Laboratories (UL) or a third-party listing agency accredited by the North Carolina Department of Insurance, and all local safety codes in effect on the date of advertisement. Comply with all regulations and codes imposed by the owner of affected utility poles.

(B) 900 MHz Radio

Furnish license free 902 - 928 MHz Serial Spread Spectrum Radios that comply with Table 1098-4.

TABLE 1098-4 SERIAL SPREAD SPECTRUM RADIO REQUIREMENTS	
Frequency Range	902 – 928 MHz
Technology	Frequency Hopping Spread Spectrum
Operational Modes	master; repeater; repeater/slave; slave; point-to-point; point-to-multipoint; peer-to-peer
Operating Voltage	Power Cube: 6 – 30 VDC
Operating Temperature/Humidity	-40°C to +75°C; 0 to 95% non-condensing
Transmitter	
Output Power	1 Watt (Max)
Modulation	Frequency Shift Keying
Hopping Patterns/Channels	Minimum of 50/minimum of 110
Data Rate(over the air)	1,200 to 115,200 bps
Receiver	
Sensitivity	-108 dBm @ 10^-6 BER
Data Transmission	
Error Detection	32 Bit CRC, Automatic Repeat Request (ARQ)
Data Encryption	128 bit
System Gain	140 dB
LED's	
Signal Strength Indicators	Data Port Indicators consisting of a minimum of 3 LED's grouped together representing a Low, Medium or High Signal Strength with regards to the communications link with another targeted radio. Units must be supplied with external labels to identify how to interpret the Signal Strength. OR Combinations of the Front Panel LED indications with flashing rates and LED Colors can be used to identify the signal strength. Units must be supplied with external labels to identify how to interpret the Signal Strength.
Front Panel Indicators	Power (Optional) Transmit Data Receive Data OR Carrier Detect Transmit Clear to Send
Data Interface	
Interface Cable	Type 1 or Type 2 or Type 3 (If not specified in the Plans, furnish a Type 1 Data Interface Cable)
Antenna Connectors	Threaded Connector (Nickel and/or Silver Plated Brass)
Port to connected device	Serial - DB 9 Female Port; RS232 Asynchronous
Programming Port	DB9 Female or USB/Mini B
Radio Frequency Signal Jumper	RG-58 coaxial cable (6' long) with one end supplied with RF Threaded Connector that is compatible with the supplied radio. The other end furnished with a Standard N-Type Male Connector to mate with the lightning arrestor.
Mounting Style	Shelf
Certification	FCC

(C) 900 MHz Serial/Ethernet Spread Spectrum Radio

Furnish 902 – 928 MHz Serial/Ethernet Spread Spectrum Radios with built-in web-based setup and that comply with Table 1098-5.

TABLE 1098-5 SERIAL/ETHERNET SPREAD SPECTRUM RADIO REQUIREMENTS	
Frequency Range	902 – 928 MHz
Technology	Frequency Hopping Spread Spectrum
Operational Modes	base; remote; repeater; remote/repeater; point-to-point; point-to-multipoint; peer-to-peer
Operating Voltage	Power Cube: 6 – 30 VDC
Operating Temperature/Humidity	-40°C to +75°C; 0 to 95% non-condensing
Transmitter	
Output Power	1Watt (Max)
Modulation	2 level GFSK, 4 and 8-ary Frequency Shift Keying
Hopping Patterns /Channels	Minimum of 15
Occupied Bandwidth	402.8 kHz
Data Rate(over the air)	Up to 4 Mbps
Receiver	
Sensitivity	-105 dBm @ 115Kbps OR -83 dBm Mbps
Data Transmission	
Error Detection	CRC & ARQ, retransmit on error, FEC
Data Encryption	128-bit and 256-bit AES CCM
Authentication	Radius Compliant
System Gain	135 dB
LED's	
Signal Strength Indicators	Data Port Indicators consisting of a minimum of 3 LED's grouped together representing a Low, Medium or High Signal Strength with regards to the communications link with another targeted radio. Units must be supplied with external labels to identify how to interpret the Signal Strength. OR Combinations of the Front Panel LED indications with flashing rates and LED Colors can be used to identify the signal strength. Units must be supplied with external labels to identify how to interpret the Signal Strength.
Front Panel Indicators	Power COM 1 COM 2 OR Carrier Detect Transmit Clear to Send
Management & Network Protocols	HTTP, SNMP, Local Console, IP Auto Discover

	Data Interface
Antenna	Threaded Connector (Nickel and/or Silver Plated Brass)
Port to Connected Devices	Serial - Dual - DB 9 Female Ports: RS232/422/485 Ethernet: RJ-45 (10/100 BaseT, auto crossover)
Network Protocols	IEEE 802.3; HTTP, TCP, UDP, ARP, IMCP, FTP
Radio Frequency Signal Jumper	RG-58 coaxial cable (6' long) with one end supplied with RF Threaded Connector that is compatible with the supplied radio. The other end furnished with a Standard N-Type Male Connector to mate with the lightning arrestor.
Certification	FCC

(D) Software for 900Mhz Serial Spread Spectrum Radios

Furnish units with a Field Set-up Software. The Field Set-up Software shall be a Window Based™ software program that uses a GUI (Graphical User Interface) to provide the following features at a minimum: remote programming, remote radio configuration, remote maintenance, remote diagnostics and a spectrum analyzer.

Furnish software supplied with drivers to allow easy set-up with all industry standard traffic signal controllers, including approved controllers containing custom software written specifically for the North Carolina Department of Transportation. Manufacturer is required to develop additional drivers (at no charge) for other equipment not supported by their existing pre-written Driver Package when needed. Drivers may be needed for other equipment such as industry standard radar and video detection packages, and Dynamic Message Sign controllers.

(E) 900 MHz Serial Data Interface Cables

Furnish "Data Interface Cables" for installation with approved controllers for the following applications:

900 MHz Data Interface Cable (Type 1)
Application: Standard RS-232 data interface cable to be installed between the Controller's RS-232 interface and the radio modem. Radio Modem can be programmed as either a Master of Local Radio.

900 MHz Data Interface Cable (Type 2)
Application: Master Controller's RS-232 data interface connected to a fiber system modem and Radio Modem with master programing

900 MHz Data Interface Cable (Type 3)
Application: Local Controller's RS-232 data interface connected to a fiber system modem and Radio Modem with master programming.

Ensure that each Data Interface Cable is a minimum of 6 feet long and compatible with approved controllers.

(F) Directional Antenna (Yagi)

Furnish a directional antenna of welded construction that allows for vertical and horizontal polarization.

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1 1/2 inch Nominal Pipe Size (approximately 2 inches OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

Furnish an 8.5 dBd. (11 dBi) Gain or 13 dBd (15.1 dBi) Gain antenna that complies with Table 1098-6 and Table 1098-7:

TABLE 1098-6 900 MHz - YAGI ANTENNA - (8.5 dBd / 11 dBi Gain)	
Property	**Requirement**
Frequency Range	896 - 940 MHz
Nominal Gain	8.5 dBd / 11 dBi
Front to Back Ratio	18 dB
Horizontal Beamwidth (at half power points)	65 degree
Vertical Beamwidth (at half power points)	55 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 Ω
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 ft/sq
Number of Elements	6
Allows for vertical or Horizontal polarization	Yes
Welded construction	Yes

TABLE 1098-7 900 MHz - YAGI ANTENNA – (13 dBd / 15.1 dBi Gain)	
Property	**Requirement**
Frequency Range	902 - 928 MHz
Nominal Gain	13 dBd / 15.1dBi
Front to Back Ratio	20 dB
Horizontal Beam width (at half power points)	40 degree
Vertical Beam width (at half power points)	35 degree
Power Rating, UHF Frequency	200 Watts
Lightning Protection	DC Ground
Termination	Coaxial pigtail with a Standard N-Type Female Connector
Impedance	50 Ω
Length (approx..)	53"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.46 ft/sq
Number Elements	13
Allows for Vertical or Horizontal polarization	Yes
Welded construction	Yes

(G) Omnidirectional Antenna

Furnish an omnidirectional antenna of a solid, single piece construction.

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1 1/2 inch Nominal Pipe Size (approximately 2 inches OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

Furnish a 3 dBd (5 dBi) Gain or 6 dBd (8.1 dBi) Gain antenna that complies with Table 1098-8 and Table 1098-9:

TABLE 1098-8 900 MHz – OMNI ANTENNA - (3 dBd / 5 dBi Gain)	
Property	**Requirement**
Frequency Range	902 - 928 MHz
Nominal Gain	Typical gains of 3 or 6 dBd (dependent upon gain needed for application)
Termination	Standard N-Type Female Connector
Impedance	50 ohms
VSWR	1.5:1
Vertical Beam Width	33 degrees (3dBd Gain), 17 degrees (6dBd Gain)
Lightning Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Length	25" (3dBd Gain), 65" (6dBd Gain)
Rated Wind Velocity	125 mph

TABLE 1098-9 900 MHz – OMNI ANTENNA - (6 dBd / 8.1 dBi Gain)	
Property	**Requirement**
Frequency Range	902 - 928 MHz
Nominal Gain	6 dBd / 8.1dBi
Termination	Standard N-Type Female Connector
Impedance	50 Ω
VSWR	1.5:1
Vertical Beam Width	17 degrees
Lightning Protection	DC Ground
Power Rating, UHF Frequency	100 Watts
Rated Wind Velocity	125 mph
Solid, single piece construction	Yes
Mount in a vertical direction and limit to vertically polarized RF systems	Yes

(H) Antenna Mounting Hardware Kit

Furnish an antenna mounting kit to support the antenna when attached to a metal pole, mast arm or wood pole.

Ensure the Antenna Mounting Hardware Kit includes at least one 96 inch galvanized steel cable with a stainless steel bolt, nut and lock washer assembly on each end. Ensure the pole base plate accepts a 1 1/2 inch NPT aluminum pipe, and provides a surface that is at least 6 3/4 inches long x 4 1/4 inches to provide contact with the pole. Ensure the pole base plate is designed to allow both ends of the 96 inch galvanized cables to be secured and tightened to the base plate. Provide a 90 degree elbow with internal threads on both ends to accommodate 1 1/2 inch NPT aluminum pipes. Provide a 1 1/2 inch x 18 inch long aluminum pipe threaded on both ends and a 1 1/2 inch x 24 inch aluminum pipe threaded on one end with an end cap.

(I) Coaxial Cable

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrestor that comply with Table 1098-10.

TABLE 1098-10 PROPERTIES AND REQUIREMENTS OF COAXIAL CABLE	
Property	**Requirement**
Attenuation (dB per 100 ft) @ 900 MHz	3.9 dB
Power Rating @ 900 Mhz	0.58 kW
Center Conductor	0.108" Copper Clad Aluminum
Dielectric: Cellular PE	0.285"
Shield (approx.)	Aluminum Tape - 0.291" Tinned Copper Braid - 0.320"
Jacket	Black UV protected polyethylene
Bend Radius	1"
Impedance	50 Ω
Capacitance	23.9 pf/ft
Water Blocking	Yes
Supply Coaxial Cable on 500 ft Reel	Yes

(J) Standard N-Type Male Connector

Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series coaxial cable and use a crimping method to secure the connector to the coaxial cable. Furnish a connector that complies with Table 1098-11.

TABLE 1098-11 REQUIREMENTS OF STANDARD N-TYPE MALE CONNECTOR	
Description	**Requirement**
Center Contact	Gold Plated Beryllium Copper (spring loaded – Non-solder)
Outer Contact	Silver Plated Brass
Body	Silver Plated Brass
Crimp Sleeve	Silver Plated Copper
Dielectric	Teflon PTFE
Water Proofing Sleeve	Adhesive Lined Polyolefin – Heat Shrink
Attachment Size	Crimp Size 0.429” (minimum) hex
Electrical Property	**Requirement**
Impedance	50 Ω
Working Voltage	1000 vrms (max)
Insertion loss	0.1 x √ FGHz
VSWR	1.25:1 (max) up to 2.5GHz

(K) Coaxial Cable Shield Grounding and Weatherproofing Kits

(1) Furnish a Coaxial Cable Shield Grounding Kit containing components that will adequately bond and ground the cable shield to the pole ground. Ensure the grounding kit complies with MIL-STD-188-124A for coaxial cable and protects the cable from lightning currents of at least 200kA. Ensure each kit is supplied, as a minimum, with the following:

(a) Preformed Strap: 24 Gauge copper strap that is at least 1 5/8 inch long and is sized to mate with the 400 series coaxial cable

(b) Tensioning Hardware: Copper nuts and lock washers

(c) Grounding Lead Cable: #6 AWG, stranded, insulated copper wire

(2) Furnish a Weatherproofing Kit containing components that will protect the coaxial cable shield grounding system against the ingress of moisture and prevent vibrations from loosening the connections. Ensure the weatherproofing kit is supplied, as a minimum, with the following:

(a) Butyl Mastic Tape: 3 3/4 inches wide by 24 inches long (approximately)

(b) Electrical Tape: 2 inches wide by 20 inches long (approximately)

(c) Instructions on properly installing the weatherproofing system.

(L) Lightning Arrestor

Furnish a lightning arrestor installed in line between each antenna and its designated radio modem inside the equipment cabinet in accordance with Table 1098-12. Furnish lightning arrestor with multistrike capability, low strike throughput energy, flange mount and bulkhead mount options and a standard N-Type female connector on both the surge-side and protected-side connectors.

TABLE 1098-12
PROPERTIES OF LIGHTNING ARRESTOR

Property	Requirement
Surge (8/20µs Waveform) Maximum Strike Multiple Strike	 40kA Max 20kA Multiple
Frequency Range	698MHz to 2.7GHz
Return Loss/VSWR	≤-26dB (VSWR≤ 1.11:1)
Insertion Loss	≤0.1 dB over frequency range
Continuous Power	500 w @ 920MHz (750 W at 122° F)
Let Through Voltage	≤± 200m Volts for 3kA @ 8/20 µs Waveform
Throughput Energy	≤0.5 nJ for 3kA @ 8/20 µs Waveform
Temperature	-40 to 185° F Storage/Operating 122° F
Vibration	1G at 5 Hz up to 100Hz
Unit Impedance	50 Ω
Standard N-Type Female Connector	On both the surge side and protected side connectors
Installation	Bi-Directional
Mounting	Bulkhead bracket with O-Ring, Lock Washer and Nut

(M) Coaxial cable – Power Divider (Splitter)

Furnish a coaxial cable power divider for repeater radio sites in accordance with Table 1098-13. Ensure the power divider accommodates a single primary input RF source and divides/splits the signal (power) equally between two output ports.

TABLE 1098-13
PROPERTIES OF COAXIAL CABLE - POWER DIVIDER

Property	Requirement
Power Division	2 - Way
Frequency	900 - 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 Ω
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female

(N) Disconnect Switch

Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover, suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag device. Ensure outlet box includes one 1/2 inch diameter hole in back of box. Furnish mounting hardware, sealing gaskets and lockout tag.

(O) Warning Signs and Decal

Furnish “RF Warning Sign” and “Decal” at locations called for in the plans. Furnish mounting hardware to secure the sign to either metal or wood poles."