

**NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH**

**STANDARD SPECIFICATIONS
FOR
ROADS AND STRUCTURES**



JANUARY 2012

FOREWORD

This publication has been prepared to provide a compilation of standard requirements used by the North Carolina Department of Transportation for construction contracts.

When this publication, entitled *Standard Specifications for Roads and Structures*, dated January 2012, is incorporated by reference into the Department's construction bid proposals or contracts; it is made a part of that document and shall be known as the *Standard Specifications*. The requirements stated herein may be revised or amended from time to time by Supplemental Specifications, by Standard Special Provisions which are unique to a select group of projects or by Project Special Provisions which are unique to the specific bid proposal or contract.

Working titles have a masculine gender, such as workman, workmen and foreman. Pronouns such as he, his, and him are used in the *Standard Specifications* for the sake of brevity and are intended to refer to persons of either sex and corporate entities.

Reference by title and date will be made to the governing provisions on plans and contract documents.

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For general questions about this publication, please contact the Contract Standards and Development Unit at specs@ncdot.gov or (919) 707-6900.

ORDERING INFORMATION

Copies of the *Standard Specifications* and the *Roadway Standard Drawings* may be purchased through the Contract Standards and Development Unit:

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DIVISION 10 MATERIALS

SECTION 1000 PORTLAND CEMENT CONCRETE PRODUCTION AND DELIVERY

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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, water and pozzolans (optional). Include chemical admixtures as required or needed. Ground granulated blast furnace slag, fly ash or silica fume may be substituted for a portion of the Portland cement. Type IP, IS or IT blended cement may be used instead of Portland cement.

Mixes for all Portland cement concrete shall be designed by a Certified Concrete Mix Design Technician or an engineer licensed by the State of North Carolina.

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.

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
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Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Portland Cement	1024-1
Silica Fume	1024-7
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 PAVEMENT

(A) Composition and Design

Submit concrete paving mix design in terms of saturated surface dry weights on Materials and Tests Form 312U for approval at least 30 days before proposed use. Use a mix that contains at least 526 lb of cement per cubic yard, a maximum water cement ratio of 0.559, an air content in the range of 4.5% to 5.5%, a maximum slump of 1.5", a minimum flexural strength of 650 psi at 28 days and a minimum compressive strength of 4,500 psi at 28 days.

The cement content of the mix design may be reduced by no more than 20% and replaced with fly ash at a minimum rate of 1.2 lb of fly ash to each pound of cement replaced. Use a maximum water-cementitious material ratio not to exceed 0.538.

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1 The cement content of the mix design may be reduced by no more than 50% and replaced
2 with blast furnace slag pound for pound.

3 Include in the mix design the source of aggregates, cement, fly ash, slag, water and
4 admixtures; the gradation and specific gravity of the aggregates; the fineness modulus of
5 the fine aggregate; and the dry rodded unit weight and size of the coarse aggregate.
6 Submit test results showing that the mix design conforms to the criteria, including the
7 1, 3, 7, 14 and 28-day strengths of the average of two 6" x 6" x 20" beams and the
8 average of two 6" x 12" cylinders for each age made and tested in accordance with
9 AASHTO R 39, T22 and T97. Design the mix to produce an average strength sufficient
10 to indicate that a minimum strength of 650 psi in flexure and 4,500 psi in compression
11 will be achieved in the field within 28 days.

12 If any change is made to the mix design, submit a new mix design.

13 If any major change is made to the mix design, also submit new test results showing the
14 mix design conforms to the criteria. Define a major change to the mix design as:

15 (1) A source change in coarse aggregate, fine aggregate, cement or pozzolan (applies
16 only to a change from one type of pozzolan to another; e.g., Class F fly ash to
17 Class C fly ash).

18 (2) A quantitative change in coarse aggregate (applies to an increase or decrease greater
19 than 5%), fine aggregate (applies to an increase or decrease greater than 5%), water
20 (applies to an increase only), cement (applies to a decrease only), or pozzolan
21 (applies to a decrease only).

22 Where concrete with a higher slump for hand methods of placing and finishing is
23 necessary, submit an adjusted mix design for approval to provide a maximum slump of 3"
24 and to maintain the water-cementitious material ratio established by the original mix
25 design.

26 **(B) Air Entrainment**

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

29 Provide an air content of $5.0\% \pm 1.5\%$ in the freshly mixed concrete. The air content will
30 be determined in accordance with AASHTO T 121, T152 or T196. At the option of the
31 Engineer, the air content may be measured by the Chace indicator, AASHTO T 199, in
32 which case sufficient tests will be made to establish correlation with the test methods of
33 AASHTO T 121, T152 or T196. Concrete will not be rejected based on tests made in
34 accordance with AASHTO T 199.

35 **(C) Slump**

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

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

40 **(D) Set Retarding Admixture and Water Reducing Admixture**

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

(E) 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 the *Standard Specifications*.

(F) 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.

1000-4 PORTLAND CEMENT CONCRETE FOR STRUCTURES AND INCIDENTAL CONSTRUCTION**(A) Composition and Design**

Provide the class of concrete required by the contract.

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1 Submit proposed concrete mix designs for each class of concrete to be used in the work.
2 Mix proportions shall be determined by a testing laboratory approved by the Department.
3 Base mix designs on laboratory trial batches that meet Table 1000-1 and this section.

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

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

12 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 T23

13 The Engineer will review the mix design for compliance with the Specifications and
14 notify the Contractor as to its acceptability. Do not use a mix until written notice has
15 been received. Acceptance of the mix design does not relieve the Contractor of his
16 responsibility to furnish a product that meets the contract. Upon written request from the
17 Contractor, a mix design accepted and used satisfactorily on any Department project may
18 be accepted for use on other projects.

19 (B) Air Entrainment

20 Entrain air in the concrete unless otherwise indicated in the plans or in the Specifications.
21 Add an air entraining agent at the time of mixing to produce an air content in the freshly
22 mixed concrete of 6.0% ± 1.5% when tested at the job site. Determine the air content in
23 accordance with AASHTO T 121, T152 or T196. Measurement of air content may also
24 be performed by the Chace indicator in accordance with AASHTO T 199, in which case
25 sufficient tests will be made in accordance with AASHTO T 121, T152 or T196 to
26 establish correlation with the Chace indicator. Concrete for structures will not be rejected
27 based on tests made in accordance with AASHTO T 199. Concrete for incidental
28 construction may be rejected based on an average of 3 or more tests made in accordance
29 with AASHTO T 199.

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

31 (C) Strength of Concrete

32 The compressive strength of the concrete will be considered the average compressive
33 strength test results of two 6" x 12" cylinders, or two 4" x 8" cylinders if the aggregate
34 size is not larger than size 57 or 57M. Make cylinders in accordance with AASHTO T 23
35 from the concrete delivered to the work. Make cylinders at such frequencies as the
36 Engineer may determine and cure them in accordance with AASHTO T 23 as modified
37 by the Department. Copies of these modified test procedures are available upon request
38 from the Materials and Tests Unit.

39 When the average compressive strength of the concrete test cylinders is less than the
40 minimum strength specified in Table 1000-1 and the Engineer determines if the concrete
41 strength will be acceptable. When the Engineer determines average cylinder strength is
42 below the specification, the in-place concrete will be tested. Based on these test results,
43 the concrete will either be accepted with no reduction in payment or accepted at
44 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 nor 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
REQUIREMENTS FOR CONCRETE**

Class of Concrete	Min. Comp. Strength at 28 days	Maximum Water-Cement Ratio				Consistency Max. Slump		Cement Content			
		Air-Entrained Concrete		Non Air-Entrained Concrete		Vibrated	Non-Vibrated	Vibrated		Non-Vibrated	
		Rounded Aggregate	Angular Aggregate	Rounded Aggregate	Angular Aggregate			Min.	Max.	Min.	Max.
<i>Units</i>	<i>psi</i>					<i>inch</i>	<i>inch</i>	<i>lb/cy</i>	<i>lb/cy</i>	<i>lb/cy</i>	<i>lb/cy</i>
AA	4,500	0.381	0.426	-	-	3.5	-	639	715	-	-
AA Slip Form	4,500	0.381	0.426	-	-	1.5	-	639	715	-	-
Drilled Pier	4,500	-	-	0.450	0.450	-	5-7 dry 7-9 wet	-	-	640	800
A	3,000	0.488	0.532	0.550	0.594	3.5	4	564	677	602	602
B	2,500	0.488	0.567	0.559	0.630	2.5	4	508	610	545	654
B Slip Formed	2,500	0.488	0.567	-	-	1.5	-	508	610	-	-
Sand Lightweight	4,500	-	0.420	-	-	4	-	715	715	-	-
Latex Modified	3,000 7 day	0.400	0.400	-	-	6	-	658	658	-	-
Flowable Fill excavatable	150 max. at 56 days	as needed	as needed	as needed	as needed	-	Flow- able	-	-	40	100
Flowable Fill non-excavatable	125	as needed	as needed	as needed	as needed	-	Flow- able	-	-	100	as needed
Pavement	4,500 design, field 650 flexural, design only	0.559	0.559	-	-	1.5 slip form 3.0 hand place	-	526	-	-	-
Precast	See Table 1077-1	as needed	as needed	-	-	6	as needed	as needed	as needed	as needed	as needed
Prestress	per contract	See Table 1078-1	See Table 1078-1	-	-	8	-	564	as needed	-	-

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1 (E) Elapsed Time for Placing Concrete

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

6 **A.** Applicable to Class AA, A and Drilled Pier concrete.

7 **B.** Applicable to Class B concrete.

8 (F) Use of Set Retarding Admixtures

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

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

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

18 (G) Use of Water Reducing Admixtures

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

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

23 (H) Use of Calcium Chloride

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

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

35 (I) Use of Fly Ash

36 Use Table 1000-3 to determine the maximum allowable water-cementitious material
37 (cement + fly ash) ratio for the classes of concrete listed. For all other classes, the

1 maximum water-cementitious material ratio will be the same as the water-cement ratio
2 listed in Table 1000-1.

TABLE 1000-3		
MAXIMUM WATER-CEMENTITIOUS MATERIAL RATIO		
Class of Concrete	Rounded Aggregate	Angular Aggregate
AA and AA Slip Form	.366	.410
A	.469	.512
B and B Slip Form	.469	.545
Pavement	.538	.538

3 **(J) Use of Ground Granulated Blast Furnace Slag**

4 For mixes that contain cement and ground granulated blast furnace slag, the
5 water-cementitious ratio (cement and slag) shall not exceed the water-cement ratio shown
6 in Table 1000-1.

7 **(K) Use of Calcium Nitrite Corrosion Inhibitor**

8 Units with calcium nitrite in a quantity less than specified are subject to rejection.
9 Furnish concrete cylinders to the Engineer, in a quantity to be specified, to verify the
10 concentrations of calcium nitrite in hardened concrete. Concrete that fails to contain
11 calcium nitrite at the required concentrations as tested is subject to rejection. Use
12 air-entraining, water-reducing and/or set-controlling admixtures compatible with calcium
13 nitrite solutions. Strictly adhere to the manufacturer's written recommendations
14 regarding the use of admixtures, including storage, transportation and method of mixing.
15 If preferred, use calcium nitrite, which acts as an accelerator, in conjunction with
16 a retarder to control the set of concrete, as per the manufacturer's recommendation. Add
17 an approved calcium nitrite corrosion inhibitor (30% solids) to the concrete mix at the
18 batch plant for the bridge elements identified by the plan notes. Use the inhibitor at
19 a minimum rate of 3.0 gal/cy. Ensure that the hardened concrete contains at least
20 5.1 lb/cy nitrite (NO₂) when tested in accordance with Materials and Tests Method
21 Chem. C-20.0. The preceding paragraph does not apply to concrete used in prestressed
22 concrete members. Concrete used in prestressed concrete members shall be tested in
23 accordance with Subarticle 1078-4(G).

24 **1000-5 HIGH EARLY STRENGTH PORTLAND CEMENT CONCRETE**

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

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

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

34 **1000-6 FLOWABLE FILL**

35 Flowable fill consists of Portland cement, water, pozzolan and/or fine aggregate and,
36 optionally, concrete admixtures.

37 Submit the proposed mix design on Materials and Tests Form 312U at least 35 days before
38 use. Use a testing laboratory approved by the Department to determine mix proportions based
39 on laboratory trial batches meeting Table 1000-1.

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1 State on Form 312U the intended use of the material. Accompany Form 312U with a listing
2 of compressive strength of at least three 4" x 8" cylinders at the age of 28 or 56 days,
3 depending on whether the mix is to be excavated or not. Air cure the cylinders during the
4 entire period before testing. The Engineer will advise the Contractor in writing of the
5 acceptability of the mix design.

6 **1000-7 LATEX MODIFIED CONCRETE**

7 **(A) Materials**

8 Refer to Division 10.

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

9 Do not use Type III high early strength cement.

10 Use a formulated latex admixture that is a non-hazardous, film forming and polymeric
11 emulsion in water and is homogeneous and uniform in composition. Add all stabilizers at
12 the point of manufacture.

13 Use a latex modifier conforming to Table 1000-4.

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

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

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

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

22 For latex modified concrete, use a workable mixture that meets Table 1000-5.

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

24 Submit the latex modified concrete mix design, completed by the latex emulsion
25 manufacturer, to the Engineer for review.

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.

1 **(B) Equipment**

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

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

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

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

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

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

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

36 Mount a tachometer on the unit to indicate the drive shaft speed.

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

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1 Use a finishing machine that meets the approval of the Engineer and the requirements of
2 the contract. Use a self-propelled finishing machine capable of forward and reverse
3 movement under positive control. Use a machine with at least 2 finishing devices, one
4 that is a vibrating screed and the other either a vibrating screed, oscillating screed, or one
5 or more rotating cylindrical drums 48" long or less and operating between 1,500 and
6 2,500 vpm. Make certain the finishing machine can finish the surface to within one foot
7 of the edges of the area being placed. Raise all screeds when the finishing machine is
8 moving backwards over the screeded surface.

9 Use screeds with a vibration frequency that is variable between 3,000 and 6,000 vpm
10 with positive controls. Use screeds with a metal covered bottom face not less than
11 4" wide. Provide screeds with positive control of the vertical position.

12 Use supporting rails for travelling of the finishing machine rigid enough to eliminate
13 deflection from the weight of the machine.

14 (C) Proportioning and Mixing of Modified Compositions

15 Meet the following requirements when proportioning and mixing modified materials:

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

19 Yield checks and other checks are permitted.

20 1000-8 MEASURING MATERIALS

21 (A) Weighing Cement

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

29 (B) Weighing Aggregates

30 Measure aggregates by weight. Base batch weights on saturated surface dry materials
31 and which are the required weights plus the total weight of surface moisture contained in
32 the aggregates. Ensure the individual aggregates, as weighed, are within $\pm 2\%$ of the
33 required weights.

34 (C) Water

35 Measure water by volume or by weight. Ensure the quantity of water measured is
36 within $\pm 1\%$ of the required amount.

37 (D) Admixture Dispensing Systems

38 Provide a separate dispensing system with separate fill and discharge lines for each type
39 of admixture to be used, except that admixtures may be measured and introduced into the
40 mix manually if approval has been obtained. Ensure each system is capable of
41 measuring, displaying and discharging the required amount of admixture into the mix.
42 Keep dispensing systems clean and in good operating condition. Use a dispensing system
43 that is either:

44 (1) Manually operated, self contained; or

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

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

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

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

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

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

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

25 **1000-9 BATCHING PLANT**

26 **(A) General**

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

28 Have ready mixed concrete plants inspected and approved by the Department before they
29 are used to produce concrete, either paving, structural or incidental, for the project.
30 Plants shall meet all the applicable requirements of these *Standard Specifications*, and in
31 addition, ensure each ready mix plant provides at least 3 acceptable truck mixers or truck
32 agitators available for use. Use trucks that have an identifying number. Plants approved
33 by the Department will be placed on a list of approved plants available to the Contractor.
34 All plants will be subject to reinspection at intervals selected by the Engineer.
35 Reapproval after each inspection will be contingent on continuing compliance with the
36 *Standard Specifications*.

37 **(B) Bins and Hoppers**

38 Provide bins with separate compartments for fine aggregates and for each required size of
39 coarse aggregate in the batching plant. Design each compartment to discharge efficiently
40 and freely into the weighing hopper. Provide control so, as the quantity desired is being
41 approached, the material may be added slowly and shut off with precision. Construct
42 weighing hoppers to eliminate accumulation of tare materials and to discharge fully
43 unless otherwise permitted. Provide a port or other opening for removing an overload of
44 any one of the several materials from the hopper.

45 **(C) Scales**

46 Use either the beam type, load cell type or the springless dial type scales for weighing
47 aggregates and cement. Ensure the minimum graduation on beam or dial is not more than
48 0.1% of the total capacity of the scale. Methods of weighing, other than beam or
49 springless dial scales, may be approved by the Engineer provided they meet the required

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1 weighing tolerances. Ensure the scales are accurate within 0.5% under operating
2 conditions. Make available ten 50 lb test weights at the plant for checking accuracy. Use
3 test weights which meet the U.S. Bureau of Standards requirements for calibrating and
4 testing equipment. Keep all exposed fulcrums, clevises and similar working parts of
5 scales clean. When beam type scales are used, make provisions for indicating to the
6 operator that the required load in the weighing hopper is being approached. Ensure the
7 device indicates at least the last 50 lb of load and design it to give a positive indication of
8 overload of the scales. During charging of the hopper, have all indicating devices in full
9 view of the operator and provide convenient access to all controls. Ensure the indicating
10 devices are in the immediate vicinity of the operator and easily readable by the operator.

11 (D) Water Measuring Devices

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

20 1000-10 MIXERS AND AGITATORS

21 (A) General

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

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

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

42 (B) Mixer Capacity

43 Do not load truck mixers with concrete with more than 63% of the gross volume of the
44 drum. Use mixers capable of combining the ingredients of the concrete into a thoroughly
45 mixed and uniform mass and of discharging the concrete with a satisfactory degree of
46 uniformity. Use stationary mixers, when loaded at the manufacturer's guaranteed mixing
47 capacity and the concrete mixed for the prescribed mixing time, capable of combining the
48 ingredients of the concrete into a thoroughly mixed and uniform mass and discharging
49 the concrete with satisfactory uniformity.

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

3 **(C) Agitator Capacity**

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

7 **(D) Consistency Tests**

8 The Engineer may, from time to time, make slump tests to measure consistency of the
9 concrete. Take individual samples at approximately the 1/5th point, the midpoint and the
10 4/5th point of the load, using AASHTO T 119. Such tests will be made within
11 20 minutes of discharge of that portion of the load. If the results vary by more than 1" in
12 slump, do not use the mixer or agitator unless the condition is corrected.

13 **1000-11 MIXING AND DELIVERY**

14 **(A) General**

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

18 When concrete is being produced for structures and incidental construction in accordance
19 with Article 1000-4, have present during all batching operations a Certified Concrete
20 Batch Technician employed by the Contractor or concrete supplier. During batching and
21 delivery, the sole duty of this employee is to supervise the production and control of the
22 concrete. Perform moisture tests, adjust mix proportions of aggregates for free moisture,
23 complete and sign Batch Tickets (Materials and Tests Form 903) or approved delivery
24 tickets and assure quality control of the batching. Delivery tickets will be permitted
25 instead of batch tickets (Materials and Tests Form 903) provided they have been
26 reviewed and approved by the Materials and Tests Unit. The Department certifies
27 technicians who satisfactorily complete examinations prepared and administered by the
28 Department.

29 **(1) Central Mixed Concrete**

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

35 **(2) Transit Mixed Concrete**

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

38 **(3) Shrink Mixed Concrete**

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

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1 (B) Mixing Time for Central Mixed Concrete

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

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

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

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 T 23

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

19 Each of the 2 samples of concrete will be separately tested for the properties listed in
20 Table 1000-6. Tests will be conducted in accordance with the test procedures specified
21 in Table 1000-6 or procedures established by the Materials and Tests Unit.

22 The mixer performance test described above will be performed on at least 2 batches of
23 concrete. For the performance test to be acceptable, have all tests in each batch tested
24 meet the requirements listed above.

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

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

30 (C) Truck Mixers and Truck Agitators

31 When a truck mixer is used for complete mixing, mix each batch of concrete for at least
32 70 revolutions of the drum or blades at the rate of rotation designated by the
33 manufacturer of the equipment as mixing speed, unless otherwise directed by the
34 Engineer. Unless the mixer is equipped with a counter which will distinguish between
35 mixing and agitating speeds, perform the minimum required number of revolutions of the
36 drum at mixing speed as directed, either at the batching plant before the mixer leaves
37 for the work site and/or at the work site before the concrete is discharged.

1 Perform any additional mixing at the speed designated by the manufacturer of the
2 equipment as agitating speed. Put all materials including mixing water in the drum
3 before actuating the revolution counter for determining the number of revolutions of the
4 drum.

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

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

16 **(D) Delivery**

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

27 **1000-12 VOLUMETRIC MIXED CONCRETE**

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

35 **(A) Materials**

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

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

44 Moisture content of the coarse and fine aggregate will be made available onsite for the
45 Engineer's review for each load. The frequency of moisture testing will be dependent on
46 certain variables such as weather, season and source; however, moisture tests should be
47 performed at least once at the beginning of the work day for each source material.
48 Additional daily moisture tests for the coarse and fine aggregate shall be performed if
49 requested by the Engineer.

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

3 (B) Equipment

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

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

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

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

- 26 (1) Contractor Name
- 27 (2) Contractor Phone Number
- 28 (3) NCDOT Project No. and TIP No.
- 29 (4) Date
- 30 (5) Truck No.
- 31 (6) Ticket No.
- 32 (7) Time Start/End of Pour
- 33 (8) Mix ID and Description (Strength)
- 34 (9) Aggregate Moisture Before Mixing

35 (C) Proportioning Devices

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

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

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

1 The volumetric mixer shall be capable of measurement of cement, pozzolan (if required),
2 liquids and aggregate being introduced into the mix.

3 **(D) Calibration**

4 Volume-weight relationships will be based on calibration. The proportioning devices
5 shall be calibrated by the contractor before the start of each NCDOT job and
6 subsequently at intervals recommended by the equipment manufacturer. Calibrations
7 will be performed in the presence of the Department and subject to approval from the
8 Department. Calibration of the cement and aggregate proportioning devices shall be
9 accomplished by weighing (determining the mass of) each component. Calibration of the
10 admixture and water proportioning devices shall be accomplished by weight (mass) or
11 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

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

14 **(E) Verification of Yield**

15 Verification of the proportioning devices may be required at any time by the Department.
16 Verification shall be accomplished by proportioning the rock and sand based on the
17 cement meter count for each concrete mobile mixer. Once the count (revolutions) for
18 94 lb of cement has been determined then delivery of the correct amount of rock and sand
19 can be verified.

20 **(F) Uniformity**

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

26 Two samples of sufficient size to make the required tests will be taken after discharge of
27 approximately 15% and 85% of the load. Each of the 2 samples of concrete will be
28 separately tested for the properties listed in Table 1000-7. Tests will be conducted in
29 accordance with the test procedures specified in Table 1000-7 or procedures established
30 by the Materials and Tests Unit. The Engineer may recheck mixer performance at any
31 time when, in his opinion, satisfactory mixing is not being accomplished.

32 **SECTION 1002**
33 **SHOTCRETE PRODUCTION AND DELIVERY**

34 **1002-1 DESCRIPTION**

35 This section addresses shotcrete to be used for temporary support of excavations and other
36 applications in accordance with the contract. Produce shotcrete by either the dry-mix or
37 wet-mix process composed of Portland cement, fine and/or coarse aggregates, water and at the
38 Contractor's option, pozzolans. Include chemical admixtures as required or needed for
39 shotcrete produced by the wet-mix process. Ground granulated blast furnace slag, fly ash or

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1 silica fume may be substituted for a portion of the Portland cement. Type IS, IP or IT blended
2 cement may be used instead of Portland cement.

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

8 **1002-2 MATERIALS**

9 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 IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Type IT Blended Cement	1024-1
Water	1024-4

10 **1002-3 SHOTCRETE FOR TEMPORARY SUPPORT OF EXCAVATIONS**

11 **(A) Composition and Design**

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

19 The Engineer will review the shotcrete mix design for compliance with the contract and
20 notify the Contractor as to its acceptability contingent upon compressive strength test
21 results for cores from preconstruction test panels. Do not use a shotcrete mix until
22 written notice has been received. Acceptance of the shotcrete mix design does not relieve
23 the Contractor of his responsibility to furnish a product that meets this contract. Upon
24 written request from the Contractor, a shotcrete mix design accepted and used
25 satisfactorily on any Department project may be accepted for use on other projects.

26 **(B) Chemical Admixtures**

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

29 **(C) Strength of Shotcrete**

30 Provide shotcrete with a compressive strength at 3 and 28 days of at least 2,000 psi and
31 4,000 psi, respectively. The compressive strength of the shotcrete will be considered the
32 average compressive strength test results of 3 cores from the same test panel at each age.

33 **(D) Preconstruction Test Panels**

34 Before beginning construction, provide one preconstruction test panel for each shotcrete
35 mix design and nozzlemen using the same equipment that will be used for the work. Use
36 3 ft x 3 ft forms at least 3.5" thick for preconstruction test panels.

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

6 **(E) Mixing and Delivery**

7 Produce shotcrete of required strength, consistency, quality and uniformity with
8 minimum rebound. Do not use rebound or previously expanded material in the shotcrete
9 mix. Thoroughly mix materials in sufficient quantity to place shotcrete continuously.
10 Regulate the delivery so the maximum interval between the shooting of batches at the
11 work site does not exceed 20 minutes. Comply with Articles 1000-9 through 1000-12 to
12 the extent applicable for shotcrete instead of concrete.

13 **(F) Shooting Requirements**

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

18 The shotcrete temperature at the time of shooting shall be not less than 50°F nor more
19 than 90°F. Do not apply shotcrete during heavy rains or runoff or high winds so the
20 nozzle stream separates during shooting. Do not apply shotcrete if surface to receive
21 shotcrete is frozen or the air temperature measured at the location of the shotcreting
22 operation in the shade away from artificial heat is below 40°F. Apply shotcrete before
23 the time between adding the mixing water to the shotcrete mix and shooting the shotcrete
24 exceeds 60 minutes.

25 **(G) Production Test Panels**

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

31 **SECTION 1003**

32 **GROUT PRODUCTION AND DELIVERY**

33 **1003-1 DESCRIPTION**

34 This section addresses grout to be used for traffic barriers, foundations, retaining walls, slopes
35 and other applications in accordance with the contract. Produce non-metallic grout composed
36 of Portland cement and water and at the Contractor's option, fine aggregate and pozzolans.
37 Include chemical admixtures as required or needed. Ground granulated blast furnace slag, fly
38 ash or silica fume may be substituted for a portion of the Portland cement. Provide nonshrink,
39 freeze-thaw durable, sand cement or neat cement grout as required. Define "sand cement
40 grout" as grout with fine aggregate and "neat cement grout" as grout without fine aggregate.

41 Mixes for all grout shall be designed by a Certified Concrete Mix Design Technician or
42 an engineer licensed by the State of North Carolina.

43 **1003-2 MATERIALS**

44 Refer to Division 10.

Item	Section
Chemical Admixtures	1024-3
Fine Aggregate	1014-1

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Item	Section
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Portland Cement	1024-1
Silica Fume	1024-7
Water	1024-4

- 1 Do not use grout that contains soluble chlorides or more than 1% soluble sulfate.
- 2 At the Contractor's option, use an approved packaged grout instead of the materials above
3 except for water. A list of approved packaged grouts is available from the Materials and Tests
4 Unit. Consult the manufacturer to determine if the packaged grout to be used is suitable for
5 the application and meets the height change, durability and compressive strength
6 requirements.

7 **1003-3 GROUT FOR TRAFFIC BARRIERS, FOUNDATIONS, RETAINING** 8 **WALLS, SLOPES AND OTHER APPLICATIONS**

9 **(A) Composition and Design**

10 When using approved packaged grout, a grout mix design submittal is not required.
11 Otherwise, submit proposed grout mix designs for each grout mix to be used in the work.
12 Mix proportions shall be determined by a testing laboratory approved by the Department.
13 Base grout mix designs on laboratory trial batches that meet this section.

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

19 Accompany Materials and Tests Form 312U with a listing of laboratory test results of
20 density, flow or viscosity and compressive strength and if applicable, aggregate
21 gradation, height change and durability. List the compressive strength of at least three
22 2" cubes at the age of 3 and 28 days.

23 The Engineer will review the grout mix design for compliance with the contract and
24 notify the Contractor as to its acceptability. Do not use a grout mix until written notice
25 has been received. Acceptance of the grout mix design or use of approved packaged
26 grouts does not relieve the Contractor of his responsibility to furnish a product that meets
27 the contract. Upon written request from the Contractor, a grout mix design accepted and
28 used satisfactorily on any Department project may be accepted for use on other projects.

29 Perform laboratory tests in accordance with the following test procedures:

Property	Test Method
Aggregate Gradation for Sand Cement Grout	AASHTO T 27
Density	AASHTO T 133
Flow for Sand Cement Grout	ASTM C939 ^A
Viscosity for Neat Cement Grout	ANSI/API RP ^B 13B-1 Section 6.2, Marsh Funnel
Height Change for Nonshrink Grout	ASTM C1090 ^C
Durability for Freeze-Thaw Durable Grout	ASTM C666 ^D
Compressive Strength	AASHTO T 106

- 30 **A.** Modify flow cone outlet diameter from 1/2" to 3/4"
31 **B.** American National Standards Institute/American Petroleum Institute Recommended
32 Practice
33 **C.** Moist room storage required
34 **D.** Procedure A (Rapid Freezing and Thawing in Water) required

1 (B) Chemical Admixtures

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

4 (C) Strength of Grout

5 Provide grout with a compressive strength at 3 and 28 days of at least 2,500 psi and
6 4,500 psi, respectively, unless required otherwise in the *Standard Specifications*. The
7 compressive strength of the grout will be considered the average compressive strength
8 test results of three 2" cubes at each age. Make cubes that meet AASHTO T 106 from the
9 grout delivered for the work or mixed on-site. Make cubes at such frequencies as the
10 Engineer may determine and cure them in accordance with AASHTO T 106.

11 (D) Height Change

12 Provide nonshrink grout with a height change at 28 days between 0% and 0.3%.

13 (E) Durability

14 Provide freeze-thaw durable grout with a durability factor of at least 80.

15 (F) Temperature Requirements

16 The grout temperature at the time of placement shall be not less than 50°F nor more
17 than 90°F. Do not place grout when the air temperature measured at the location of the
18 grouting operation in the shade away from artificial heat is below 40°F.

19 (G) Elapsed Time for Placing Grout

20 Agitate grout continuously before placement. Regulate the delivery so the maximum
21 interval between the placing of batches at the work site does not exceed 20 minutes.
22 Place grout before exceeding the times in Table 1003-1. Measure the elapsed time as the
23 time between adding the mixing water to the grout mix and placing the grout.

TABLE 1003-1 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

24 (H) Mixing and Delivery

25 Use grout free of any lumps and undispersed cement. Comply with Articles 1000-9
26 through 1000-12 to the extent applicable for grout instead of concrete.

**SECTION 1005
GENERAL REQUIREMENTS FOR AGGREGATE**

29 1005-1 GENERAL

30 Obtain aggregates from sources participating in the Department's Aggregate QC/QA Program
31 as described in Section 1006. Obtain aggregates from pre-approved sources, or have the
32 source approved before use. Approval of such sources is based not only on the quality of the
33 aggregate, but also on satisfactory production facilities and procedures. A list of approved
34 aggregate sources participating in the Department's Aggregate QC/QA Program in

Section 1005

1 North Carolina and adjoining states is available from the Materials and Tests Unit. This list
2 includes aggregates meeting Specification requirements but whose use is restricted due to
3 history of unsatisfactory service performance. Use of aggregates is allowed in the work
4 provided they have been properly stockpiled in units of not less than 300 tons, tests of
5 representative samples of these aggregates indicate satisfactory compliance with the
6 Specifications and the source meets all the requirements of the Aggregate QC/QA Program.

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

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

13 1005-2 HANDLING AND STORING AGGREGATES

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

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

19 Space or separate with suitable walls or partitions stockpiles of different types or sizes of
20 aggregates to prevent the mixing of the aggregates. Identify stockpiles with signs that can be
21 read from a distance of at least 50 ft from the pile.

22 Do not allow the stockpile to become contaminated with foreign matter or degrade
23 excessively. Failure of aggregate samples to meet all gradation requirements due to excessive
24 degradation will be determined by sieve tests of samples taken from any portion of the
25 stockpile and is cause for discontinuance of such stockpiling procedure.

26 Use material that consists mainly of rock dust produced through normal handling of the
27 aggregate and that is essentially free from clay or shale.

28 1005-3 GRADATION

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

30 1005-4 TESTING

31 Aggregates will be tested in accordance with the test methods below except where other test
32 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

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

**TABLE 1005-1
AGGREGATE GRADATION - COARSE AGGREGATE**

Std. Size #	Percentage of Total by Weight Passing															Remarks
	2"	1 1/2"	1"	3/4"	1/2"	#4	#8	1/2"	#10	#16	#40	#200				
4	100	90-100	20-55	0-15	-	-	-	-	-	-	-	0-0.6 ^A	Asphalt Plant Mix			
467M	100	95-100	-	35-70	-	0-5	-	-	-	-	-	0-0.6 ^A	Asphalt Plant Mix			
5	-	100	90-100	20-55	0-10	-	-	0-10	-	-	-	0-0.6 ^A	AST Mat Coat, Sediment Control Stone			
57	-	100	95-100	-	25-60	0-10	0-5	25-60	-	-	-	0-0.6 ^A	AST, Str. Conc., Shoulder Drain, Sediment Control Stone			
57M	-	100	95-100	-	25-45	0-10	0-5	25-45	-	-	-	0-0.6 ^A	AST, Portland Cement			
6M	-	-	100	90-100	20-55	0-8	-	20-55	-	-	-	-	AST, Concrete Pavement			
67	-	-	100	90-100	-	0-10	0-5	-	-	-	-	0-0.6 ^A	AST			
78M	-	-	-	100	98-100	20-45	0-15	98-100	-	-	-	0-0.6 ^A	AST, Str. Conc., Drilled Piers, Asphalt Plant Mix			
14M	-	-	-	-	-	35-70	5-20	-	-	0-8	-	0-0.6 ^A	AST, Weep Hole Drains, Str. Concrete			
9	-	-	-	-	-	85-100	10-40	-	-	0-10	-	0-0.6 ^A	AST			
ABC	-	100	75-97	-	55-80	35-55	-	55-80	25-45	-	14-30	4-12 ^B	-			
ABC (M)	-	-	-	-	100	5-40	0-20	100	-	0-10	-	0-2.5 ^B	Aggregate Stabilization, Aggregate/Base Course, Asphalt Plant Mix			
Light-weight	-	100	75-100	-	45-79	20-40	-	45-79	0-25	-	-	0-12	AST			

A. See Subarticle 1005-4(A).

B. See Subarticle 1005-4(B).

Section 1005

- 1 (A) When aggregates are used for Portland cement concrete, asphalt treatment and asphalt
 2 plant mix, the requirements pertaining to material passing the No. 200 sieve are as
 3 follows:
- 4 (1) When tested during production, the amount of material passing the No. 200 sieve
 5 shall be no greater than 0.6%. When tested in a stockpile at the quarry site, the
 6 amount of material passing the No. 200 sieve shall be no greater than 1.0%.
- 7 (2) When tested at the job site before use, the amount of material passing the
 8 No. 200 sieve shall:
- 9 (a) Be no greater than 1.5% for aggregate used in Portland cement concrete or
 10 asphalt surface treatment.
- 11 (b) Be no greater than 2.0% for aggregate used in asphalt plant mix.
- 12 (3) If a stockpile at the job site is found to contain in excess of the specified amount of
 13 material passing the No. 200 sieve before use, the Engineer may approve its use
 14 provided:
- 15 (a) For aggregate used in Portland cement concrete, the total percentage by weight
 16 passing the No. 200 sieve in the combined coarse and fine aggregate in the mix
 17 does not exceed 2.0%, and provided no increase in water-cement ratio is
 18 required by the use of this aggregate.
- 19 (b) For aggregate used in asphalt plant mix, the total percentage by weight of minus
 20 No. 200 material in the plant mix being produced, as determined by the
 21 extraction test, can be maintained within the limits allowed by the job mix
 22 formula.
- 23 (B) For ABC and ABC(M), in addition to the gradation requirements, the material passing
 24 the No. 40 sieve shall not have a LL in excess of 30 nor a PI in excess of 6. For ABC
 25 used in asphalt plant mix, when tested during production, in a stockpile at the quarry site
 26 or at the job site before use, the amount of material passing the No. 200 sieve shall be
 27 from 0.0% to 12.0% by weight and the gradation requirements for material passing the
 28 No. 10 sieve (soil mortar) required in Section 1010 for ABC will not apply. For ABC not
 29 used in asphalt plant mix, the gradation requirements for material passing the
 30 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

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

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SECTION 1006

AGGREGATE QUALITY CONTROL/QUALITY ASSURANCE

The Aggregate QC/QA Program is designed to give aggregate producers 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 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 is 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 Department's *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 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 1012

1 **1010-2 AGGREGATE FOR PLANT MIXED CEMENT TREATED BASE COURSE**

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

4 **SECTION 1012**
5 **AGGREGATE FOR ASPHALT PAVEMENTS**
6 **AND SURFACE TREATMENTS**

7 **1012-1 AGGREGATE FOR ASPHALT PLANT MIXES**

8 **(A) General**

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

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

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

23 **(B) Coarse Aggregate**

24 (1) General

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

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

34 (2) Gradation

35 Use standard size coarse aggregate meeting Table 1005-1 and these *Standard*
36 *Specifications* unless otherwise approved.

37 (3) Coarse Aggregate Angularity (Fractured Faces)

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

40 (4) Flat and Elongated Pieces

41 Use coarse aggregate meeting Table 1012-1 for flat and elongated pieces when tested
42 in accordance with ASTM D4791 on the No. 4 sieve and larger with a 5:1 aspect
43 ratio (maximum to minimum) for all pavement types, except there is no requirement
44 for Types SF9.5A and S9.5B.

1 (5) Soundness

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

TABLE 1012-1 AGGREGATE CONSENSUS PROPERTIES^A				
Mix Type	Coarse Aggregate Angularities^B	Fine Aggregate Angularities % Minimum	Sand Equivalent % Minimum	Flat and Elongated 5 : 1 Ratio % Maximum
<i>Test Method</i>	<i>ASTM D5821</i>	<i>AASHTO T 304</i>	<i>AASHTO T 176</i>	<i>ASTM D4791</i>
SF9.5A; S9.5B	75 / -	40	40	-
I19.0B; B25.0B	75 / -	40	40	10
S9.5C; S12.5C; I19.0C; B25.0C	95 / 90	45	45	10
S9.5D; S12.5D; I19.0D	100 / 100	45	50	10
OGAFC	100 / 100	45	45	10
UBWC	100 / 85	45	45	10

5 **A.** Requirements apply to the design aggregate blend.

6 **B.** 95/90 denotes that 95% of the coarse aggregate has one fractured face and 90% has
 7 2 or more fractured faces.

8 (6) Toughness (Resistance to Abrasion)

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

14 (7) Deleterious Materials

15 The maximum allowable percentage by weight of clay lumps and friable particles in
 16 individual aggregate sources shall be 0.3% when tested in accordance with
 17 AASHTO T 112.

18 (8) Durability (Micro-Deval test)

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

21 **(C) Fine Aggregate**

22 (1) General

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

Section 1012

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

7 Furnish sand from approved sources. Do not use sources contaminated by industrial
8 waste. A sufficient number of samples of fine aggregate, but in no case less than 3,
9 will be taken to indicate any variation within any stockpile or source of supply.

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

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

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

16 (2) Gradation

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

20 (3) Clay Content (Sand Equivalent)

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

23 (4) Soundness

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

27 Natural sand that contains grains of questionable hardness will be subjected to
28 5 cycles of the soundness test. The weighted average loss shall be not more
29 than 15%. The soundness test will be performed before establishing the mix design.

30 (5) Deleterious Materials

31 The maximum percentage by weight of clay lumps and friable particles in individual
32 fine aggregate sources shall be 0.3% when tested in accordance with
33 AASHTO T 112.

34 (6) Fine Aggregate Angularity

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

37 (D) Mineral Filler

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

40 (E) Reclaimed Asphalt Shingles (RAS)

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

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

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

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

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

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

23 Blend RAS with fine aggregate or RAP, meeting the requirements of this Section, if
24 needed to keep the processed material workable.

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

26 (1) Mix Design RAS

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

29 (2) Mix Production RAS

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

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

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

43 Field approval of new source RAS will be based on the table below and volumetric
44 mix properties on the mix with the new source RAS included. Provided these
45 tolerances are met, volumetric properties of the new mix will then be performed. If
46 all volumetric mix properties meet the mix design criteria for that mix type, the new
47 source RAS may continue to be used.

Section 1012

1 If the gradation, binder content, or any of the volumetric mix properties are not
 2 within the allowable tolerances of the table below, do not use the new source RAS
 3 unless approved by the Engineer. The Contractor may elect to either not use the
 4 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
<i>Sieve Size, mm</i>	<i>Tolerance</i>
4.75	± 5
2.36	± 4
1.18	± 4
0.300	± 4
0.150	± 4
0.075	± 2.0

5 **(F) Reclaimed Asphalt Pavement (RAP)**

6 (1) Mix Design RAP

7 Incorporate RAP from stockpiles or other sources tested for uniformity of gradation
 8 and binder content before use in an asphalt mix design. Use RAP that meets all
 9 requirements specified for the following classifications.

10 (a) Millings

11 Existing RAP that is removed from its original location by a milling process as
 12 specified in Section 607. Millings should be such that it has a uniform gradation
 13 and binder content and all materials will pass a 2" sieve before introduction into
 14 the plant mixer unit.

15 (b) Processed RAP

16 RAP that is processed in some manner (possibly by crushing and/or use of
 17 a blending method) to produce a uniform gradation and binder content in the
 18 RAP before use in a recycled mix. Process RAP so all materials have a uniform
 19 gradation and binder content and will pass a 1" sieve before introduction into the
 20 plant mixer unit.

21 (c) Fractionated RAP

22 Fractionated RAP is defined as having 2 or more RAP stockpiles, where the
 23 RAP is divided into coarse and fine fractions. Grade RAP so all materials will
 24 pass a 1" sieve. The coarse RAP stockpile shall only contain material retained
 25 on a 3/8" screen, unless otherwise approved. The fine RAP stockpile shall only
 26 contain material passing the 3/8" screen, unless otherwise approved. The
 27 Engineer may allow the Contractor to use an alternate to the 3/8" screen to
 28 fractionate the RAP. The maximum percentages of fractionated RAP may be
 29 comprised of coarse, fine, or the combination of both. Use a separate cold feed
 30 bin for each stockpile of fractionated RAP introduced into the mix.

31 (d) Approved Stockpiled RAP

32 Approved Stockpiled RAP is defined as fractionated RAP which has been
 33 isolated and tested for asphalt content, gradation and asphalt binder
 34 characteristics with the intent to be used in mix designs with greater than
 35 30% RAP materials. Fractionate the RAP in accordance with
 36 Subsection 1012-1(F)(1)(c). Use a separate cold feed bin for each approved
 37 stockpile of RAP used.

1 Perform extraction tests at a rate of one per 1,000 tons of RAP, with at least
 2 5 tests per stockpile to determine the asphalt content and gradation. Separate
 3 stockpiles of RAP material by fine and coarse fractions. Erect and maintain
 4 a sign satisfactory to the Engineer on each stockpile to identify the material.
 5 Assure that no deleterious material is allowed to contaminate any stockpile. The
 6 Engineer may reject by visual inspection any stockpiles that are not kept clean,
 7 separated and free of foreign materials.

8 Submit requests for RAP stockpile approval to the Engineer with the following
 9 information at the time of the request:

- 10 (i) Approximate tons of materials in stockpile,
 11 (ii) Name or Identification number for the stockpile,
 12 (iii) Asphalt binder content and gradation test results, and
 13 (iv) Asphalt characteristics of the stockpile.

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

TABLE 1012-3	
APPROVED STOCKPILED RAP GRADATION AND BINDER TOLERANCES^A	
(Apply Tolerances to Mix Design Data)	
P_b %	± 0.3%
<i>Sieve Size, mm</i>	<i>Tolerance</i>
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%

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

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

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

27 (2) Mix Production RAP

28 During mix production, use RAP that meets the criteria for one of the following
 29 categories:

30 (a) Mix Design RAP

31 RAP contained in the mix design stockpiles as described above may be used in
 32 all applicable JMFs. These stockpiles have been pretested; however, they are
 33 subject to required QC/QA testing in accordance with the *HMA/QMS Manual*.

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(b) New Source RAP

Define “new source RAP” as any acceptable material that was not included in the stockpile or other source when samples were taken for mix design purposes. Process new source RAP so all materials have a uniform gradation and binder content and will pass a 2" sieve before introduction into the plant mixer unit.

**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

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 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 on the mix with the new source RAP included. Provided the Table 1012-4 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.

1 **(G) Anti-Strip Additives**

2 Anti-strip additives may either be hydrated lime or a chemical additive or a combination
3 of both. Use an anti-strip additive capable of preventing the separation of the asphalt
4 binder from the aggregate and achieving the required tensile strength ratio (TSR) on the
5 asphalt mix when tested in accordance with AASHTO T 283 as modified by the
6 Department.

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

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

13 **(H) Silicone**

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

15 **(I) Fiber Stabilizing Additives**

16 Use fiber stabilizing additives that are capable of stabilizing the asphalt film surrounding
17 the aggregate particles to reduce drain-down of the asphalt binder. A fiber stabilizer such
18 as mineral fiber or cellulose may be used. The selected fiber shall meet the properties
19 described below. Dosage rates given are typical ranges but the actual dosage rate used
20 will be approved by the Engineer.

21 (1) Mineral Fibers

22 Mineral fibers shall be made from virgin basalt, diabase or slag treated with
23 a cationic sizing agent to enhance disbursement of the fiber as well as increase
24 adhesion of the fiber surface to the asphalt binder. Mineral fibers shall be in
25 accordance with Table 1012-5. Add the fiber at a dosage rate between 0.2% and
26 0.4% by weight of total mix, as approved.

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

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1 (2) Cellulose Fibers

2 Add cellulose fibers at a dosage rate between 0.2% and 0.4% by weight of total mix
3 as approved. Fiber properties shall be in accordance with Table 1012-6.

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

4 (3) Cellulose Pellets

5 Cellulose pellets consist of a 50/50 blend of cellulose fiber and asphalt binder. Use
6 cellulose that complies with Subarticle 1012-1(I)(2) and Table 1012-7. Add the
7 cellulose pellets at a dosage rate between 0.4% and 0.8% by weight of total mix, as
8 approved.

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

9 **1012-2 AGGREGATES FOR ASPHALT SURFACE TREATMENT**

10 **(A) General**

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

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

16 **(B) Gradation**

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

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

22 **(C) Fractured Faces**

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

26 **(D) Soundness**

27 The maximum weighted average loss of either coarse or fine aggregate when subjected
28 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 course aggregate for asphalt surface treatment when tested in accordance with AASHTO T 96 is 55%.

(F) Blending of Aggregates

Blending of 2 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.

(G) Weight of Slag

The minimum weight of crushed slag is 70 lb/cf as determined in accordance with AASHTO T 19.

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 1012-8 and AASHTO M 195 with the exception of Sections 3, 6, 8 and any other references to concrete samples or concrete strength.

TABLE 1012-8 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.

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1 When the aggregates have a low and uniform moisture content and the consistency of the
2 concrete can be satisfactorily controlled without stockpiling the aggregates for 24 hours,
3 the minimum stockpiling period may be reduced or waived entirely by the Engineer.

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

8 (B) Soundness

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

11 (C) Deleterious Substances

12 Determine the percentage of deleterious substances (clay lumps and friable particles) in
13 accordance with AASHTO T 112. The amount of deleterious substances shall not exceed
14 2.0% by weight for natural sand or 1.0% by weight for manufactured sand.

15 (D) Organic Impurities

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

20 (E) Mortar Strength

21 Mortar made with the fine aggregate shall have a compressive strength at the age of
22 3 and 7 days using Type III Portland cement, or 7 and 28 days using Type I or II Portland
23 cement, of not less than 95% of that developed by a comparison mortar. Make the
24 comparison mortar with the same cement, graded Ottawa sand with a fineness modulus of
25 2.40 ± 0.05 , and the same water-cement ratio and consistency as the test mortar. Test the
26 mortar strength in accordance with AASHTO T 106.

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

31 (F) Gradation

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

34 (G) Blending Fine Aggregate

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

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

1 1014-2 COARSE AGGREGATE**2 (A) General**

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

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

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

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

23 (B) Soundness

24 When subjected to 5 cycles of the soundness test, the weighted average loss shall not
25 exceed 15%. For concrete with a 28 day design compressive strength greater than
26 6,000 psi, the loss shall not exceed 8%.

27 (C) Deleterious Substances

28 Determine the percentage of deleterious substances (clay lumps and friable particles) in
29 accordance with AASHTO T 112. The amount of deleterious substances shall not exceed
30 3.2% by weight.

31 (D) Resistance to Abrasion

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

34 (E) Aggregate Sizes**35 (1) General**

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

38 (2) Latex Modified Concrete

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

40 (3) Prestressed and Precast Concrete

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

43 (4) Use of More Than One Size

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

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- 1 (5) Portland Cement Concrete Pavement
- 2 Use standard size No. 57, No. 57M, No. 67 or No. 78M coarse aggregate in concrete
- 3 for Portland cement concrete pavement unless otherwise specified by the Engineer.
- 4 (6) Sand Lightweight Concrete
- 5 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

- 6 (7) Drilled Pier Concrete
- 7 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. Use select material called for on the contract.

1016-2 USES

Select material may be specified for use in:

- | | |
|-------------------------|--------------------------------|
| Subgrade | Slope and shoulder embankment |
| Backfill in undercut | Rock embankment in open water |
| Core material | Material placement over fabric |
| Foundation conditioning | Pipe backfill |

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	% Passing
3/8 in	100
#4	80 - 100
#10	65 - 95
#40	25 - 55
#200	0 - 20
LL	≤ 30
PI	≤ 6

1 **Type 2 Select Material**

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

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

7 **CLASS III**

8 **Type 1 Select Material**

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

12 **Type 2 Select Material**

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

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

17 **CLASS IV**

18 Select material is a coarse aggregate material meeting the graduation requirements of standard
19 size ABC as described in Section 1010.

20 **CLASS V**

21 Select material is a coarse aggregate material meeting the graduation requirements of standard
22 size 78M in Table 1005-1 as described in Section 1005 and 1006.

23 **CLASS VI**

24 Select material is a coarse aggregate material meeting the graduation requirements of standard
25 size 57 in Table 1005-1 as described in Section 1005 and 1006.

26 **Class VII**

27 Select material is clean, unweathered durable, blasted rock material with the following
28 gradation:

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

30 **(B)** 40% of the rock ranges in size from 2" to 1.5 ft in diameter, and

31 **(C)** Not more than 10% of the rock is less than 2" in diameter. No rippable rock will be
32 permitted.

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**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 SOURCE

The approval of borrow sources 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 2 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 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 2 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.

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

4 **SECTION 1019**
5 **SHOULDER AND SLOPE MATERIAL**

6 **1019-1 GENERAL**

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

10 **1019-2 SHOULDER AND SLOPE BORROW**

11 Use borrow sources in accordance with Article 1018-2.

12 Use soil consisting of loose, friable, sandy material with a PI greater than 6 and less than 25
13 and a pH ranging from 5.5 to 6.8. Remove stones and other foreign material 2" or larger in
14 diameter.

15 Use approved material obtained from unclassified excavation, fine grading operations or
16 borrow sources as provided in Section 230.

17 **1019-3 AGGREGATE SHOULDER BORROW**

18 Use aggregate shoulder borrow (ASB) that meets the following gradation in Table 1019-1.

TABLE 1019-1	
GRADATION OF AGGREGATE SHOULDER BORROW	
Sieve	Percentage Passing
1 1/2"	100
1/2"	55-95
#4	35-74

19 **SECTION 1020**
20 **ASPHALT MATERIALS**

21 **1020-1 DELIVERY AND ACCEPTANCE OF ASPHALT MATERIALS**

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

23 All asphalt transport tankers, including rail and truck tankers, shall have a sampling valve in
24 accordance with Asphalt Institute Publication MS-18, ASTM D140 or a comparable device
25 acceptable to the Engineer.

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

30 Furnish with each shipment 2 copies of a delivery ticket. Ensure both copies accompany the
31 shipment and are delivered to the Engineer or his representative at the destination. The
32 delivery ticket shall contain the following information:

- 33 (A) Name of Producer/Supplier and location
34 (B) A statement that the material has been tested and meets AASHTO specifications or is
35 being provided by an approved supplier under Approved Supplier Certification (ASC)
36 (C) The grade of the material
37 (D) If applicable, the rotational viscosity in Pascal-Seconds (Pa-S) at 135°C and 165°C
38 (E) If applicable, the recommended laboratory mixing and compaction temperature (°C for
39 the PGAB)

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- 1 (F) Delivery ticket number
- 2 (G) Date and time loaded (mm/dd/yyyy AM:PM)
- 3 (H) Date and time shipped (mm/dd/yyyy AM:PM)
- 4 (I) State project or purchase order number
- 5 (J) NCDOT assigned batch number
- 6 (K) Destination
- 7 (L) Name of consignee
- 8 (M) Trailer or car number
- 9 (N) Producer's or Supplier's storage tank and batch number
- 10 (O) Quantity loaded in tons or gallons (kg/L) at 60°F
- 11 (P) Loading temperature
- 12 (Q) Net gallon at 60°F

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

15 The Contractor's asphalt materials supplier shall furnish to the Materials and Tests Unit
16 a typical viscosity-temperature chart at the beginning of each calendar year and a new chart
17 whenever a change in production results in a shift of 5°F or more.

18 Furnish a statement of certification from the supplier and a separate statement of certification
19 from the transporter. Sign each certification by an authorized representative of the supplier or
20 transporter. Stamp, write or print these certifications on the delivery ticket, or attach to the
21 delivery ticket.

22 Unless otherwise approved by the Engineer, the following form shall be used in the supplier's
23 certification:

24 This is to certify that this shipment of _____ gallons/liters or
25 tons/metric tons of _____ grade asphalt including _____
26 gallons/liters of _____ anti-strip meet all requirements of
27 NC Department of Transportation Specifications.

28 Signed _____
29 Authorized Representative of Supplier

30 When no anti-strip additive is included with the load, the supplier shall indicate zero (0) in the
31 gallons field and "NA" in the anti-strip field on the above certification.

32 Unless otherwise approved by the Engineer, the following form shall be used in the
33 transporter's certification:

34 This is to certify that this transport tank was clean and free from
35 contaminating materials when loaded. The material transported on the
36 previous load in this tanker was _____.

37 Signed _____
38 Authorized Representative of Transporter

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

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

44 **1020-2 ASPHALT BINDER**

45 Use performance graded asphalt binder meeting AASHTO M 320 Table 1. See Article 610-3
46 for the specified grades.

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

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

10 **1020-3 ASPHALT EMULSION**

11 Submit a QC Plan for asphalt emulsion. The Department's Asphalt Emulsion
 12 QC/QA Program shall be implemented in accordance with Article 1020-6.

13 **(A) Anionic**

14 Use asphalt emulsion, except for Grade RS-1H, that meets AASHTO M 140. Use asphalt
 15 emulsion Grade RS-1H that meets AASHTO M 140 for Grade RS-1, except the
 16 penetration of residue shall be at least 50 and no more than 100.

17 Perform the testing of the asphalt in accordance with AASHTO T 59 except as follows:

- 18 (1) Use a hot plate instead of an oven to perform the residue by evaporation.
- 19 (2) The determination of coating test, oil distillate, pH, solubility of residue, ash and
 20 particle charge will be made when deemed necessary.
- 21 (3) Use Materials and Tests Method A-24 to determine the coating ability and water
 22 resistance using either crushed or uncrushed aggregate from a source selected by the
 23 Department.

24 **(B) Cationic**

25 Asphalt emulsion shall meet AASHTO M 208 except as follows:

- 26 (1) Asphalt emulsion Grade CRS-1H shall meet AASHTO M 208 for Grade CRS-1
 27 except as follows:
 - 28 (a) The residue after distillation shall be at least 55%.
 - 29 (b) The penetration of residue shall be at least 50 and no more than 100.
 - 30 (c) Viscosity, Saybolt Furol at 77°F shall be at least 20 and no more than 100.
- 31 (2) All polymer or latex modified cationic asphalt emulsion materials, CRS-2P and
 32 CRS-2L, are subject to the following requirements:
 - 33 (a) The viscosity at 122°F shall be at least 100 seconds and no more than
 34 400 seconds.
 - 35 (b) The sieve shall be no more than 0.15%.
 - 36 (c) The 24 hour storage stability shall not exceed 1%.
 - 37 (d) The residue by evaporation (oven evaporation) shall be at least 65%.
 - 38 (e) The elastic recovery (AASHTO T 301) at 50°F shall be at least 50%.
 - 39 (f) The ring and ball softening point (AASHTO T 53) shall be at least 110°F.
 - 40 (g) Polymer content may be analyzed, if deemed necessary.

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(3) Perform the testing of the asphalt in accordance with AASHTO T 59 except as follows:

(a) Residue by evaporation will be performed using a hot plate instead of an oven with a maximum temperature of 400°F. Referee testing will be performed in accordance with AASHTO T 59.

(b) The determination of coating test, oil distillate, pH, solubility of residue, ash and particle charge will be made when deemed necessary by the Engineer.

(c) Materials and Tests Method A-24 is used to determine the coating ability and water resistance using either crushed or uncrushed aggregate from a source selected by the Department.

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
	Min.	Max.	
EMULSION:			
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 @ 400°F, % ^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, % ^C	97.5		AASHTO T 44
Elastic Recovery, 50°F			
20 cm elongation % ^D	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.

C. ASTM D5546 may be substituted where polymers block the filter in Method D 2042.

D. ASTM D6084 except that the elongation is 20 cm and the test temperature is 50°F.

1020-5 PRIME COAT MATERIALS

Supply prime coat materials from pre-approved sources in accordance with Materials and Tests Unit Method A and listed by the Materials and Tests Unit. 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. 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 Department and such restriction will be noted on the list of approved products.

- 1 (C) Proposed materials for prime coat applications that are not listed as approved will be
 2 investigated upon the request of the supplier or Contractor. The maximum volatile
 3 organic compounds for the products (materials) on the approved list for prime coat
 4 applications shall not exceed 6.8 oz/gal of material or the current applicable regulatory
 5 limit. Submit a MSDS and a 2 quart sample from 3 different batches of the same material
 6 to the Materials and Tests Unit for evaluation.
- 7 (D) The sand penetration results for a material used as a prime coat are penetration depth of at
 8 least 12 mm and penetration time of not more than 90 seconds. Copies of the *Sand*
 9 *Penetration Test Procedure* are available upon request from the Materials and Tests Unit.
- 10 (E) Materials used as a prime coat shall have a minimum rating of fair on the No-Tracking
 11 Time Test. Copies of the *No-Tracking Time Test Procedures* are available upon request
 12 from the Materials and Tests Unit.
- 13 (F) Materials used as a prime coat shall have a minimum rating of fair on the coating ability
 14 and water resistance test in accordance with AASHTO T 59.
- 15 (G) For materials stored longer than one day at the destination point (Contractors'/Divisions'
 16 tanks), submit to the Engineer a certified laboratory report on the performance of the
 17 material for storage stability test in accordance with AASHTO T 59.
- 18 (H) The diluted materials shall be tested for asphalt residue percent in accordance with
 19 AASHTO T 59, Section 55, and shall have a minimum asphalt residue percent of 15%.

20 **1020-6 PERFORMANCE GRADED ASPHALT BINDER AND ASPHALT**
 21 **EMULSION QUALITY CONTROL/QUALITY ASSURANCE**

22 The Performance Graded Asphalt Binder and Asphalt emulsion QC/QA Programs are
 23 designed to give asphalt binder and asphalt emulsion producers/suppliers (henceforth
 24 Producer designates Producer/Supplier) more responsibility for controlling the quality of
 25 material they produce and to use the quality control information they provide in the
 26 acceptance process by the Department. It requires asphalt binder and asphalt emulsion
 27 producers to perform quality control sampling, testing and record keeping on materials they
 28 ship for use by the Department. It documents that the Department will perform quality
 29 assurance sampling, testing and record keeping confirming the performance of the producers'
 30 control plan. In addition, the Producer is required to participate in independent assurance
 31 comparative sample activities. The program is described in the *Performance Graded Asphalt*
 32 *Binder and Asphalt Emulsion QC/QA Program Manuals*. An electronic copy of the program
 33 manuals may be obtained by accessing the Materials and Tests website.

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

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

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

42 **1020-7 WATERPROOFING AND DAMPPROOFING MATERIALS**

43 **(A) Asphalt Primer**

44 Asphalt primer shall meet ASTM D41.

45 **(B) Asphalt Binder**

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

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(C) Tar

Tar shall meet ASTM D490.

(D) Fabric

Woven cotton fabric for waterproofing shall meet ASTM D173.

**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 fly ash, cement and ground granulated blast furnace slag or cement and microsilica may be used. The pozzolan 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 pozzolan 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 POZZOLANS FOR USE IN PORTLAND CEMENT CONCRETE	
Pozzolan	Rate
Class F Fly Ash	20% by weight of required cement content with 1.2 lb Class F fly ash per lb of cement replaced
Ground Granulated Blast Furnace Slag	35%-50% by weight of required cement content with 1.0 lb slag per lb of cement replaced
Microsilica	4%-8% by weight of required cement content with 1.0 lb microsilica per lb of cement replaced

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-pozzolan 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 or for Portland cement in high early strength concrete.

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 17 and 23% 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.

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.

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

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

5 **1024-2 AGGREGATE**

6 Provide aggregate that meets Section 1014.

7 **1024-3 ADMIXTURES**

8 **(A) Basis of Acceptance**

9 Admixtures from an approved source are accepted without prior testing. Do not use
10 admixtures that are not from an approved source until the admixture is approved by the
11 Department.

12 **(B) Approved Sources**

13 An approved source is considered to be any manufacturer of admixtures who complies
14 with this subarticle.

15 The manufacturer shall submit to the Materials and Tests Unit certified reports of tests
16 that show that the admixture meets the applicable Specifications. Perform tests in
17 a laboratory certified by the Cement and Concrete Reference Laboratory of the National
18 Bureau of Standards.

19 Admixtures that contain chloride other than calcium chloride as provided herein are not
20 permitted. The manufacturer is required to state in writing that no chloride was added
21 during the manufacture of the admixture.

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

27 The Engineer has the option to make any or all tests deemed desirable to verify the
28 manufacturer's certification. Failure of the admixture in such tests is cause for
29 discontinuation of its use. Failure of an admixture to perform satisfactorily under job
30 conditions is cause for rejection of the source.

31 The Engineer maintains a list of approved sources on file.

32 **(C) Air Entraining Agent**

33 Provide air entraining agents that meet AASHTO M 154.

34 **(D) Chemical Admixtures**

35 (1) Set Retarding Admixtures

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

38 (2) Water Reducing Admixtures

39 Use water reducing admixtures that meet AASHTO M 194 for Type A admixtures.

40 (3) Calcium Chloride

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

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1 (4) High-Range Water Reducing Admixtures

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

4 (5) Calcium Nitrite Corrosion Inhibitor

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

6 (E) Other Admixtures

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

9 1024-4 WATER

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

15 Test all water from wells and public water supplies from all out of state locations and in the
16 following counties: Beaufort, Bertie, Brunswick, Camden, Carteret, Chowan, Craven,
17 Currituck, Dare, Gates, Hyde, New Hanover, Onslow, Pamlico, Pasquotank, Pender,
18 Perquimans, Tyrell and Washington unless the Engineer waives the testing requirements.
19 Water from a municipal water supply in all other NC counties may be accepted by the
20 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%	NCDOT Modified / AASHTO T 106
Time of set, deviation from control	From 1:00 hr. earlier to 1:30 hr. later	NCDOT Modified / AASHTO T 131
pH	4.5 to 8.5	NCDOT Modified / AASHTO T 26
Chloride Ion Content, Max.	250 ppm	ASTM D512
Total Solids Content (Residue), Max.	1,000 ppm	NCDOT Modified / Standard Methods for Examination of Water and Wastewater
Resistivity, Min.	0.500 kohm-cm	NCDOT Modified / ASTM D1125
Sulfate as SO ₄ , Max.	1,500 ppm	NCDOT Modified / ASTM D516
Presence of Sugar	None	NCDOT Procedure
Dissolved Organic Matter	None	NCDOT Modified / AASHTO T 26

21 1024-5 FLY ASH

22 Provide fly ash that meets ASTM C618 for Class F or Class C, except ensure that the loss on
23 ignition does not exceed 4%. Table 1A of ASTM C618 applies to Class F fly ash. Use fly
24 ash that meets the optional physical requirements for uniformity shown in Table 2A of
25 ASTM C618.

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

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

3 **1024-6 GROUND GRANULATED BLAST FURNACE SLAG**

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

7 **1024-7 SILICA FUME**

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

11 **SECTION 1026** 12 **CURING AGENTS FOR CONCRETE**

13 **1026-1 GENERAL**

14 All curing agents shall be free from impurities that may be detrimental to the concrete. Do
15 not use curing agent until the applicable tests have been performed and the Engineer has
16 approved the curing agent.

17 **1026-2 LIQUID MEMBRANE CURING COMPOUNDS**

18 **(A) General**

19 Liquid membrane curing compounds shall meet AASHTO M 148, except that when
20 tested in the water retention test described in AASHTO T 155 the curing compound shall
21 restrict the loss of water in the test specimen at the time of application of the compound
22 to not more than 0.007 oz./sq.in.

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

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

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

33 **(B) Test Procedures**

34 Curing compound will be tested in accordance with AASHTO M 148, except the size of
35 molds for making test specimens will be approximately 5.5" in diameter by
36 approximately 1" deep, or any other size selected by the Engineer.

37 **1026-3 POLYETHYLENE FILM**

38 Polyethylene film shall meet AASHTO M 171 for white opaque polyethylene film, except
39 that when tested for moisture retention efficiency the loss shall not be more than
40 0.007 oz./sq.in of surface area.

41 **1026-4 WATER**

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

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1 **1026-5 BURLAP**

2 Burlap shall meet AASHTO M 182. Any class of burlap will be acceptable.
3 Use new burlap or burlap that has been used for no purpose other than curing concrete. New
4 burlap shall be free from starch, filler or other substances added during manufacture, or shall
5 be washed to remove such substances before use.

6 **SECTION 1028**
7 **JOINT MATERIALS**

8 **1028-1 JOINT FILLER**

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

12 **1028-2 HOT APPLIED JOINT SEALER**

13 Provide a hot applied joint sealer that conforms to ASTM D6690 and has been evaluated by
14 NTPEP. Furnish a Type 3 material certification in accordance with Article 106-3 for each lot
15 of the joint sealer supplied to each project.

16 **1028-3 LOW MODULUS SILICONE SEALANT**

17 Provide a cold applied, single component, chemically curing low modulus silicone sealant
18 from the Department’s approved list on the website and evaluated by NTPEP. Acid cure
19 sealants are not acceptable for use on Portland cement concrete. Bond breakers shall meet
20 Article 1028-4.

21 **(A) Silicone Sealant Types**

22 (1) Type NS
23 A non-sag silicone for use in sealing horizontal and vertical joints in Portland cement
24 concrete pavements and bridges. Tooling is required.

25 (2) Type SL
26 A self-leveling silicone used to seal horizontal joints in Portland cement concrete
27 pavements and bridges. Tooling is not normally required.

28 **(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

29 Silicone sealant shall meet the Table 1028-1, ASTM D5893 and shall have been
30 evaluated by NTPEP.

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

1 **1028-4 BOND BREAKER**

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

6 **(A) Type L**

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

10 **(B) Type M**

11 Type M backer rod is a closed-cell polyolefin foam backer rod which has a closed-cell
12 skin over an open cell core. Use this backer rod in roadway and bridge joints with both
13 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 D1622
Min. Tensile Strength	25 psi	ASTM D1623
Max. Water Absorbtion	0.5% by volume	ASTM C509

14 **(C) Type N**

15 Provide bond breaking tape made from extruded polyethylene that has a pressure
16 sensitive adhesive on one side. Bond breaking tape may be used with both types of
17 silicone but is suitable for bridge joints only. Bond breaking tapes shall be at least
18 0.005" in thickness.

19 **SECTION 1032**
20 **CULVERT PIPE**

21 **1032-1 CORRUGATED METAL CULVERT PIPE**

22 Use corrugated metal culvert pipe from sources on the Department's approved list and that
23 participate in the Department's Brand Registration program for metal culvert pipe available
24 from the website or the Materials and Tests Unit's Central Laboratory. The Department will
25 remove a manufacturer of metal culvert pipe from this program if the monitoring efforts
26 indicated that non-specification material is being provided or test procedures are not being
27 followed.

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

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

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

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

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

34 **(E)** Welded steel pipe.

35 **1032-2 CORRUGATED ALUMINUM ALLOY CULVERT PIPE**36 **(A) Corrugated Aluminum Alloy Culvert Pipe**

37 Corrugated aluminum alloy culvert pipe shall meet AASHTO M 196, except that
38 Type IA pipe will not be permitted.

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

3 Coupling bands with projections may be used for circumferential pipe, helical pipe, or
4 a combination of both.

5 (B) Corrugated Aluminum Alloy Pipe Tees and Elbows

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

8 (C) Acceptance

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

13 Culvert pipe materials not meeting the above requirements will be rejected, unless written
14 approval is obtained from the State Materials Engineer.

15 1032-3 CORRUGATED STEEL CULVERT PIPE

16 (A) Corrugated Steel Culvert Pipe and Pipe Arch

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

19 (1) Coupling Bands

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

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

23 (c) Coupling bands with projections may be used where it is necessary to join new
24 pipe to existing pipe having helical corrugations at the joint locations. Use
25 an approved sealer with this type of coupling band.

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

27 (e) Annular corrugated bands shall have a minimum width of 10 1/2" where
28 2 2/3" x 1/2" corrugations are used.

29 (2) Corrugations

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

32 Where 3" x 1" corrugations are required, the Contractor will be permitted to use
33 5" x 1" corrugations.

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

36 (3) Elongated Pipe

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

1 (4) Lifting Straps

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

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

9 (5) Coating Repair

10 Repair shall be in accordance with Section 1076-7.

11 (6) Type IA Pipe

12 Type IA pipe will not be permitted.

13 (7) Aluminized Pipe

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

17 (8) Marking Requirements

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

21 **(B) Prefabricated Corrugated Steel Pipe End Sections**

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

25 **(C) Corrugated Steel Pipe Tees and Elbows**

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

27 **(D) Corrugated Steel Eccentric Reducers**

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

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

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

34 **(E) Acceptance**

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

38 Culvert pipe materials not meeting the above requirements will be rejected, unless written
 39 approval is obtained from the State Materials Engineer.

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

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

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

17 **1032-4 COATED, PAVED AND LINED CORRUGATED STEEL CULVERT PIPE**

18 **(A) Coatings for Steel Culvert Pipe or Pipe Arch**

19 The below coating requirements apply for steel culvert pipe, pipe arch, end sections, tees,
20 elbows and eccentric reducers.

- 21 (1) Steel Culvert pipe shall have an aluminized coating, meeting the requirement of
22 AASHTO M 274.
- 23 (2) When shown in the plans or as approved by the Engineer, a polymeric coating
24 meeting AASHTO M 246 for Type B coating may be substituted for aluminized
25 coating.

26 **(B) Acceptance**

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

30 **1032-5 WELDED STEEL PIPE FOR DRAINAGE**

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

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

35 Culvert pipe materials not meeting the above requirements will be rejected, unless written
36 approval is obtained from the State Materials Engineer.

37 **1032-6 CONCRETE CULVERT PIPE**

38 **(A) General**

39 Use concrete pipe from sources participating in the Department's Concrete Pipe QC/QA
40 Program. A list of participating sources is available from the Materials and Tests Unit's
41 Central Laboratory. The Department will remove a manufacturer of concrete pipe from
42 this program if the monitoring efforts indicated that non-specification material is being
43 provided or testing procedures are not being followed.

1 (B) Reinforced Concrete Culvert Pipe

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

- 4 (1) The permissible wall thickness outside of the joint configuration shall not be more
5 than that shown in the design by more than 5% or 3/16", whichever is greater.
- 6 (2) The maximum weighted average loss for both fine and coarse aggregates shall be
7 15% when subjected to 5 cycles of the soundness test.
- 8 (3) The maximum percentage of wear for coarse aggregates is 55%.

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

17 (C) Precast Concrete Pipe End Sections

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

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

24 (D) Concrete Pipe Tees and Elbows

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

27 (E) Marking

- 28 (1) Clearly etchmark the following information on the outside of each section of pipe,
29 pipe end section, tee and elbow:
- 30 (a) Pipe class and type of wall if reinforced,
31 (b) The date of manufacture, and
32 (c) Name or trademark of the manufacturer.
- 33 (2) Clearly stamp, stencil, sticker or paint the following information on each section of
34 pipe, pipe end section, tee and elbow:
- 35 (a) The State assigned plant number,
36 (b) The inside diameter of the pipe product, and
37 (c) The year of manufacture. This marking shall be in the following format: State
38 plant number - diameter - year (CP99-24-06).

39 When concrete pipe, pipe end sections, tees and elbows have been inspected and accepted
40 they will be stamped with the Department seal of approval. Do not use pipe sections,
41 pipe end sections, tees, or elbows which do not have this seal of approval. Failure of as
42 much as 20% of any lot of pipe due to cracks, fractures, variation in alignment
43 or other manufacturing defects will be cause for the rejection of the entire lot.
44 The lots shall be as designated by the manufacturer before inspection.

Section 1034

1 Individual lengths of pipe within the lot which were not specifically rejected but which
2 are considered acceptable by the manufacturer may be removed from the rejected lot and
3 resubmitted for inspection as a separate lot.

4 (F) Joint Materials

5 Cement shall meet Article 1024-1. Sand shall meet Article 1014-1 for fine aggregate or
6 Article 1040-7 for mortar sand. Hydrated lime shall meet Article 1040-6.

7 Flexible plastic joint material shall meet AASHTO M 198 for Type B flexible plastic
8 gaskets, except as follows:

- 9 (1) The flash point, Cleveland Open Cup (C.O.C.) shall be at least 325°F.
- 10 (2) The fire point, C.O.C. shall be at least 350°F.

11 1032-7 CORRUGATED POLYETHYLENE (HDPE) CULVERT PIPE

12 (A) General

13 Use corrugated polyethylene pipe from sources participating in the Department's HDPE
14 Pipe QC/QA Program. A list of participating sources is available from the Materials and
15 Tests Unit. The Department will remove a manufacturer of polyethylene pipe from this
16 program if the monitoring efforts indicated that non-specification material is being
17 provided or test procedures are not being followed.

18 Use corrugated polyethylene culvert pipe that meets AASHTO M 294 for Type S or
19 Type D and has been evaluated by NTPEP.

20 (B) End Treatments, Pipe Tees and Elbows

21 End treatments, pipe tees and elbows shall meet AASHTO M 294, Section 7.8.

22 (C) Marking

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

- 25 (1) AASHTO Designation
- 26 (2) The date of manufacture
- 27 (3) Name or trademark of the manufacturer

28 When polyethylene pipe, end sections, tees and elbows have been inspected and accepted
29 they will be stamped with the Department seal of approval. Do not use pipe sections,
30 flared end sections, tees or elbows which do not have this seal of approval.

31 1032-8 PVC PROFILE WALL DRAIN PIPE

32 PVC pipe shall conform to AASHTO M 304. When rubber gaskets are to be installed in the
33 pipe joint, the gasket shall be the sole element relied on to maintain a tight joint. Watertight
34 joints shall be watertight in accordance with AASHTO M 304, unless a higher pressure rating
35 is specified in the plans.

36 SECTION 1034

37 SANITARY SEWER PIPE AND FITTINGS

38 1034-1 CLAY PIPE

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

1 1034-2 PLASTIC PIPE**2 (A) PVC Gravity Flow Sewer Pipe**

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

6 (B) PVC Force Main Sewer Pipe**7 (1) Pressure Rated Pipe**

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

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

17 (2) Pressure Class Pipe

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

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

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

25 1034-3 CONCRETE SEWER PIPE

26 Use reinforced concrete sewer pipe conforming to ASTM C76 or AASHTO M 170 with
27 a Class III minimum rating. Use pipe with gasket joints conforming to ASTM C443 or
28 AASHTO M 198 Type A or B.

29 1034-4 DUCTILE IRON PIPE**30 (A) Gravity Flow Sewer Pipe**

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

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

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

35 (B) Force Main Sewer Pipe

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

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

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

Section 1036

**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.

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 ANSI/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 ANSI/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 ANSI/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 ANSI/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 ANSI/AWWA C151/A21.51.

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

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

8 **1036-6 FIRE HYDRANTS**

9 Use dry barrel type fire hydrants conforming to ANSI/AWWA C502 with a minimum
10 4 1/2" diameter valve opening with a 6" mechanical joint inlet connection, with two
11 2 1/2" hose connections and with one 4 1/2" pumper connection. Outlets shall have national
12 standard fire hose coupling threads. Use fire hydrants with a minimum bury length of 36".
13 Securely chain nipple caps to the barrel. Paint hydrants with one coat of primer paint and
14 2 coats of an approved paint of the owner's standard color. Apply the final coat after hydrant
15 installation.

16 **1036-7 WATER VALVES**

17 **(A) Gate Valves**

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

25 **(B) Bronze Gate Valves**

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

28 **(C) Tapping Valves**

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

31 **1036-8 SLEEVES, COUPLINGS AND MISCELLANEOUS**

32 **(A) Tapping Sleeves**

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

37 **(B) Transition Sleeves and Couplings**

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

42 **1036-9 SERVICE LINE VALVES AND FITTINGS**

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

Section 1040

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

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

SECTION 1040

MASONRY

1040-1 BRICK

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

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

13 Brick of the same manufacturer shall not vary more than $\pm 1/16$ " in thickness, $\pm 1/8$ " in width
14 and $\pm 1/4$ " in length.

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

1040-2 CONCRETE BUILDING BLOCK

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

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

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

26 Concrete block for block manholes shall meet ASTM C139.

1040-3 CONCRETE PAVING BLOCK

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

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

1040-4 SEGMENTAL RETAINING WALL UNITS

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

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

42 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% maxA	ASTM C1262

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

2 **1040-5 CEMENT**

3 Portland cement shall meet Article 1024-1.

4 Masonry cement shall meet ASTM C91.

5 **1040-6 HYDRATED LIME**

6 Hydrated lime shall meet ASTM C207 for Type N.

7 **1040-7 MORTAR SAND**

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

10 **1040-8 WATER**

11 Water shall meet Article 1024-4.

12 **1040-9 MORTAR**

13 Proportion mortar used in all brick and block masonry by volume as shown below. Do not
14 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)

15 Apply Articles 1040-4, 1040-5, 1040-6 and 1040-7 to all cement, hydrated lime, mortar sand
16 and water.

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

23

24

**SECTION 1042
RIP RAP MATERIALS**

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

Section 1043

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

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

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

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

SECTION 1043 AGGREGATE FROM CRUSHED CONCRETE

1043-1 GENERAL

12 Aggregate from crushed concrete is a recycled product made by crushing concrete obtained
13 from concrete truck clean out, demolition of existing concrete structures or pavement, or
14 similar sources and transported from a crushing facility. It does not include concrete
15 pavements that are rubblelized, broken or otherwise crushed in place on the roadway.

16 The crushed material must meet all sources approval requirements described in Sections 1005
17 and 1006 with the exception of the sodium sulfate test requirement. Deleterious materials
18 shall not be more than 3%.

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

1043-2 AGGREGATE BASE COURSE

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

1043-3 AGGREGATE SHOULDER BORROW

25 The material shall meet Section 1019.

1043-4 CLEAN COARSE AGGREGATE FOR ASPHALT

27 The material shall meet the gradation of a standard size in Table 1005-1. Use of the material
28 shall be approved by the Engineer, and the mix shall meet all requirements.

1043-5 CLEAN COARSE AGGREGATE FOR CONCRETE

30 The material shall meet the gradation of a standard size in Table 1005-1. Use of the material
31 is restricted to Class B concrete mixes only. Use of the material shall be approved by the
32 Engineer, and the concrete shall meet all requirements.

SECTION 1044 SUBSURFACE DRAINAGE MATERIALS

1044-1 SUBDRAIN FINE AGGREGATE

36 Subdrain fine aggregate shall meet No. 2S or 2MS in Table 1005-2.

1 1044-2 SUBDRAIN COARSE AGGREGATE

2 Subdrain coarse aggregate shall meet No. 78M in Table 1005-1.

3 1044-3 PIPE AND FITTINGS

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

6 1044-4 CONCRETE PIPE AND FITTINGS

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

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

11 Joint materials shall meet Section 1028.

12 1044-5 CORRUGATED STEEL PIPE AND FITTINGS

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

14 Perforated corrugated steel pipe shall meet AASHTO M 36.

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

16 1044-6 PVC PIPE

17 PVC pipe shall meet ASTM D1785.

18 1044-7 CORRUGATED PLASTIC PIPE AND FITTINGS

19 Corrugated plastic pipe and fittings shall meet AASHTO M 252 for heavy duty tubing, except
20 that the maximum stretch resistance shall be 10%.

21 1044-8 OUTLET PIPE

22 Outlets constructed of PVC Schedule 40 pipe shall meet ASTM D2665. HDPE pipe shall
23 meet AASHTO M 294, Type S.

24 **SECTION 1046**
25 **GUARDRAIL MATERIALS**

26 1046-1 GENERAL

27 Use guardrail materials from sources meeting requirements of the Department's Brand
28 Registration Program for guardrail. A list of these sources is available from the Materials and
29 Test Unit's Central Laboratory. The Department will remove a manufacturer of guardrail
30 materials from this program if the monitoring efforts indicated that non-specification material
31 is being provided or test procedures are not being followed.

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

35 1046-2 RAIL ELEMENTS

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

37 1046-3 POSTS AND OFFSET BLOCKS**38 (A) General**

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

Section 1046

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

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

4 (b) Steel 4.5" x 6.0" C-shape posts

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

8 (a) Timber 6" x 8" posts

9 (b) Timber 8" x 8" posts

10 (B) Structural Steel Posts

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

17 (C) Treated Timber Posts

18 Timber guardrail posts shall be of treated southern pine meeting Articles 1082-2
19 and 1082-3.

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

23 (D) Offset Blocks

24 Provide 8" deep recycled plastic or composite offset blocks approved for use with the
25 guardrail shown in the *Roadway Standard Drawings* or plans. Only one type of offset
26 block will be permitted at any one continuous installation. Before beginning the
27 installation of recycled offset block, submit the FHWA acceptance letter for each type of
28 block to the Engineer for approval.

29 Treated timber offset blocks with steel beam guardrail will not be allowed unless required
30 by Specifications, directed by the Engineer or detailed in the plans. Steel offset blocks
31 with steel beam guardrail will not be allowed.

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

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%
Testing	Pass NCHRP Report 350, Test Level 3 by Crash Testing
Approval	Approved for use by the FHWA

1 1046-4 HARDWARE

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

4 1046-5 ANCHORS AND ANCHOR ASSEMBLIES

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

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

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

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

18 Perform welding in accordance with Article 1072-18.

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

22 1046-6 REPAIR OF GALVANIZING

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

24 1046-7 CABLE GUIDERAIL

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

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

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

30 Cable guiderail is not covered under the Brand Certification Program for guardrail materials.
31 Sample cable guiderail according to the *Minimum Sampling Guide*.

32 1046-8 ACCEPTANCE

33 Acceptance of guiderail materials and its accessories will be based on, but not limited to,
34 visual inspections, classification requirements and check samples taken from material
35 delivered to the project and conformance to the annual Brand Registration. Guiderail
36 materials not meeting the above requirements will be rejected, unless written approval is
37 obtained from the State.

38 SECTION 1050
39 FENCE MATERIALS**40 1050-1 GENERAL**

41 All fence material and accessories shall be melted and manufactured in the USA.

Section 1050

1 (A) Chain Link Fence

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

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

9 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

10 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

11 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

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

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

17 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

18 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

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

1 (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

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

5 **1050-2 TIMBER POSTS AND BRACES**

6 (A) General

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

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

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

25 A tolerance of 1" plus and 1/2" minus will be allowed for the diameter of round posts and
 26 braces, measured at the small end after peeling. Where they are out of round, this
 27 tolerance will apply to the smaller diameter, and the larger diameter shall not exceed the
 28 smaller by more than 20%. The maximum rate of increase in diameter at the butt shall be
 29 1 1/2" in 10 ft.

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

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1 (B) Optional Steel Posts and Braces

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

6 1050-3 METAL POSTS AND RAILS

7 (A) Chain Link Fence

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

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

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

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

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

27 For pipe 1.90" O.D. and under, the outside diameter at any point shall not vary more than
28 1/64" over no more than 1/32" under the standard specified. For pipe 2.375" O.D. and
29 over, the outside diameter shall not vary more than $\pm 1\%$ from the standard specified nor
30 shall the minimum wall thickness at any point be more than 12.5% under the nominal
31 wall thickness specified.

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

33 (B) Woven Wire Fence

34 Steel posts used instead of 4" timber posts shall be a standard studded T-section
35 7.5 ft long designed exclusively for use as a fence post and be equipped with a metal
36 anchor plate securely attached to the post. The T-posts shall weigh 1.33 lb/lf exclusive of
37 the weight of the anchor plate, and have a total weight, including anchor plate, of
38 10.65 lb. Nominal dimensions of the T-post shall be 1 3/8" wide and 1 3/8" deep.
39 A tolerance of $\pm 3/16$ " will be permitted from these nominal dimensions. The anchor
40 plate shall be sufficiently sturdy to withstand the strain of driving with no loss of
41 effectiveness, and have a minimum area of 14.0 sq.in.

42 Steel posts used instead of 5" timber posts may be either tubular posts or angle posts.
43 They shall be 8 ft long and be embedded in a concrete anchor at least 3.3 ft deep and
44 10" in diameter. Fit tubular posts with ornamental tops that fit over the top of the post to
45 cap against moisture. Fabricate the tubular posts from 2" diameter pipe meeting
46 AASHTO M 181 for Grades 1 or 2 metallic coated posts and rails. Fabricate angle posts
47 from angle sections measuring 2 1/2" x 2 1/2" x 1/4", $\pm 1/16$ " on the 2 1/2" dimensions
48 and ± 0.015 " on the 1/4" dimension and weighing 4.10 lb/ft.

1 Use steel braces with steel posts and either tubular braces or angle braces to match the
 2 posts. Furnish the braces with suitable metal connections to fasten them securely to the
 3 posts. Fabricate tubular braces from 1 1/4" diameter pipe meeting AASHTO M 181 for
 4 Grades 1 or 2 metallic coated posts and rails. Fabricate angle braces from angle sections
 5 measuring 2" x 2" x 1/4" \pm 3/64" on the 2" dimensions and \pm 0.010" on the
 6 1/4" dimension and weighing 3.19 lb/ft.

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

8 For pipe 1.90" O.D. and under, the outside diameter at any point shall not vary more than
 9 1/64" over nor more than 1/32" under the standard specified. For pipe 2.375" O.D. and
 10 over, the outside diameter shall not vary more than \pm 1% from the standard specified nor
 11 shall the minimum wall thickness at any point be more than 12.5% under the nominal
 12 wall thickness specified.

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

15 **1050-4 BARBED WIRE**

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

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

21 Two strand galvanized steel barbed wire shall be fabricated from either 12 1/2 gauge or
 22 15 1/2 gauge strand wire with 4 point galvanized steel 14 gauge barbs. The 12 1/2 gauge shall
 23 be Standard Grade with a Class 3 coating on the wire and a Class 1 coating on the barbs.
 24 The 15 1/2 gauge shall be Chain Link Fence Grade with a Class 3 coating on both the wire
 25 and barbs.

26 Two strand aluminum coated steel barbed wire shall be fabricated from 2 strands of
 27 12 1/2 gauge aluminum coated steel wire with the 4-point barbs being either 14 gauge
 28 aluminum coated steel or aluminum alloy wire.

29 **1050-5 WOVEN WIRE**

30 Woven wire fencing shall conform to ASTM A116 or AASHTO M 279. The fence fabric
 31 shall be 47" high, with 10 horizontal strands. Space the strands 3" apart at the bottom and
 32 8" apart at the top with progressive spacing between. Space vertical strands at 6" intervals.
 33 Any of the following styles and coating classes may be used.

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

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

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

42 Brace wire shall be a 9 gauge steel in accordance with ASTM A641, except that the minimum
 43 zinc coating shall be 0.80 oz/sf.

44 **1050-6 CHAIN LINK FABRIC**

45 Chain link fence fabrics shall meet AASHTO M 181. Galvanized steel fabric shall have
 46 a Class D coating. Polyvinyl coated fabric shall be Type IV, Class A or B and the vinyl
 47 coating shall be a standard color meeting AASHTO M 181 or ASTM F934 Table 1.

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1 Glare screen fabric with a 0.5" mesh shall have a Class 1 zinc coating in accordance with
2 ASTM A392. The height of the chain link fence fabrics shall be as shown in the pay item
3 description. Weave the fabric from 11 gauge wire, unless otherwise required by the contract.
4 Glare screen fabric shall be 11 1/2 gauge unless otherwise required by the contract.

5 **1050-7 FENCE FITTINGS, HARDWARE AND ACCESSORIES**

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

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

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

12 Tension wire for use with galvanized steel chain link fabric shall meet AASHTO M 181 for
13 zinc coated tension wire. Tension wire for use with aluminum or aluminum coated chain link
14 fabric may be either aluminum coated tension wire meeting AASHTO M 181, or solid
15 aluminum wire with a minimum diameter of 0.192". The aluminum for solid aluminum wire
16 shall meet ASTM B211 for Alloy 5056 or 6061, and have a minimum breaking strength of
17 1,216 lbf and a minimum elongation of 10%. Tension wire for use with guardrail mounted
18 glare screen fabric shall be 6 gauge and for barrier mounted glare screen the wire shall be
19 9 gauge unless otherwise required by the contract.

20 Vinyl coated fittings and accessories shall be galvanized steel or aluminum coated steel
21 meeting this article and have a bonded vinyl coating. The vinyl shall meet Section 6 of
22 AASHTO M 181 and be a standard color meeting AASHTO M 181 or ASTM F934 Table 1.
23 The vinyl coating shall be at least 6 mils thick, except that the coating on tension wire, hog
24 rings and tie wires shall be 6 to 10 mils thick.

25 **1050-8 REPAIR OF GALVANIZING**

26 Repair of galvanizing shall be in accordance with Article 1076-7. Do not use aerosol can
27 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	-	-

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SECTION 1052 SALT AND LIME STABILIZERS

1052-1 SODIUM CHLORIDE

Sodium chloride shall meet AASHTO M 143.

1052-2 CALCIUM CHLORIDE

Calcium chloride shall be Class S or L meeting AASHTO M 144.

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1 1052-3 LIME

2 (A) Chemical Requirements

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

5 (B) Physical Requirements

6 (1) Hydrated Lime

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

8 (2) Quicklime

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

10 (C) Sampling and Inspection

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

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

17 SECTION 1054 18 DRAINS

19 1054-1 DECK DRAINS

20 Provide deck drains made of PVC pipe or of steel pipe. Use the type of pipe as shown in the
21 plans.

22 PVC pipe shall meet ASTM D1785 or D2665, and have four 1/2" square lugs shop glued at
23 approximately equal spacing around the pipe at 3" from the top end of each deck drain.

24 Steel pipe shall meet ASTM A53 for standard weight galvanized pipe.

25 1054-2 FUNNELS AND FUNNEL DRAINS

26 (A) Funnels

27 Fabricate funnels for corrugated aluminum alloy pipe from clad aluminum alloy sheets
28 meeting AASHTO M 196. Perform fabrication by riveting. The completed funnel shall
29 meet AASHTO M 196.

30 Fabricate funnels for corrugated steel pipe of steel meeting AASHTO M 218.
31 Fabrication may be by riveting or by welding. The completed funnel shall meet
32 AASHTO M 36.

33 (B) Funnel Drain Pipe, Elbows and Fittings

34 Funnel drain pipe, elbows and other fittings may be, at the option of the Contractor, either
35 corrugated aluminum alloy or corrugated steel. Corrugated aluminum alloy pipe, elbows
36 and other fittings shall meet Article 1032-2. Corrugated steel pipe, elbows and other
37 fittings shall meet Article 1032-3.

SECTION 1056 GEOSYNTHETICS

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1056-1 DESCRIPTION

4 The section addresses geosynthetics consisting of geotextiles and geocomposites to be used
5 for subsurface drainage, separation, stabilization, reinforcement, erosion control, filtration,
6 temporary silt fence and other applications in accordance with the contract.

7 Use geotextile fabrics that meet Article 4.1 of AASHTO M 288 and have been evaluated by
8 NTPEP. Use prefabricated geocomposite drain strips consisting of a non-woven
9 polypropylene geotextile bonded to one side of a high density polyethylene or polystyrene
10 drainage core, e.g., sheet drain.

11 1056-2 HANDLING AND STORING

12 Load, transport, unload and store geosynthetics so geosynthetics are kept clean and free of
13 damage. Label, ship and store geosynthetics in accordance with Section 7 of
14 AASHTO M 288. Geosynthetics with defects, flaws, deterioration or damage will be
15 rejected. Do not unwrap geosynthetics until just before installation. Do not leave
16 geosynthetics exposed for more than 7 days before covering except for geotextiles for erosion
17 control devices and mechanically stabilized earth (MSE) wall faces.

18 If necessary or required, hold geosynthetics in place with wire staples that meet
19 Subarticle 1060-8(D) or anchor pins. Use steel anchor pins with a diameter of at least 3/16"
20 and a length of at least 18" with a point at one end and a head at the other end that will retain
21 a steel washer with an outside diameter of at least 1.5".

22 1056-3 CERTIFICATIONS

23 Provide Type 1, Type 2 or Type 4 material certifications in accordance with Article 106-3 for
24 geosynthetics. Define "minimum average roll value" (MARV) in accordance with
25 ASTM D4439. Provide certifications with MARV for geosynthetic properties except as noted
26 in Tables 1056-1 and 1056-2. Test geosynthetics using laboratories accredited by the
27 Geosynthetic Accreditation Institute (GAI) to perform the required test methods. For testing
28 geosynthetics, define a "lot" as a single day's production.

29 1056-4 GEOTEXTILES

30 When required, sew geotextiles together in accordance with Article X1.1.4 of
31 AASHTO M 288. Provide sewn seams with seam strengths meeting the required strengths for
32 the geotextile type and class specified.

33 Provide geotextile types and classes in accordance with the contract. Use woven or
34 nonwoven geotextiles with properties that meet Table 1056-1. Define "machine direction"
35 (MD) and "cross-machine direction" (CD) in accordance with ASTM D4439.

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**TABLE 1056-1
GEOTEXTILE REQUIREMENTS**

Property	Requirement (MARV ^A)					Test Method
	Type 1	Type 2	Type 3 ^B	Type 4	Type 5 ^C	
<i>Typical Application</i>	<i>Shoulder Drains</i>	<i>Under Rip Rap</i>	<i>Temporary Silt Fence</i>	<i>Soil Stabilization</i>	<i>Temporary MSE Walls</i>	
Elongation (MD & CD)	≥ 50%	≥ 50%	≤ 25%	< 50%	< 50%	ASTM D4632
Grab Strength (MD & CD)	90 lb	205 lb	100 lb	180 lb	-	ASTM D4632
Tear Strength (MD & CD)	40 lb	80 lb	-	70 lb	-	ASTM D4533
Puncture Strength	220 lb	440 lb	-	370 lb	-	ASTM D6241
Wide Width Tensile Strength @ Ultimate (MD & CD)	-	-	-	-	2,400 lb/ft (unless required otherwise in the contract)	ASTM D4595
Permittivity	0.20 sec ⁻¹	0.20 sec ⁻¹	0.05 sec ⁻¹	0.05 sec ⁻¹	0.20 sec ⁻¹	ASTM D4491
Apparent Opening Size ^D	#60	#60	#30	#40	#30	ASTM D4751
UV Stability (Retained Strength) ^E	50%	50%	70%	50%	50%	ASTM D4355

- 1 **A.** MARV does not apply to elongation
- 2 **B.** Minimum roll width of 36" required
- 3 **C.** Minimum roll width of 13 ft required
- 4 **D.** US Sieve No. per AASHTO M 92
- 5 **E.** After 500 hours of exposure

6 **1056-5 GEOCOMPOSITES**

7 Provide geocomposite drain strips with widths of at least 12" and cores that meet
8 Table 1056-2.

**TABLE 1056-2
CORE REQUIREMENTS**

Property	Requirement (MARV ^A)	Test Method
Thickness	1/4" - 1/2"	ASTM D5199
Compressive Strength	40 psi	ASTM D1621
Flow Rate (with gradient of 1.0)	5 gpm ^B	ASTM D4716

- 9 **A.** MARV does not apply to thickness
- 10 **B.** Per foot of width tested

**SECTION 1060
LANDSCAPE DEVELOPMENT MATERIALS**

13 **1060-1 GENERAL**

14 Supply certifications for all landscape development materials as required below. If no
15 certification is required, supply the Department with a statement certifying that all materials
16 conform to these Specifications and those of the NC Department of Agriculture or both. All
17 landscape development materials shall comply with all applicable Federal and State domestic
18 plant quarantines.

1 1060-2 FERTILIZER

2 The quality of all fertilizer and all operations in connection with the furnishing of this material
3 shall comply with the North Carolina Fertilizer Law and with the rules and regulations,
4 adopted by the North Carolina Board of Agriculture in accordance with said law, in effect at
5 the time of sampling. All fertilizer will be subject to sampling and testing by the Engineer, or
6 by an authorized representative of the North Carolina Department of Agriculture, or both.

7 Dry fertilizer shall be manufactured from cured stock. Care for the fertilizer during handling
8 and storing in such a manner that it will be protected against hardening, caking or loss of plant
9 food values. Pulverize any hardened or caked fertilizer to its original condition before using.

10 1060-3 LIMESTONE

11 The quality of all limestone and all operations in connection with the furnishing of this
12 material shall comply with the North Carolina Lime Law and with the rules and regulations,
13 adopted by the North Carolina Board of Agriculture in accordance with said law, in effect at
14 the time of sampling. All limestone will be subject to sampling and testing by the Engineer,
15 or by an authorized representative of the North Carolina Department of Agriculture, or both.

16 Limestone shall be agricultural grade ground limestone. Either dolomitic or calcitic limestone
17 may be used.

18 All limestone shall contain not less than 90% calcium carbonate equivalents. Dolomitic
19 limestone shall contain not less than 10% of magnesium. Grade dolomitic limestone so at
20 least 90% will pass through a U.S. Standard 20 mesh screen and at least 35% will pass
21 through a U.S. Standard 100 mesh screen. Grade calcitic limestone so at least 90% will pass
22 through a U.S. Standard 20 mesh screen and at least 25% will pass through a U.S. Standard
23 100 mesh screen. Where the current grading requirements of the North Carolina Board of
24 Agriculture are different from the above, the requirements of the Board of Agriculture will
25 apply.

26 During handling and storing, care for the limestone in such manner that it will be protected
27 against hardening or caking. Pulverize any hardened or caked limestone to its original
28 condition before using.

29 1060-4 SEED

30 The quality of all seed and all operations in connection with the furnishing of this material
31 shall comply with the North Carolina Seed Law and with the rules and regulations, adopted
32 by the North Carolina Board of Agriculture in accordance with said law, in effect at the time
33 of sampling, and with the quality requirements of the *Standard Specifications*. All seed will
34 be subject to sampling by the Engineer, or by an authorized representative of the North
35 Carolina Department of Agriculture, or both; and will be tested by the North Carolina
36 Department of Agriculture. Supplementary testing for seed germination may be performed by
37 the Engineer.

38 The quality of all seed will be based on the percentage of pure live seed, which will be
39 computed by multiplying the percentage of purity by the percentage of germination and
40 dividing the result by 100.

41 Seed shall have been approved by the North Carolina Department of Agriculture before being
42 sown. No seed will be accepted with a date of test more than 8 months before the date of
43 sowing, excluding the month in which the test was completed. Such testing, however, will
44 not relieve the Contractor from responsibility for furnishing and sowing seed that meets these
45 *Standard Specifications* at the time of sowing. The Engineer may retest seed for germination
46 after 5 months of storage; at the beginning of each normal seeding season for the particular
47 kind of seed involved or at any time that the condition of the seed appears to have
48 deteriorated.

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1 When a low percentage of germination causes the quality of the seed to fall below the
2 minimum pure live seed specified, the Contractor may elect, subject to the approval of the
3 Engineer, to increase the rate of application sufficiently to obtain the minimum pure live seed
4 content specified, provided that such an increase in the rate of application does not cause the
5 quantity of noxious weed seed per acre or square yard, as the case may be, to exceed the
6 quantity that would be allowable at the regular rate of application.

7 Furnish and deliver each of the species or varieties of seed in separate bags. If seed is to be
8 mixed before sowing, perform such mixing in a commercial seed mixing machine, or by
9 an equally thorough means, after sampling and testing have been completed.

10 During handling and storing, care for the seed in such a manner that it will be protected from
11 damage by heat, moisture, rodents or other causes.

12 **1060-5 MULCH FOR EROSION CONTROL**

13 Mulch for erosion control shall consist of grain straw, or other acceptable material, and be
14 approved by the Engineer before being used. All mulch shall be reasonably free from mature
15 seedbearing stalks, roots or bulblets of Johnson Grass, Nutgrass, Sandbur, Wild Garlic, Wild
16 Onion, Crotalaria, Witchweed and an excessive amount of restricted noxious weeds as
17 defined by the North Carolina Board of Agriculture at the time of use of the mulch. Loose
18 and separate straw mulch that is matted or lumpy before being used.

19 Material for holding mulch in place shall be asphalt or other approved binding material.

20 **1060-6 SPRIGS**

21 Sprigs shall consist of freshly dug live stolons or rhizomes of permanent grasses, at least
22 2" in length, and be first class representatives of the required species or varieties specified in
23 the specifications. The areas from which sprigs are to be obtained shall be free from Johnson
24 Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Crotalaria, Witchweed and an excessive
25 amount of restricted noxious weeds as defined by the North Carolina Board of Agriculture at
26 the time of digging the sprigs. The areas shall have been mowed and raked, burned off, or
27 otherwise prepared in a manner acceptable to the engineer before digging of sprigs begins.

28 **1060-7 SOD**

29 Sod shall consist of a live, dense, well-rooted growth of permanent grasses, free from Johnson
30 Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Crotalaria, Witchweed and an excessive
31 amount of restricted noxious weeds as defined by the North Carolina Board of Agriculture at
32 the time of cutting the sod. Mow the area from which sod is to be obtained to a height of not
33 more than 2". Rake free of grass clippings and debris and otherwise prepared in a manner
34 satisfactory to the Engineer before cutting of sod begins.

35 Cut the sod into rectangular sections of sizes convenient for handling without breaking or loss
36 of soil. Cut it with a sod cutter or other acceptable means to a depth that will retain in the sod
37 practically all of the dense root system of the grass.

38 During wet weather, allow the sod to dry sufficiently before lifting to prevent tearing during
39 handling and placing. During extremely dry weather, water it before lifting if such watering
40 is necessary to insure its vitality and to prevent loss of soil during handling.

41 **1060-8 MATTING FOR EROSION CONTROL**

42 **(A) General**

43 Matting for erosion control shall be excelsior matting or straw matting. Furnish
44 a Type 3 material certification in accordance with Article 106-3 certifying that the
45 matting meets this article. Other acceptable material manufactured especially for erosion
46 control may be used when approved by the Engineer in writing before being used.
47 Matting for erosion control shall not be dyed, bleached or otherwise treated in a manner
48 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" in width and weigh 0.975 lb/sy with a tolerance of $\pm 10\%$. At least 80% of the individual excelsior fibers shall be 6" 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" x 1".

(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" and no more than 90" 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" x 0.75" 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" in length with a throat of not less than 1" in width.

1060-9 WATER

Water used in the planting or care of vegetation shall meet Class C fresh waters as defined in 15 NCAC 2B.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, Entomology Division. Fire ant treatment certification, where applicable, is required.

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1 When nursery stock from other states is used on projects in North Carolina, this stock
2 shall be accompanied by a tag or certificate stating that the nursery stock has been
3 inspected and certified by an authorized official of the state of origin as apparently free
4 from injurious plant pests.

5 All plant materials are subject to inspection at any time by the Engineer. Any such
6 inspection before or during planting operations, however, will not be construed as final
7 acceptance of the plants involved.

8 All geophytes; bulbs, corms and tuberous plants; shall be synonymous to the term “plant”
9 within the contract. Examples include, but are not limited to, Narcissi (Daffodil), Tulipa
10 (Tulip), Iris and Canna; the terms “bulb”, “corm”, “tuber”; and specific plant names such
11 as “Daffodil”, “Tulip”, “Canna lily”, etc.

12 (B) Balled and Burlapped Plants

13 Dig plants to be balled and burlapped so as to retain a firm ball of soil and the plant’s
14 fibrous root system. The soil in the ball shall be the original and undisturbed soil in
15 which the plant has been grown. Dig, wrap, transport and handle the plant so the soil in
16 the ball shall not become frozen, loosened, cause stripping of the small feeding roots nor
17 movements of the soil away from contact with such roots.

18 (C) Container Grown Plants

19 Container grown plants shall be healthy, vigorous, well-rooted and established in the
20 container in which they are delivered. These plants shall be in the container long enough
21 for the fibrous roots to have developed so the root mass will retain its shape and hold
22 together when removed from the container. The container shall be sufficiently rigid to
23 firmly hold the soil protecting the root mass during transporting, handling and planting.
24 The soil shall not be allowed to become frozen.

25 (D) Bare Root Plants

26 Bare root plants shall have a heavy fibrous root system that has been developed by proper
27 cultural treatment. Dig, package, transport and handle bare root plants in a manner that
28 will prevent injury to or drying out of the trunks, branches or roots, or freezing of the
29 roots. Bare root plants damaged through improper handling, freezing, drying out, etc.
30 will result in rejection of material.

31 (E) Plant Substitution

32 No change in the *Standard Specifications* (species, variety, size, caliper, furnish) will be
33 made without written approval of the Engineer. Present all requests for substitutions in
34 writing and include a listing of the sources contacted in an attempt to secure specified
35 plant material. Requests for substitutions shall include the botanical name, common
36 name, cultivar, where applicable, size, caliper and furnish description of the proposed
37 substitute. No increase in compensation will be made to the Contractor as a result of the
38 use of approved substitute plants. The Department reserves the right to locate specified
39 plant material for the project when it has knowledge that specified material is available.

40 (F) Geophytes

41 Geophytes; bulbs, corms and tuberous plants; shall be healthy and free of disease caused
42 by fungi, nematodes, bacteria and wilt. Plants that are lightweight and lacking adequate
43 mass will result in rejection. Plants shall be firm and absent of discolored patches with
44 soft or spongy areas or signs of rot, slime or mold. Plants with new root growth will
45 result in rejection.

46 Dig, package, transport and handle these plants as to prevent injury, drying out, excessive
47 wetness or freezing. Damaged plants through improper handling, freezing, drying out or
48 excessive moisture will result in rejection.

1 All geophytes, bulbs, corms and tuberous plants shall be inspected for size and condition
2 and rejected plants shall be removed from the supply before planting.

3 **1060-11 MULCH FOR PLANTING**

4 Use mulch for planting as specified in the specifications, shown in the plans, or approved by
5 the Engineer. Mulch for planting shall not contain substances injurious to plants or which
6 will inhibit normal development and growth of plants. Mulch for a project shall come from
7 a single source, as approved by the Engineer, unless an additional source is submitted and
8 approved before use.

9 **1060-12 MATERIALS FOR STAKING OR GUYING**

10 **(A) Stakes**

11 Use stakes made of cypress, cedar, oak, locust or other acceptable wood free from defects
12 that would compromise the strength of the stake. Stakes shall be at least
13 2" x 2" (nominal). Use stakes of the size and length as shown in the plans.

14 **(B) Wire**

15 Wire shall be new soft No. 14 gauge steel wire or as shown in the plans.

16 **(C) Hose**

17 Hose to be used with wire shall have a minimum inside diameter of 1/2". All hose shall
18 be garden type hose composed of rubber and fabric, or as shown in the plans.

19 **(D) Other**

20 Other staking and guying materials may be used if a sample is submitted and approved by
21 the Engineer before use.

22 **1060-13 HERBICIDES**

23 The herbicide to be used for a particular application shall be as specified or approved by the
24 Engineer.

25 Herbicides shall be properly labeled and registered with the United States Department of
26 Agriculture and the North Carolina Department of Agriculture. A container shall contain only
27 the herbicide that meets the analysis guaranteed on the label. Keep all herbicides in such
28 original labeled containers until used.

29 Herbicide application shall only be conducted by individuals who possess a pesticide license
30 from the NC Department of Agriculture or individuals under their direction and who has read,
31 understands, and follows the herbicide labeling before applying the product.

32 **1060-14 COIR FIBER MAT**

33 Coir fiber mat shall consist of 100% coconut fiber (coir) twine woven into high strength
34 matrix. The coir fiber mat shall have a thickness of at least 0.30" and weigh at least 20 oz/sy.
35 The coir fiber mat shall have a tensile strength of at least 1,348 x 626 lb/ft and elongation of
36 no more than 34% x 38%. The coir fiber mat shall have a flexibility of
37 65,030 x 29,590 mg-cm. The coir fiber mat shall have an observed flow velocity of 11 ft/sec.
38 The coir fiber mat shall have a C-Factor of 0.002. The size of the coir fiber mat shall be
39 6.6 ft x 164 ft and the measured open area shall be 50%.

40 **1060-15 SPECIAL STILLING BASIN**

41 The special stilling basin shall be a bag constructed to a minimum size of 10 ft x 15 ft made
42 from a nonwoven fabric. It shall have a sewn-in 8" (maximum) spout for receiving pump
43 discharge. The bag seams shall be sewn with a double needle machine using a high strength
44 thread. The seams shall have a minimum wide width strength of 60 lb/in tested in accordance
45 with ASTM D4884.

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**SECTION 1070
REINFORCING STEEL**

1070-1 GENERAL

Store steel reinforcement on blocking at least 12" above the ground; protect the steel at all times from damage; and when placing in the work, ensure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials.

1070-2 DEFORMED STEEL BAR REINFORCEMENT FOR STRUCTURES

Supply deformed steel bar reinforcement conforming to ASTM A615 for Grade 60. Bend and cut during fabrication with tolerances in accordance with the *Manual of Standard Practice* published by the Concrete Reinforcing Steel Institute. 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 32. Epoxy coat all spacers on spirals when the spirals are epoxy coated.

Use smooth welded wire reinforcement conforming to AASHTO M 55.

Use deformed welded wire reinforcement conforming to AASHTO M 221.

1070-4 REINFORCING STEEL BAR SUPPORTS

Make 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" 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. Do not use plastic legs molded to the top wire.

Use plastic bar supports meeting the requirements listed in the *Manual of Standard Practice* 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 7 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" round seven-wire stress-relieved Grades 250 or 270 prestressing strands meeting AASHTO M 203.

1 Mark the outer layer of each reel pack of strand with a wide color band as follows: white for
2 Grade 270 stress relieved strand, green for low relaxation strand, and a double marking of
3 green and red for special low relaxation strand. In addition, attach a metal tag to each reel
4 pack labeled in accordance with AASHTO M 203.

5 **1070-6 DOWELS AND TIE BARS FOR PORTLAND CEMENT CONCRETE**
6 **PAVEMENT**

7 Use smooth plain round steel dowel bars conforming to AASHTO M 31 Grade 60. Do not
8 use dowel bars with burred ends. A tolerance of $\pm 1/4$ " is permitted from the dowel length
9 required by the plans. A straightness tolerance of 0.075" from a straight line is permitted.

10 Epoxy coat all dowel bars in accordance with AASHTO M 284 and these provisions, with
11 a coating thickness of 7 to 13 mils after curing. Coated bars will be taken by the Engineer
12 from the production run on a random basis at the point of coating application for testing and
13 evaluation. The Engineer determines the sampling and testing schedule for the number and
14 frequency of tests for thickness of coating, adhesion of coating and holidays. At least one bar
15 for each 20 coated is tested for holidays and coating thickness. Perform at least 2 bend tests
16 for each 8 hours of production coating or any fraction thereof for determining that adhesion
17 and flexibility of the coating meets specification requirements. Payment is not made by the
18 Department for coated bars selected for testing and evaluation purposes at the point of coating
19 application. All coated bars are inspected at both the coating and fabrication shops. Furnish
20 a Type 1 material certification in accordance with Article 106-3 and attach it to a completed
21 Reinforcing Steel Certification, M&T Form 913, for all coated reinforcing bars before
22 cleaning and coating operations, of the time and location where the work is performed.
23 A blank Reinforcing Steel Certification, M&T Form 913, may be obtained from the Materials
24 and Tests Unit.

25 Use dowel assemblies for supporting dowel bars of rigid construction capable of holding the
26 dowel bars in proper position during placing of concrete, and of such design to permit
27 unrestricted movement of the pavement slab. Use wire for dowel assemblies meeting
28 AASHTO M 32. Use a dowel assembly that holds the dowels in the required position within
29 a tolerance of $\pm 1/4$ " in vertical and horizontal planes. Obtain written approval for the dowel
30 assembly before use.

31 Coat dowel bars and the entire dowel assembly with an approved wax base coating. Apply
32 the coating by dipping or spraying such that the wax coating on the dowel bars is of uniform
33 thickness sufficient to allow pulling of the dowel from the concrete as provided in
34 AASHTO T 253 and M254. Furnish to the Department for testing one dowel basket assembly
35 for each 200 assemblies incorporated into the project.

36 Use deformed tie bars conforming to AASHTO M 31 for Grade 40 or Grade 60.

37 **1070-7 EPOXY COATED REINFORCING STEEL**

38 **(A) General**

39 Coaters of epoxy coated reinforcing steel shall establish proof of their competency and
40 responsibility in accordance with the Concrete Reinforcing Steel Institute's Fusion
41 Bonded Epoxy Coating Applicator Plant Certification Program. Registration and
42 certification of the plant or shop under the CRSI Program and submission of the valid
43 annual certificate to the State Materials Engineer is required before beginning any
44 coating. The same requirement applies to coaters subcontracting work from the coater
45 directly employed by the contractor.

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1 Obtain approval of each coater and/or fabricator of epoxy coated reinforcing steel before
2 coating or fabricating bars. Approval is based upon the following:

3 (1) The coating applicator and/or fabricator establishing and maintaining an effective
4 quality control program and

5 (2) The coating applicator having equipment for cleaning, coating and/or fabricating that
6 produces coated material conforming to these *Standard Specifications*.

7 Include in requests for approval a well defined quality control program and direct the
8 requests to the State Materials Engineer. Before Department approval is issued, the
9 condition of equipment for blast cleaning, coating and/or fabricating material is evaluated
10 by the Engineer for determining the equipment capability of producing a coated product
11 conforming to the *Standard Specifications*. Lists of Department approved epoxy coating
12 and fabricating companies are available from the State Materials Engineer.

13 (B) Coating Materials

14 Obtain approval for the epoxy resin powder before use. A list of prequalified powder
15 sources is available from the State Materials Engineer.

16 Submit prequalified products other than those now approved for use to the State
17 Materials Engineer for approval. Requalify each product every 5 years and any time
18 a change is made in the manufacturing process or chemical composition of the epoxy
19 resin.

20 Use powdered resin of any color that provides contrast to the corroded or uncorroded
21 surface of the steel. Provide material of the same quality as that used for prequalification
22 tests and as represented by test reports forwarded to the State Materials Engineer.

23 Ensure the manufacturer of the epoxy resin supplies to the coating applier information on
24 the resin that is essential to the proper use and performance of the resin as a coating.
25 Ensure the manufacturer of the resin furnish the coating applier a written certification
26 signed by a responsible officer of the company that the material furnished for coating the
27 reinforced steel is the same formulation as that for which test reports were previously
28 submitted to the State Materials Engineer.

29 With each batch of coating material, furnish a written certification by the coating applier
30 to the Engineer which properly identifies the batch number, material, quantity
31 represented, date of manufacture, name and address of manufacturer and includes
32 a statement that the supplied coating material is the same composition as that
33 prequalified.

34 (C) Patching Material

35 Ensure the epoxy resin manufacturer supplies a prequalified and approved patching or
36 repair material that is compatible with the coating and inert in concrete. Ensure that the
37 material is suitable for making repairs with a minimum dry film thickness of 6 mils from
38 2 coats on damaged areas of the coating. Ensure that each coater, fabricator and
39 contractor has a copy of the manufacturer's written instructions for application of the
40 patching material and the instructions are closely followed during coating damage
41 repairs.

42 Apply 2 coats of patch material where needed with the second coat applied only after the
43 first coat dries to the touch. Do not apply any patch material when the surface
44 temperature of the steel or the air temperature is below 40°F. Do not ship or place steel
45 until the patch material is dry to the touch.

(D) 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 that produce holidays in the coating. Ensure the coater visually inspects the bars to avoid coating bars containing such surface irregularities. If the coater fails to detect surface irregularities that produce holidays in the coating, patch the holidays with 6 mils of patching material as specified in Subarticle 1070-7(C) to avoid rejection of the bars.

(E) Surface Preparation of Bars

Subject coated reinforcing steel surfaces to a very thorough blast (near white) cleaning, before coating. Ensure that the appearance of the surface after cleaning corresponds to ASTM D2200 and the pictorial standards of SSPC-VIS 1, degree of cleaning SSPC-SP 10. Produce a suitable anchor pattern profile by the cleaning media. A target profile depth of 1/3 of the coating thickness is considered a suitable anchor pattern.

Apply the coating to the cleaned surface as soon as possible after cleaning. Remove any formation of rust blooms on the cleaned bars by blast cleaning before application of the coating. However, never delay the coating more than 8 hours after cleaning unless otherwise permitted. Provide surface characteristics of the steel as described above at the time of coating.

After blast cleaning, and before application of the coating, remove all visible traces of grit and dust from the bars.

(F) Application of Coating

Apply the coating as an electrostatically charged dry powder sprayed into the grounded steel bar using an electrostatic spray gun. Apply the powder to either a hot or cold bar. Give the coated bar a thermal treatment as specified by the manufacturer of the epoxy resin that provides a fully cured and bonded finish coating. Control temperature as recommended by the manufacturer of the coating material to ensure a workmanlike finish without blistering or other defects. Completely coat all bars, including bar ends, with epoxy resin powder to the minimum thickness specified in Subarticle 1070-7(G).

Run the production line at such a speed as to provide proper cure time before quench by air or water.

(G) Quality Control Requirements

For acceptance purposes, ensure that each recorded film thickness measurement is in the range of 7 to 12 mils after cure, with the entire area of a bar having a minimum coating thickness of 7 mils.

A single recorded coated reinforcing bar thickness measurement is the average of 3 individual readings obtained from 3 adjacent areas on the body of the bar (3 adjacent areas between deformations). Obtain at least 5 recorded measurements approximately evenly spaced along each side of the test bar (at least 10 recorded measurements per bar).

Ensure the coating applicator visually inspects each coated bar after cure for continuity of coating and to ensure that the coating is free of holes, voids, contamination, cracks and damaged areas discernible to the unaided eye. In addition, no more than an average of 2 holidays per linear foot of bar are permitted providing the total quantity of holidays does not exceed 5 in any linear foot. Bars that contain no more than 5 holidays in any linear foot of bar are acceptable provided any holidays in excess of 2 per linear foot are coated with 6 mils of patching material specified in Subarticle 1070-7(C). Retest the bars after patching to confirm that no more than 2 holidays exist in any linear foot of bar.

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1 Ensure the coating applier evaluates the adhesion of the coating on a representative
2 number of bars selected by the Engineer from each proposed shipment as specified in
3 Subarticle 1070-7(L). No visible cracks or disbonding of the coating are allowed when
4 tested in accordance with Subarticle 1070-7(H).

5 (H) Test Methods Required of the Coater

6 The thickness of the coating is measured on the body of the bar between the deformations
7 or ribs. Conduct non-destructive coating thickness measurements using magnetic gauges
8 in accordance with ASTM G12, with the following additions applicable to commercially
9 available pull-off gauges, and to fixed probe gauges with a magnetic field of vision not
10 exceeding 0.015" of steel depth; 0.015" is the minimum thickness of smooth steel to
11 which adding more material does not change the zero reading.

12 Perform gauge calibration with shims on a smooth, clean low-carbon steel plate with
13 minimum dimensions of 3" x 3 1/2", rather than on a cleaned reinforcing bar.

14 Determine a correction factor defining the effect of the bar preparation process as the
15 difference between (a) the average of 10 gauge readings on a cleaned, but uncoated
16 reinforcing bar of the size and lot coated, and (b) the average of 5 gauge readings on
17 a smooth mild steel plate. This correction factor is then subtracted from all subsequent
18 gauge readings on coated bars.

Bar No.	Mandrel Diameter, inch
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
14	17
18	23

19 Fixed probe gauges are checked to ensure that the force generated by the springloaded
20 probe housing is sufficient to ensure intimate contact between the probe tip and the
21 coatings of the curved bar surface. If intimate contact does not result, remove the probe
22 housing and use hand pressure to obtain valid indicated thickness readings.

23 As an option, use thumbwheel pulloff gauges to provide valid thickness measurements on
24 coated reinforcing bars with a deformation spacing which is less than the maximum outer
25 dimensions of the probe housing. Position the base of the probe housing against the top
26 of 2 adjacent deformations and extend the probe through the air gap to the body of the
27 bar. Hold the gauge very steady and apply continuous light downward pressure to the
28 housing during the measurement.

29 Use a 67.5V holiday detector equipped with a holiday marker in accordance with the
30 detector manufacturer's instructions. Maintain the detector in perfect working condition
31 at all times during the bar coating process. Immediately after coating, route each bar
32 through the detector for holiday detection. Bars containing more than five holidays in
33 a linear foot of bar or averaging more than 2 holidays per foot of bar are either rejected or
34 cleaned, recoated, and retested for holidays. A coating holiday for the purpose of this
35 specification is defined as a discontinuity in the applied coating that occurs during the
36 coating process that is detected either visually or electromechanically.

1 The adhesion of the coating is evaluated by bending production coated bars 120° (after
2 rebound) around a mandrel of specified size as prescribed in Table 1070-1. Conduct the
3 bend test at a uniform rate and take up to 90 seconds to complete. Place the
4 2 longitudinal deformations in a plane perpendicular to the mandrel radius, and maintain
5 the test specimen at thermal equilibrium between 68°F and 85°F. If the specimen for the
6 adhesion of coating shows evidence of cracking or debonding of the coating, conduct
7 2 retests on random samples. If the results of both retests meet the specified
8 requirements, the coated bars represented by the samples are acceptable.

9 The fracture or partial failure of the steel-reinforcing bar in the bend test for adhesion of
10 coating is not considered as an adhesion failure of the coating. If failure of the bar
11 occurs, test 2 check samples without bar failure.

12 Condition test bars at a temperature range of 68°F to 85°F. In cases of dispute, conduct
13 tests at 73°F and 50% relative humidity in accordance with recommended practices in
14 ASTM D3451.

15 **(I) Handling and Identification**

16 Provide padded contact areas for all systems for handling coated bars at the coating plant,
17 fabricator and project. Pad or suitably band all bundling bands to prevent damage to the
18 coating. Lift all bundles of coated bars with a strong back, spreader bar, multiple
19 supports or a platform bridge to prevent bar-to-bar abrasion from sag in the bundles of
20 coated bars.

21 **(J) Fabrication of Steel-Reinforcing Bars After Coating**

22 Protect drive rolls and automatic kick-off levers on shear beds, and drive pins, center pins
23 and back-up barrels on benders with a suitable covering to minimize damage during the
24 fabrication process. Note that these *Standard Specifications* permit no more than 5% of
25 the surface area of a bar to contain patching material. This includes patching due to
26 damage to the coating by the coater, fabricator, transporter and contractor.

27 Store coated bars as required by Subarticle 1070-7(M).

28 Ensure the fabricator maintains the identification of the coated bars and that the coated,
29 fabricated bars are identified with proper tags for final shipment to the job site.

30 Perform coating repairs as described in Subarticle 1070-7(K) with material specified in
31 Subarticle 1070-7(C).

32 Flame cutting of coated bars to the required dimensions is not permitted. Maintain any
33 mechanical device used for cutting the coated bars to required length in good working
34 order to minimize damaging the coating in the vicinity of the cut ends. Repair coating
35 damage in these areas as described in Subarticle 1070-7(K) with material specified in
36 Subarticle 1070-7(C).

37 **(K) Procedures for Repair of Coating**

38 Repair all coating damage of the reinforcing bars with material described in
39 Subarticle 1070-7(C) when coating bond loss and damage exist, including crushed
40 coating and hairline cracking if bare metal is evident. When repair is required, clean and
41 repair all damage. Remove crushed coating and loose or deleterious material. In areas
42 where rust is present, remove it by wire brushing with a power tool to the surface finish
43 specified in Subarticle 1070-7(E) before repair.

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1 (L) Inspection by the Department

2 Coated bars are inspected at both the coating and fabrication shops unless otherwise
3 approved. The coater and/or fabricator shall furnish Type 3 material certification in
4 accordance with Article 106-3, attached to a completed Reinforcing Steel Certification,
5 M&T Form 913, for all coated reinforcing bars. Include a completed Epoxy Coated
6 Reinforcing Bar Inspection Report, Form 310, with each shipment. These certification
7 forms are available from the State Materials Engineer. Do not epoxy coat, fabricate or
8 ship reinforcing steel to the project site without the approval of the Engineer.

9 Provide free entry to the plant and facilities of the coater and/or fabricator for the
10 inspection of all manufacturing processes including, but not limited to, the cleaning,
11 coating and fabrication of the ordered bars.

12 On a random basis, lengths of coated bars or fabricated bars are taken from the
13 production run at the point of coating application for testing and evaluation.

14 All bar tests are made at the coating applicator and/or fabricator's plant, before shipment,
15 unless otherwise approved. Ensure the coating applicator and/or fabricator notify the State
16 Materials Engineer 5 working days before the time the material is coated or fabricated.
17 Do not ship bars until they are inspected and tagged by the Department.

18 The Engineer randomly selects 3 coated bars of each size from each proposed shipment
19 to test for holidays, damage and coating thickness. If any bar fails to conform to these
20 Specification requirements, 6 samples are selected and tested. If these tests reveal that
21 the coating conforms to Specification requirements the shipment is acceptable. If any of
22 the second set of samples fail to conform to these Specifications the coater is required to
23 test all bars of that size that are included in the shipment and re-submit the shipment to
24 the Department for inspection. The Engineer selects from each proposed shipment
25 2 samples of each size bar for bend tests by the coater for determining that the adhesion
26 and flexibility of the coating conforms to Subarticle 1070-7(H).

27 (M) Repairs to Coating Due to Loading, Transporting and Handling

28 Transport the bundled bars from the coater or fabricator to the project site with padding,
29 such as carpet padding or used carpet, placed over each bundle of steel upon which
30 another bundle of steel is placed unless wooden spacers are placed between each bundle
31 to prevent contact.

32 Load all bundles of bars horizontally for transporting. Transport the bars on a flatbed
33 trailer. Do not allow the length of bars extending beyond the trailer bed to exceed 8 ft.

34 Repair coating damage due to handling and transporting or other causes with material
35 specified in Subarticle 1070-7(C) and in accordance with Subarticle 1070-7(K).

36 (N) Rejection

37 Coated bars that do not meet the *Standard Specifications* are rejected. At the
38 Contractor's option, replace coated bars containing defects beyond the limits of the
39 *Standard Specifications*. Alternatively, strip the bars of coating, reclean and recoat in
40 accordance with the *Standard Specifications*.

41 1070-8 SPIRAL COLUMN REINFORCING STEEL

42 Furnish spiral column reinforcing steel with the following areas and weights as required in
43 Table 1070-2 and in the plans.

TABLE 1070-2			
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

1 Use cold drawn wire conforming to AASHTO M 32. Use plain or deformed bars conforming
2 to AASHTO M 31 for Grade 60. Use deformed cold drawn wire conforming to
3 AASHTO M 225.

4 The diameter of the spiral reinforcing steel is the outside to outside measurement of the bars
5 or wire, with an allowance of 1/2" more or 1/2" less than the specified diameter as shown in
6 the plans.

7 Furnish spirals with 1.5 extra turns at top and at bottom of the completed spiral cage. Where
8 splicing of the spirals is necessary other than those shown in the plans, provide a minimum
9 lap splice of 3 ft.

10 Do not weld on the spiral reinforcing steel.

11 When required by the plans, use epoxy coated spiral column reinforcing steel including
12 spacers in accordance with Article 1070-7.

13 Use the minimum number of spiral spacers as shown in the plans. Ensure a minimum section
14 modulus per spiral spacer of 0.030 cu.in.

15 **1070-9 MECHANICAL BUTT SPLICES**

16 When called for by the contract or when directed by the Engineer, use a mechanical butt
17 reinforcing steel splice from an approved source. Use a standard metal filled sleeve, cement
18 mortar filled sleeve, threaded steel couplings, forged steel sleeve or cold-forged sleeve.
19 An exothermic process whereby molten filler metal, contained by a high strength steel sleeve
20 of larger inside diameter than the bars, is introduced into the annular space between the bars
21 and the sleeve and between the ends of the bars may be used. Provide a splice that is capable
22 of transferring at least 125% of the yield strength of the bars from one bar to the other by the
23 mechanical strength of the splice components.

24 For splices not on the approved list, before use and as a condition of approval, assemble 3 test
25 splices in the presence of the Engineer for each size of bar which is proposed for use on the
26 project. Forward the test splices to the Materials and Tests Unit in Raleigh, NC for testing
27 and approval.

28 **SECTION 1072**

29 **STRUCTURAL STEEL**

30 **1072-1 GENERAL**

31 Furnish and fabricate all structural steel and related incidental materials including sign
32 supports and high mount lighting standards and use materials in accordance with this section.

33 **(A) Fabricator Qualification**

34 Use steel fabricators on the Department's Approved Structural Steel Fabricators List for
35 the type work being performed. The list is available from the Materials and Tests Unit or
36 on the Department's website.

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1 Employ fabricators of high mount lighting standards in excess of 80 ft in length,
2 structural steel components of fender systems, retaining walls and noise walls, sign
3 supports, sign structures, pot and expansion bearings, simple span rolled beams,
4 including those requiring cover plates, solar array platforms and modular expansion joints
5 that are AISC certified in Simple Steel Bridges. Employ fabricators of heat curved rolled
6 beams, rolled beams for continuous spans and plate girders that are AISC certified in
7 Major Steel Bridges. Employ fabricators of fracture critical bridge beams and girders
8 that have a Fracture Critical Members Endorsement from AISC. Ensure that fabricators,
9 applying over 1,500 sf of coating for each project, have a Sophisticated Paint System
10 Endorsement from AISC or a Quality Procedure 3 Certification from the Society of
11 Protective Coatings.

12 When AISC certification is required, submit proof of registration and certification of the
13 plant or shop under the AISC program to the State Materials Engineer before beginning
14 fabrication and on an annual basis. The same requirements apply to fabricators
15 subcontracting work from the fabricator directly employed by the Contractor.

16 **(B) Office**

17 Ensure that fabricators of main structural steel components of bridges provide an office
18 area with an approximate floor space of 100 sf, a desk or drafting table, 2 chairs,
19 telephone, facilities for proper heating and cooling, telephone, separate dial-up or faster
20 internet access and adequate lighting and located at the plant site for the exclusive use of
21 the Engineer. Ensure fabricators of other structural steel items furnish reasonable work
22 areas for the Engineer.

23 **1072-2 SHAPES, PLATES, BARS AND SHEETS**

24 Use shapes, plates, bars and sheets meeting AASHTO M 270 Grade 36 unless otherwise
25 required by the contract. For painted beams or girders, use sheet material of 1/32" in
26 thickness meeting ASTM A1008 or A1011, and sheet material of 1/16" through 5/32"
27 thickness meeting ASTM A1011 for Grades 36, 40 or 45. For unpainted beams or girders,
28 use sheet material less than 3/16" thickness meeting ASTM A606 for Type 4.

29 **1072-3 BEARING PLATE ASSEMBLIES**

30 Unless otherwise shown in the plans, galvanize steel bearing assemblies for both structural
31 steel beams and girders and prestressed concrete girders. Galvanize anchor bolts, nuts and
32 washers in accordance with AASHTO M 232. Cut pipe sleeves and collars from Schedule 40
33 PVC pipe meeting ASTM D1785.

34 Except for attachments of bearing plates to beams, fabricate and weld bearing plate
35 assemblies before galvanizing the steel. Seal all joints of welded parts with weld material.
36 After the fabrication of the bearing plate assembly is complete, galvanize the assembly in
37 accordance with AASHTO M 111. For prestressed concrete girders, clean welds made for
38 attaching bearing plates to beams or girders and give them 2 coats of organic zinc repair paint
39 having a minimum total coating thickness of 3 dry mils. For steel beams and girders, clean
40 and paint in accordance with Article 442-10.

41 Repair galvanized surfaces that are abraded or damaged at any time after the application of
42 the zinc coating by thoroughly wire brushing the damaged areas and removing all loose and
43 cracked coating, after which give the cleaned area 2 coats of organic zinc repair paint having
44 a minimum total coating thickness of 3 dry mils.

45 Use zinc rich paint meeting Article 1080-9.

46 **1072-4 ANCHOR BOLTS**

47 Unless otherwise stated herein, use anchor bolts meeting ASTM A307 for Grade A.

48 Provide anchor bolts for bearing plate assemblies meeting ASTM A449.

1 Swedge anchor bolts for a distance equal to the embedment length minus 3" measured from
2 the embedded end.

3 Hot-dip galvanize anchor bolts, nuts and washers in accordance with AASHTO M 232.

4 **1072-5 HIGH STRENGTH BOLTS, NUTS AND WASHERS**

5 **(A) General**

6 Furnish all high-strength bolts, nuts and washers, including direct tension indicators, in
7 accordance with the appropriate AASHTO or ASTM materials specifications as amended
8 and revised herein.

9 Furnish the Engineer a copy of the manufacturer's test report for each component.
10 Ensure the report indicates the testing date, the city and state where the components were
11 manufactured, the lot number of the material represented, the rotational capacity tests lot
12 number and the source identification marking used by the manufacturer of each
13 component. On test reports for direct tension indicators, include the tension load at
14 which indicators are tested, gap clearance, nominal size and coating thickness.

15 Produce each permanent fastener component installed in a structure from domestically
16 processed material containing the grade identification markings required by the
17 applicable reference specification and the manufacturer's source identification marking.
18 A copy of the source identification marking used by each manufacturer is on file with the
19 Department's Materials and Tests Unit.

20 Obtaining permanent bolts, nuts and washers in any one structure from different
21 manufacturers is allowed provided:

22 (1) All bolts are produced by only one manufacturer.

23 (2) All nuts are produced by only one manufacturer.

24 (3) All washers are produced by only one manufacturer.

25 Have all fasteners used in a structure furnished by the fabricator of the steel. Require the
26 fabricator to submit the fasteners for sampling and testing at least 5 weeks before delivery
27 to the project site. Sample and test each diameter and length of bolt, nut and washer
28 assembly in accordance with Table 1072-1.

TABLE 1072-1	
SAMPLING REQUIREMENTS FOR	
HIGH STRENGTH BOLTS, NUTS AND WASHERS	
Lot Quantity	Number of Samples
0-800	3 Assemblies
801-8000	6 Assemblies
> 8000	9 Assemblies

29 Ship only those fasteners to the project that are sampled, tested and approved. Protect the
30 material from moisture during storage such that it does not contain any indication of rust
31 at the time of installation. Ensure that each component contains a thin coat of lubricant at
32 the time of installation.

33 When galvanized high strength bolts are required, use bolts, nuts and washers meeting
34 Subarticle 1072-5(F).

35 When corrosion resistant structural steel is required by the plans, provide fasteners with
36 atmospheric corrosion resistance and weathering characteristics comparable to that of the
37 structural steel.

38 **(B) Specifications**

39 Ensure that all bolts meet ASTM A325.

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1 Ensure that all nuts meet ASTM A194 as applicable or ASTM A563. Completely coat
2 each nut with a wax lubricant.

3 Ensure that all washers meet ASTM F436.

4 Ensure that all direct tension indicators meet ASTM F959.

5 (C) Manufacturing

6 (1) Bolts

7 Hardness for bolt diameters 1/2" to 1" inclusive shall be 248 to 311 Brinell hardness
8 and 24 to 33 Rockwell C hardness.

9 (2) Nuts

10 (a) Heat treat galvanized nuts to Grades 2H, DH or DH3.

11 (b) Use plain (ungalvanized) nuts of Grades 2, C, D or C3 with a minimum
12 Rockwell hardness of 89 HRB or Brinell hardness of 180 HB, or heat treat to
13 Grades 2H, DH or DH3. The hardness requirements for Grades 2, C, D and C3
14 exceed the current AASHTO/ASTM requirements.

15 (c) Tap oversize galvanized nuts the minimum amount required by ASTM A563.
16 Overtap the nut such that the nut assembles freely on the bolt in the coated
17 condition and meets mechanical requirements of ASTM A563 and the
18 rotational-capacity test herein.

19 (3) Mark all bolts, nuts and washers in accordance with the appropriate
20 AASHTO/ASTM Specifications.

21 (4) Direct Tension Indicators

22 (a) For Type 3 high strength bolts, mechanically galvanize direct tension indicators
23 to ASTM B695, Class 55, and then apply baked epoxy to a thickness of 1 mil
24 minimum. Direct tension indicators need not be mechanically galvanized or
25 epoxy coated if they are made from material conforming to ASTM A325,
26 Type 3 bolts.

27 (b) For plain Type 1 high strength bolts, provide direct tension indicators that are
28 plain or mechanically galvanized to ASTM B695, Class 55.

29 (c) For galvanized Type 1 high strength bolts, mechanically galvanize direct tension
30 indicators to ASTM B695, Class 55.

31 (D) Testing

32 (1) Bolts

33 (a) Proof load tests in accordance with ASTM F606, Method 1, are required at the
34 minimum frequency as specified in AASHTO M 164, Paragraph 9.2.4.

35 (b) Wedge tests on full size bolts in accordance with ASTM F606, Paragraph 3.5,
36 are required. If bolts are galvanized, perform the tests after galvanizing. Test at
37 a minimum frequency as specified in AASHTO M 164, Paragraph 9.2.4.

38 (c) If galvanized bolts are supplied, measure the thickness of the zinc coating. Take
39 measurements on the wrench flats or top of bolt head.

40 (2) Nuts

41 (a) Proof load tests in accordance with ASTM F606, Paragraph 4.2, are required at
42 the minimum frequency of as specified in ASTM A563 and ASTM A194. If
43 nuts are galvanized, perform the tests after galvanizing, overlapping and
44 lubricating.

- 1 (b) If galvanized nuts are supplied, measure the thickness of the zinc coating. Take
2 measurements on the wrench flats.
- 3 (3) Washers
- 4 (a) If galvanized washers are supplied, perform hardness testing after galvanizing.
- 5 (b) Remove the coating before taking hardness measurements.
- 6 (c) If galvanized washers are supplied, measure the thickness of the zinc coating.
- 7 (d) Test direct tension indicators in accordance with ASTM F959.
- 8 (4) Assemblies
- 9 Rotational-capacity tests are required. Ensure the manufacturer or distributor
10 perform such tests on all black or galvanized (after galvanizing) bolt, nut and washer
11 assemblies before shipping. Washers are required as part of the test.
- 12 The following applies:
- 13 (a) Except as modified herein, perform the rotational-capacity test in accordance
14 with ASTM A325.
- 15 (b) Test each combination of bolt production lot, nut lot and washer lot as
16 an assembly. Where washers are not required by the installation procedures,
17 do not include in the lot identification.
- 18 (c) Assign a rotational-capacity lot number to each combination of lots tested.
- 19 (d) The minimum frequency of testing is 2 assemblies per rotational-capacity lot.
- 20 (e) Assemble the bolt, nut and washer assembly in a Skidmore-Wilhelm Calibrator
21 or an acceptable equivalent device (This requirement supersedes the current
22 ASTM A325 requirement to perform the test in a steel joint). For short bolts
23 that are too short for assembly in the Skidmore-Wilhelm Calibrator, see
24 Subarticle 1072-5(D)(4)(i).
- 25 (f) The minimum rotation, from a snug tight condition (10% of the specified proof
26 load), is: 240° (2/3 turn) for bolt lengths less than 4 diameters; 360° (1 turn) for
27 bolt lengths greater than 4 diameters and less than 8 diameters; 480° (1 1/3 turn)
28 for bolt lengths greater than 8 diameters.
- 29 (g) These values differ from the AASHTO M 164 Table 8 specifications.
- 30 (h) Achieve tension at the above rotation equal to or greater than 1.15 times the
31 required installation tension. The installation tension and the tension for the turn
32 test are shown in Table 1072-2.

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	27	39	51	56	71	85	103
Turn Test Tension, kips	14	22	32	45	59	64	82	98	118

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- 1 (i) After the required installation tension listed in Table 1072-2 is exceeded, one
2 reading of tension and torque is taken and recorded. The torque value shall
3 conform to the following equation:

$$\text{Torque} \leq 0.25(P \times D)$$

Where:

Torque = measured torque in foot-pounds
P = measured bolt tension in pounds
D = bolt diameter in feet

- 4 For bolts that are too short to test in a Skidmore-Wilhelm Calibrator, test in
5 a steel joint. The tension requirement of Subarticle 1072-5(D)(4)(h) is
6 computed using a value of **P** equal to the turn test tension shown in the
7 Table 1072-2.

8 (5) Reporting

- 9 (a) Record the results of all tests, including zinc coating thickness, required herein
10 and in the appropriate AASHTO specifications on the appropriate document.
11 (b) Report the location where tests are performed and date of tests on the
12 appropriate document.

13 (6) Witnessing

14 Witness of the test by an inspection agency is not required; however, ensure the
15 manufacturer or distributor performing the tests certifies that the recorded results are
16 accurate.

17 (7) Documentation

18 (a) Mill Test Report(s)

- 19 (i) Furnish Mill Test Report(s) for all mill steel used in the manufacture of the
20 bolts, nuts or washers.
21 (ii) Indicate in the Mill Test Report the place where the material was melted
22 and manufactured, the lot number of the material represented and the source
23 identification used by the manufacturer.

24 (b) Manufacturer Certified Test Report(s)

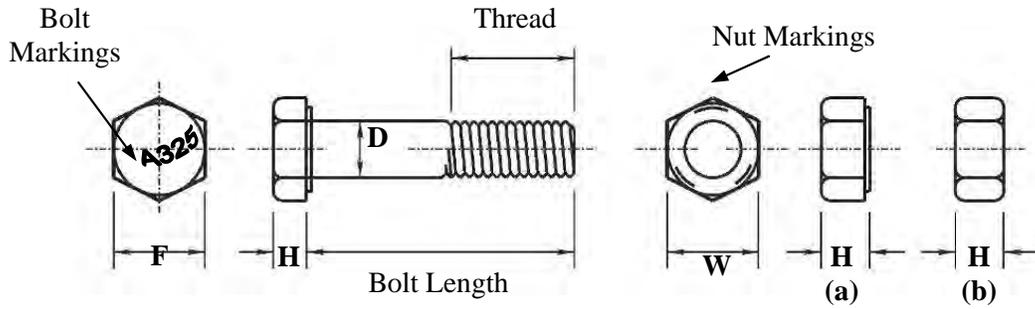
- 25 (i) Have the manufacturer of the bolts, nuts and washers furnish Manufacturer
26 Certified Test Report(s) for the item furnished.
27 (ii) Include in each Manufacturer Certified Test Report the relevant information
28 required in accordance with Subarticle 1072-5(D)(5).
29 (iii) Have the manufacturer performing the rotational-capacity test include on
30 the Manufacturer Certified Test Report:
31 A) The lot number of each of the items tested.
32 B) The rotational-capacity lot number as required in
33 Subarticle 1072-5(D)(4)(c).
34 C) The results of the tests required in Subarticle 1072-5(D)(4).
35 D) The pertinent information required in Subarticle 1072-5(D)(5)(b).
36 E) A statement that the Manufacturer Certified Test Report for the items
37 are in conformance to the *Standard Specifications* and the appropriate
38 AASHTO specifications.
39 F) The location where the bolt assembly components were manufactured.

- 1 (c) Distributor Certified Test Report(s)
- 2 (i) Ensure that the Distributor Certified Test Report(s) includes Manufacturer
- 3 Certified Test Reports above for the various bolt assembly components.
- 4 (ii) Ensure the rotational-capacity test is performed by a distributor or
- 5 a manufacturer and reported on the Distributor Certified Test Report.
- 6 (iii) Include in the Distributor Certified Test Report the results of the tests
- 7 required in Subarticle 1072-5(D)(4).
- 8 (iv) Include in the Distributor Certified Test Report the pertinent information
- 9 required in Subarticle 1072-5(D)(5)
- 10 (v) Include in the Distributor Certified Test Report the rotational-capacity lot
- 11 number as required in Subarticle 1072-5(D)(4)(c).
- 12 (vi) Ensure that the Distributor Certified Test Report certifies that the
- 13 Manufacturer Certified Test Reports are in conformance to this *Standard*
- 14 *Specifications* and the appropriate AASHTO specifications.

15 **(E) Shipping**

- 16 (1) Ship bolts, nuts and washers, where required, from each rotational-capacity lot in the
- 17 same container. If there is only one production lot number for each size of nut and
- 18 washer, shipping of the nuts and washers in separate containers is allowed.
- 19 Permanently mark each container on the side with the rotational-capacity lot number
- 20 such that identification is possible at any stage before installation.
- 21 (2) Provide the appropriate MTR and MCTR or DCTR to the contractor or owner as
- 22 required by the contract.

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- 1 **Figure 1072-1. Bolt and nut description.** Bolt and nut marking varies. Refer to
- 2 Subarticle 1072-5(B). **F** is the width across the flats of the bolt. **H** is the height of the bolt or
- 3 nut. Nuts may be washer facing as in (a) or double chamfered as in (b). **D** is the bolt
- 4 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
<i>(D)</i>	<i>(F)</i>	<i>(H)</i>	<i>(Thread)</i>	<i>(W)</i>	<i>(H)</i>
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.	2D-1/2	D+1/8	.24 ^B	.34 ^B	-	-	-

1 **A.** 3/16" nominal

2 **B.** 1/4" nominal

3 **(F) Galvanized High Strength Bolts, Nuts and Washers**

4 Use galvanized high strength bolts, nuts and washers meeting all other requirements of
5 this subarticle except as follows:

6 (1) Use Type 1 bolts.

7 (2) Quench and temper washers.

8 (3) Mechanically galvanize in accordance with ASTM B695, Class 55.

9 (4) Ship galvanized bolts and nuts in the same container.

10 (5) Use organic zinc repair paint for touch-up of galvanized surfaces meeting
11 Article 1080-9.

12 (6) Include in manufacturer's test reports results of the zinc coating thickness
13 measurements.

14 (7) Have each galvanized nut coated with a wax lubricant with a color contrast to that of
15 the zinc coating.

16 **1072-6 WELDED STUD SHEAR CONNECTORS**

17 Use Type B shear studs in accordance with the Bridge Welding Code as defined in
18 Article 1072-18.

19 Use and install welded stud shear connectors meeting Article 1072-18. Ensure that shear
20 studs and the areas of beams, girders or other structural steel to which the studs are welded are
21 free of rust, rust pits, oil, grease, moisture, paint, galvanizing, loose mill scale or other
22 deleterious matter which adversely affects the welding operation. Apply shear studs on steel
23 with tightly adhering mill scale as determined by the Engineer provided acceptable results are
24 achieved and the installed studs meet the Bridge Welding Code.

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1 1072-7 INSPECTION

2 (A) General

3 Give the Materials and Tests Unit 72 hours notice for in-state producers and 192 hours
4 notice for producers out-of-state before beginning work in the shop. Do not manufacture
5 or fabricate any material, other than stock items, before the Materials and Tests Unit is
6 notified and the final shop drawings are reviewed, accepted and returned to the fabricator.

7 The contractor/fabricator shall be responsible for and shall be required to perform all
8 quality control procedures and nondestructive testing in accordance with the Bridge
9 Welding Code as defined in Article 1072-18 and as required by the contract. Perform all
10 quality control procedures and nondestructive testing in the presence of the Department's
11 inspector unless otherwise approved by the Department's inspector. Obtain approval for
12 all quality control inspectors from the Department's inspector and ensure their
13 qualification in accordance with the Bridge Welding Code. Maintain all QC reports as
14 required by the Bridge Welding Code, including, but not limited to, visual and
15 nondestructive testing reports and all phases of coating application inspection. Provide
16 copies of all QC reports, including all radiographic films, to the Department inspector
17 upon request. These copies become the property of the Department. No separate
18 payment is made for this inspection and testing. The entire cost of this work is included
19 in the unit contract price for the structural steel items involved.

20 Furnish facilities for the inspection of material and work in the mill and shop, and allow
21 the inspectors free access to the necessary parts of the mill or shop. Do not ship any
22 member or component of the structural steel from the shop to the job site before approval
23 by the Department's inspector. Such approval is stamped on the member or appropriate
24 container by the Department's inspector.

25 Furnish the Engineer with as many copies of mill orders and shipping statements as
26 directed. The acceptance of any material or finished member by the Department's
27 inspector is not a bar to their subsequent rejection, if found defective. Replace rejected
28 material and correct rejected work promptly and satisfactorily.

29 (B) Shop and Mill Inspection

30 Shop inspection is performed on all structural steel used on any project. Mill inspection
31 of structural steel is performed when so noted in the plans or in the Specifications.
32 Furnish complete certified mill test reports for all structural steel used except
33 a Type 6 material certification in accordance with Article 106-3 as to the grade of steel
34 used is acceptable for small amounts of structural steel items which are furnished from
35 the supplier's stock and which are difficult to identify on any mill test report.

36 Show in the supplier's certification the items fabricated from stock material and the
37 pounds of steel required for each item. A supplier's certification represents only anchor
38 bolts, pipe sleeves, masonry plates, sole plates, diaphragm tees, connector plates and web
39 stiffener plates. Represent all other items required for a structure by certified mill test
40 reports as specified above.

41 Indicate in the complete certified mill test reports the pounds of steel and the item or
42 items they represent and show heat number of steel, mechanical tests, chemical analyses,
43 Department's project number, station number, the ASTM or AASHTO specification to
44 which the material conforms and a signed statement certifying where the steel was melted
45 and manufactured.

46 Forward to the Materials and Tests Unit a letter which states by station the items and
47 pounds of steel that are represented by a supplier's certification and those represented by
48 the certified mill test reports identifying the beam and/or plate material for each main
49 member.

1 The Department reserves the right to select any item for test. Bear any expense of
2 obtaining the sample. The tests are performed at the Department's expense.

3 **(C) Sampling Structural Steel**

4 Furnish samples of structural steel at the beginning of fabrication when random sampling
5 is required.

6 Furnish one 2 1/2" x 24" sample for each grade of steel used on a project per
7 1,000,000 lb. No more than 2 are required per project.

8 Take all samples at the location and in the manner directed by an authorized
9 representative of the Engineer. Furnish the necessary personnel and equipment for
10 obtaining samples and be responsible for providing a smooth finish to the areas from
11 which the samples are taken.

12 **(D) Charpy V-Notch Tests**

13 Furnish all structural steel for girders, beams and diaphragm components connecting
14 horizontally curved members meeting the longitudinal Charpy V-Notch Tests specified in
15 the supplementary requirements in AASHTO M 270 for Zone 1. Unless otherwise noted
16 in the plans, mark and test the materials as non-fracture critical. Sample and test in
17 accordance with AASHTO T 243 and use the (H) frequency of heat testing. Use the
18 grade or grades of structural steel required in the plans. Obtain and submit certified mill
19 test reports to the Materials and Tests Unit to show the results of each test required by the
20 *Standard Specifications*.

21 **1072-8 WORKING DRAWINGS**

22 Submit prints of checked structural steel shop drawings and changes thereto, including
23 shipping diagrams for review, comments, acceptance and distribution as follows:

24 **(A)** Submit 2 sets for review, comments and acceptance on all steel structures. After review,
25 comments and acceptance, submit 7 sets for distribution.

26 **(B)** Submit 5 sets for review, comments and acceptance for all bridges carrying railroad
27 traffic, and after acceptance, submit 9 sets for distribution.

28 **(C)** Furnish any additional sets requested by the Engineer or for his use, review, comments,
29 acceptance and/or distribution.

30 Shop drawings are not checked by the Engineer except to ascertain general compliance with
31 the design and the *Standard Specifications*. Thoroughly check all shop drawings in all
32 respects. Review, comments and acceptance of shop drawings by the Engineer is not
33 considered as relieving the Contractor of his responsibility for the accuracy of his drawings,
34 or for the fit of all shop and field connections and anchors.

35 The maximum size of prints for shop drawings is 22" x 36", including borders which are at
36 least 1" at the left edge of the sheet. Provide shop drawings on any medium provided they are
37 legible and are reproducible. Upon completion of the project, furnish to the Engineer one
38 complete set of reproducible shop drawings that represent the as-built condition of the
39 structural steel including all approved changes if any. Supply drawings that are 22" x 36".
40 These drawings will become the property of the Department.

41 Changes on shop drawings after acceptance or distribution are subject to the approval of the
42 Engineer. Furnish a record of such changes.

43 Make substitution of sections different from those on the structure plans only when approved
44 in writing.

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1 1072-9 HANDLING AND STORING MATERIALS

- 2 Load, transport, unload and store structural material so the metal is kept clean and free from
3 damage. Repair any coating damage. Do not use chains, cables or hooks that damage or scar
4 the material. Repair all materials which are scarred or damaged and inspect at the fabricators
5 expense as deemed necessary by the Engineer.
- 6 Use lifting equipment and rigging equipment with adequate capacity to handle the material at
7 all times. Do not bend, twist, damage or excessively stress any materials. Do not perform
8 hammering which injures or distorts the members. Operate and maintain all lifting equipment
9 in a safe manner and in accordance with the manufacturer's directions.
- 10 When lifting main structural steel members, use spreader bars. Do not use one point pick-ups
11 on members over 50 ft in length. Use 2 point pick-ups so the amount of overhang and the
12 distance between hooks does not exceed the distances as noted in Table 1072-5.

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

- 13 Store structural material, either plain or fabricated, above the ground upon platforms, skids or
14 other supports. Keep free from dirt, grease, vegetation and other foreign matter, and protect
15 as far as practicable from corrosion.
- 16 Keep material clean and properly drained. Transport and store girders and beams with the
17 web in the vertical plane and the top flange up. Request permission in writing and await
18 approval to invert haunched girders and beams for transport for safety reasons. Use extreme
19 care in turn-over operations to prevent excessive bending stresses in the edge of flanges.
20 Support long members on blocking placed near enough together to prevent damage from
21 deflection.
- 22 Do not use any beam, girder, diaphragm, cross frame or other material, in any stage of
23 fabrication that will be permanently incorporated into the finished structure as a workbench,
24 lifting device, dunnage or for any purpose for which it was not specifically intended.

25 1072-10 STRAIGHTNESS, CAMBER AND DIMENSIONAL TOLERANCES

26 (A) General

- 27 Ensure that rolled material, before being laid out or fabricated, is straight.
28 If straightening is necessary, use methods that do not damage the metal. Kinks or sharp
29 bends are cause for rejection of the material.
- 30 Ensure that heat straightened or heat cambered parts are substantially free from external
31 forces, except those resulting from mechanical means used in conjunction with the
32 application of heat.
- 33 After heating, allow the metal to cool, without artificial cooling, down to 600°F. Below
34 600°F, only dry compressed air is permitted to artificially cool steels having minimum
35 yield strength greater than 36,000 psi as indicated by a Type 1 material certification in
36 accordance with Article 106-3.

37 (B) Straightening

- 38 Straighten distorted members and bent material by mechanical means or, if approved, by
39 the carefully planned and supervised application of a limited amount of localized heat.
40 Do not allow the temperature of the heated area to exceed 1,200°F as controlled by
41 temperature indicating crayons or other approved methods.

1 Following the straightening of a bend or buckle, free the surface of the metal from
 2 evidence of fracture as indicated by visual inspection or, if directed, by appropriate
 3 nondestructive testing.

4 Shop straighten the bottom flanges of steel beams or girders at bearings as necessary to
 5 provide uniform contact between the flanges and the bearings.

6 **(C) Camber**

7 Show the required camber on the drawings.

8 Make adequate provision in the fabrication of structural members to compensate for
 9 change of camber due to welding of the shear connectors and other fabrication work.

10 Fabricate camber into the members on built-up plate girders and trusses. Where camber
 11 is required on rolled sections, induce it by heat cambering, except that for rolled sections
 12 within the depth, length and camber ordinate range shown in Table 1072-6, induce
 13 camber by cold cambering or "gagging" at the mill or in the shop provided approval
 14 procedures for cold cambering are employed.

15 Attach cover plates on rolled sections after cambering.

16 Where reverse curvature is required in a single rolled shape, induce it by heat cambering.

17 Show camber diagrams showing the required offset at each tenth point of the span and at
 18 any web splice or field splice location and blocking diagrams on the shop drawings.
 19 Show additional points if desired by the fabricator. Ensure that the beams, girders or
 20 other members with field splices meet all of the blocking ordinates without inducing
 21 stress into the members.

22 Following cambering or camber correction, correct evidence of fracture indicated by
 23 visual inspection or, if directed, by appropriate nondestructive testing.

24 Show camber and blocking diagrams on the shop drawings. Shop assemble continuous
 25 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

26 **(D) Heat Cambering of Rolled Beams and Welded Plate Girders**

27 (1) General

28 Where heat cambering is used, only V-type heating is permitted. Perform V-type
 29 heating by the carefully planned and supervised application of a limited amount of
 30 localized heat.

31 When minor corrections in camber are required, use small localized heats limited to
 32 the flange material. Perform major corrections in camber by V-type heating to
 33 prevent web distortion.

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1 Begin heating at the apex of the heating pattern and progress slowly towards the base
2 of the pattern as each area is brought up to temperature as stated in
3 Subarticle 1072-10(D)(5). Do not progress the heating torches toward the base of
4 the heating pattern until the apex of the pattern is brought up to the specified
5 temperature. Do not return the heating torch toward the apex of the heating triangle
6 after heating has progressed towards the base. Continue heating to successive areas
7 until the base of the triangular heating pattern is brought up to the required
8 temperature across the full width of the flange.

9 (2) Heat Cambering of Rolled Beams

10 Heat cambering of rolled beams is allowed to provide the required vertical curvature.
11 Space triangular heating patterns throughout the length of the member to provide the
12 required curvature. Locate the apex of the heating triangle at a point not less
13 than 75% of the depth of the member measured from the flange that is concave after
14 cambering. Limit the total included angle of the heating pattern to 20°.

15 Weld all detail material such as connection plates, bearing stiffeners and gusset
16 plates attached to the member to the rolled beam after the beam is cambered as
17 required.

18 (3) Heat Cambering of Welded Plate Girders

19 Heat cambering of welded plate girders is only permitted when approved in writing
20 as a necessary repair procedure for plate girders rejected for camber deviation.

21 When it is necessary to correct camber deviation in welded plate girders, heating is
22 permitted in V-type heating patterns centered on intermediate stiffeners and
23 connection plates. Where necessary, add stiffeners for this purpose if approved.
24 Locate the apex of the heating pattern not less than 3/4 of the depth of the member
25 from the flange that is shortened after cooling. The maximum included angle of the
26 heating pattern is 10°. The maximum width of the base of the heating pattern is 10".
27 Where shallow members or thin webs prescribe heating patterns with a width
28 substantially less than 10" at the junction of the web to flange, extend the heating
29 pattern in the flange at that location beyond the limits of the heating pattern in the
30 web by no more than 1" provided the total width of pattern in the flange does not
31 exceed the 10" limit stated above.

32 (4) Support of Members for Heat Cambering

33 Heat camber members with the web vertical and supports spaced to take the
34 maximum advantage of dead load in the member before applying heat. Ensure all
35 supports are approved by the Department's inspector before beginning work.

36 Do not place any combination of support system or external load on the member that
37 causes a compressive stress in the flange to exceed 20,000 psi before heating for
38 AASHTO M 270 Grades 36, 50 and 50W steels.

39 (5) Heating Process and Equipment

40 Heat using large, approximately 1" diameter, multi-orifice (rosebud) heating torches
41 operating on approximately 25 psi thermal gas and 125 psi oxygen.

42 The torches and tips used are subject to approval. Choose torches and tips that
43 promote heating efficiency and prevent unnecessary distortion.

44 Confine heating to the patterns described herein and conduct to bring the steel within
45 the planned pattern to a temperature between 1,100°F and 1,200°F as rapidly as
46 possible without overheating the steel.

1 Any heating procedure which causes a portion of the steel to exceed a temperature
2 greater than 1,200°F is destructive heating and is automatically cause for rejection of
3 the steel. Steel rejected for destructive heating is investigated for re-acceptance,
4 repair or replacement if allowed by the Engineer. Bear the cost of such tests and any
5 necessary repair or replacement.

6 (6) Heat Measurement

7 Specified temperatures are checked using portable digital pyrometers.

8 **(E) Heat Curving Girders**

9 (1) Type of Heating

10 With approval, use continuous or V-type heating methods to curve girders. For the
11 continuous method, simultaneously heat a strip along the edge of the top and bottom
12 flanges that is of sufficient width and temperature to obtain the required curvature.
13 For V-type heating, heat the top and bottom flanges simultaneously in truncated
14 triangular or wedge-shaped areas. Position the areas with their base along the flange
15 edge and spaced at regular intervals along each flange. Set the spacing and
16 temperatures to approximate the required curvature by a series of short chords. Heat
17 along the top and bottom flanges at approximately the same rate.

18 For V-type heating, terminate the apex of the truncated triangular area applied to the
19 inside flange surface just before the juncture of the web and flange. To avoid web
20 distortion, make certain that heat is not applied directly to the web when heating the
21 inside flange surfaces (the surfaces that intersect the web). Extend the apex of the
22 truncated triangular heating pattern applied to the outside flange surface to the
23 juncture of the flange and web. Use an included angle of approximately 15° to 30°
24 in the truncated triangular pattern, but do not allow the base of the triangle to
25 exceed 10". Vary the patterns prescribed above only with the Engineer's approval.

26 For both types of heating, heat the flange edges that will be on the inside of the
27 horizontal curve after cooling. Concurrently heat both inside and outside flange
28 surfaces for flange thicknesses of 1.25" and greater. Adhere to the temperature
29 requirements presented below.

30 (2) Temperature

31 Conduct the heat curving operation so the temperature of the steel never exceeds
32 1,150°F as measured by temperature indicating crayons or other suitable means. Do
33 not artificially cool the girder until it naturally cools to 600°F. Below 600°F, use dry
34 compressed air to artificially cool the girder.

35 (3) Position for Heating

36 Heat-curving the girder with the web in either a vertical or horizontal position is
37 permitted. When curved in the vertical position, brace or support the girder so the
38 tendency of the girder to deflect laterally during the heat-curving process does not
39 cause the girder to overturn.

40 When curved in the horizontal position, support the girder near its ends and at
41 intermediate points, if required, to obtain a uniform curvature. Do not allow the
42 bending stress in the flanges to exceed 27,000 psi. To prevent a sudden sag due to
43 plastic flange buckling when the girder is positioned horizontally for heating, place
44 intermediate safety catch blocks at the midlength of the girder within 2" of the
45 flanges at all times during the heating process.

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1 (4) Sequence of Operations

2 Conduct the heat-curving operation either before or after completing all the required
3 welding of transverse intermediate stiffeners to the web. However, unless provisions
4 are made for shrinkage, position and attach connection plates and bearing stiffeners
5 after heat-curving. In any event, weld the stiffeners, connection plates, and bearing
6 stiffeners to the girder flanges after the member is curved. If longitudinal stiffeners
7 are required, heat-curve or oxygen-cut these stiffeners separately before welding to
8 the curved girder.

9 (5) Camber and Curvature

10 Camber the girders before heat-curving. Cut the web to the prescribed camber
11 allowing for shrinkage due to cutting welding and heat-curving. If approved,
12 a carefully supervised application of heat is permitted to correct moderate deviations
13 from the specified camber.

14 Horizontal curvature and vertical camber is measured for final acceptance after all
15 welding and heating operations are complete and the flanges have cooled to
16 a uniform temperature. Horizontal curvature is checked with the web in the vertical
17 position by measuring offsets from a string line or wire attached to both flanges or by
18 using other suitable means. Camber is checked with the web in the horizontal
19 position. Camber the girder so it meets the horizontal and vertical curvature
20 ordinates without inducing stress into the girders by mechanical force.

21 Compensate for loss of camber in the heat-curved girders as residual stresses
22 dissipate during service life of the structure. Compute this anticipated loss of camber
23 in accordance with the *AASHTO LRFD Bridge Design Specifications*.

24 (6) Procedure Specification and Shop Drawings

25 Submit structural steel shop drawings, including a detailed written procedure
26 specification for heat curving the girders, supplemented by calculations and sketches,
27 for review, comments and acceptance. On the shop drawings, indicate the type,
28 location and spacing of heat sectors, if used, supports and catch blocking for each
29 field section of girders. Include suitable blocking diagrams for measuring horizontal
30 curvature similar to those usually prepared for camber and vertical curvature.

31 (F) Camber Measurement

32 At the time of acceptance at the shop and after erection, ensure that all stringers and
33 girders for bridges meet the required camber values within the tolerances specified in
34 Subarticle 1072-10(G). Follow the procedure for measuring camber as outlined below:

35 (1) Assemble the member at the shop as specified in Article 1072-19 and measure with
36 the member lying on its side.

37 (2) Camber repairs are only allowed when approved by the Engineer. Camber deviation
38 is judged irreparable if corrective measures in the shop produce web buckling in
39 excess of the specified tolerance, in which case the member is rejected.

40 (3) The final camber measurement is made by the Engineer in the field after erection.
41 At the time of this measurement, ensure that the members have all of the specified
42 camber less the dead load deflection of the steel as specified in
43 Subarticle 1072-10(G).

44 (G) Dimensional Tolerances

45 Ensure that dimensions of all material covered by Section 1072 conform to ASTM A6
46 when received at the fabrication shop. Fabricate member dimensions conforming to this
47 subarticle whether designated to be straight, cambered or curved and regardless of
48 whether curvature is heat-induced (when so permitted). Dimensional tolerances not listed

1 in this subarticle shall be as specified by the Bridge Welding Code as defined in
 2 Article 1072-18 and applied to rolled shapes where applicable as well as to welded
 3 members.

4 Place welded butt joints no further than 1/2" from the point detailed. Intermediate
 5 stiffeners varying $\pm 1/2"$ from the point detailed are allowed. Connector plates for field
 6 connections varying $\pm 1/8"$ from the point detailed are allowed. Ensure that the actual
 7 centerline of bearing lies within the thickness of the bearing stiffener.

8 Members with end milled for bearing and members with faced end connection angles
 9 deviating from the detailed length by $-0, +1/32"$ are acceptable. All other members
 10 varying from detailed length by $\pm 1/8"$ are acceptable.

11 Align to within $\pm 1/8"$ from the location shown on the approved shop drawings all steel
 12 requiring shop assembly for reaming, drilling from the solid or weld joint preparation.

13 Deviation from specified camber of fabricated members before shipment from the
 14 fabrication shop is limited to:

15 -0;

16 $\frac{+3/32" \times \text{No. of ft from nearest bearing}}{10}$, up to 3/4" maximum.
 17

18 Deviation from specified camber of erected steel bridge superstructures measured when
 19 the steel work is complete and the superstructure is subject to steel dead load stresses only
 20 is limited to:

21 -0;

22 $\frac{+1/8" \times \text{No. of ft from nearest bearing}}{10}$, up to 1" maximum.
 23

24 If the plans do not require shop induced camber, provide an actual member that is straight
 25 or one of the following:

26 (1) If natural camber "turned up" is required, the maximum plus camber is the algebraic
 27 sum of the allowable deviation, dead load deflection, vertical curve ordinate and
 28 superelevation ordinate;

29 (2) If natural camber "turned down" is required, the maximum negative camber is equal
 30 to the algebraic sum of the dead load deflection, vertical curve ordinate and
 31 superelevation ordinate.

32 Do not exceed 1/8" per 10 ft length for the actual deviation from curvature shown in the
 33 plans.

34 **1072-11 OXYGEN CUTTING**

35 Oxygen cutting of structural steel is allowed, provided a smooth surface free from cracks and
 36 notches is secured and an accurate profile is secured by the use of a mechanical guide. Hand
 37 cut only where approved and grind smooth leaving no burnt edges.

38 In all oxygen cutting, adjust and manipulate the cutting agent to avoid cutting beyond (inside)
 39 the prescribed lines. Provide oxygen cut surfaces meeting the ANSI surface roughness rating
 40 value of 1,000 except ensure that oxygen cut surfaces of members not subject to calculated
 41 stress meet the surface roughness value of 2,000. Round corners of oxygen cut surfaces of
 42 members carrying calculated stress to a 1/16" radius, or an equivalent flat surface at a suitable
 43 angle, by grinding after oxygen cutting.

44 Fillet re-entrant cuts to a radius of not less than 1".

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1 Remove surface roughness exceeding the above values and occasional notches, gouges and
2 cracks not more than 1/16" deep on otherwise satisfactory oxygen cut surfaces by chipping or
3 grinding. Flair corrections of the defects with the surface of the cut on a bevel of one to 6 or
4 flatter.

5 Repair occasional gouges of oxygen cut edges more than 3/16" deep, but not more than
6 7/16" deep, by welding with low hydrogen electrodes not exceeding 5/32" in diameter and
7 with a minimum preheat of 250°F. Grind the completed weld smooth and flush with the
8 adjacent surface. Radiographically test any gouge over 1/8" deep after the repair.

9 **1072-12 EDGE PLANING**

10 Plane sheared edges of plates more than 5/8" in thickness that carry calculated stress to
11 a depth of 1/4". Fillet re-entrant cuts before cutting. Round all edges of plates and shapes
12 parallel to calculated stress and all free edges of plates and shapes intended for coating or
13 galvanizing to 1/16" radius or provide an equivalent flat surface at a suitable angle. Grind
14 edges of all other plates and shapes to remove burrs, slag or shear lip. The ends of all steel
15 piles, intended for coating or galvanizing, are not required to be radiused, but remove all
16 burrs, slag and shear lip.

17 **1072-13 FACING OR BEARING SURFACES**

18 Provide a surface finish of bearing and base plates and other bearing surfaces that come in
19 contact with each other or with concrete that meet Table 1072-7 following ANSI surface
20 roughness requirements as defined in ANSI B46.1.

Item	ANSI Surface Roughness
Steel slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

21 **1072-14 ABUTTING JOINTS**

22 Face and bring to an even bearing abutting joints in compression members, girder flanges and
23 tension members where so indicated on the drawings. Where joints are not faced, do not
24 exceed an opening of 1/4".

25 **1072-15 BENT PLATES**

26 Provide cold-bent, load carrying rolled-steel plates conforming to the following:

27 **(A)** Take from the stock plates so the bendline is at right angles to the direction of rolling.

28 **(B)** Use a radius of bends such that no cracking of the plate occurs. Use minimum bend radii,
29 measured to the concave face of the metal, as shown in Table 1072-8.

30 If a shorter radius is essential, bend the plates hot at a temperature not greater than
31 1,200°F and air cool slowly down to a temperature of 600°F. Below 600°F, use only dry
32 compressed air to artificially cool steels having a minimum yield strength greater than
33 36,000 psi. Use hot bent plates conforming to Subarticle 1072-15(A) above.

34 **(C)** Before bending, round the corners of the plates to a radius of 1/16" throughout the
35 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"	2t
Over 1/2" to 1"	2 1/2t
Over 1" to 1 1/2"	3t
Over 1 1/2" to 2 1/2"	3 1/2t
Over 2 1/2" to 4"	4t

1 Hot bend low alloy steel in thicknesses over 1/2" for small radii, if required.

2 **1072-16 HOLES FOR BOLTS AND OTHER FASTENERS**

3 **(A) General**

4 Punch or drill all holes and remove any burrs. Punching material forming parts of
5 a member composed of not more than 5 thickness of metal 1/16" larger than the nominal
6 diameter of the fastener is allowed whenever the thickness of the material is not greater
7 than 3/4" for structural steel, 5/8" for high-strength steel or 1/2" for quenched and
8 tempered alloy steel, unless subpunching and reaming is required by
9 Subarticle 1072-16(D).

10 When there are more than 5 thicknesses or when any of the main material is thicker than
11 3/4" for structural steel, 5/8" for high-strength steel or 1/2" for quenched and tempered
12 alloy steel, either subdrill and ream or drill all holes full size.

13 When required by Subarticle 1072-16(D), subpunch or subdrill all holes (subdrill if
14 thickness limitation governs) 1/4" smaller and, after assembling, ream 1/16" larger or
15 drill full size to 1/16" larger than the nominal diameter of the fastener.

16 **(B) Punched Holes**

17 Do not use a diameter of the die exceeding the diameter of the punch by more than 1/16".
18 If any holes require enlargement to admit the fasteners, ream such holes. Clean cut holes
19 without torn or ragged edges. Poor matching of holes is cause for rejection. Grind all
20 burrs smooth.

21 **(C) Reamed or Drilled Holes**

22 Make reamed or drilled holes cylindrical and perpendicular to the member complying
23 with the size requirements of Subarticle 1072-16(A). Where practicable, direct reamers
24 by mechanical means. Grind all burrs smooth. Poor matching of holes is cause for
25 rejection. Ream and drill with twist drills. If required, take assembled parts apart for
26 removal of burrs caused by drilling. Assemble connecting parts requiring reamed or
27 drilled holes, securely hold while reaming or drilling and match mark before
28 disassembling.

29 **(D) Subpunching and Reaming of Field Connections**

30 Subpunch or subdrill, if required according to Subarticle 1072-16(A), holes in all field
31 connections and field splices of main members of trusses, arches, continuous beam spans,
32 bents, towers (each face), plate girders, and rigid frames. Subsequently ream while
33 assembled as required by Article 1072-19. Subpunch and ream to a steel template or
34 ream while assembled all holes for floor beam and stringer field end connections. Ream
35 or drill full size field connection holes through a steel template after the template is
36 located with utmost care as to position and angle and firmly bolted in place. Use
37 templates for reaming matching members, or the opposite faces of a single member that
38 are exact duplicates. Accurately locate templates used for connections on like parts of
39 members such that the parts or members are duplicates and require no match-marking.

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1 (E) Accuracy of Punched and Subdrilled Holes

2 Accurately punch or subdrill all holes punched full size, subpunched or subdrilled such
3 that after assembling, and before any reaming is done, a cylindrical pin 1/8" smaller in
4 diameter than the nominal size of the hole enters perpendicular to the face of the member,
5 without drifting, in at least 75% of the contiguous holes in the same plane. If the
6 requirement is not fulfilled, the badly punched pieces are rejected. If any hole does not
7 pass a pin 3/16" smaller in diameter than the nominal size of the hole, this is cause for
8 rejection.

9 (F) Accuracy of Reamed and Drilled Holes

10 When holes are reamed or drilled, ensure that 85% of the holes in any contiguous group,
11 after reaming or drilling, show no offset greater than 1/32" between adjacent thicknesses
12 of metal.

13 Use all steel templates with hardened steel bushings in holes accurately dimensioned
14 from the centerlines of the connection as inscribed on the template. Use the centerlines in
15 locating accurately by the template from the milled or scribed ends of the members.

16 (G) Alternate Methods

17 As an option, make the fastener holes by procedures other than those described in
18 Subarticles 1072-16(A) through 1072-16(F) provided that the requirements for quality
19 and for dimensional accuracy are met. Wherever an alternate method is employed,
20 demonstrate the ability of each alternate method to produce holes and connections
21 consistently meeting all requirements for quality and dimensional accuracy for the type of
22 joint fabricated. When such ability of an alternate method is previously demonstrated on
23 similar work for the Department, continue its use by certifying, on each subsequent
24 project, that the procedure and equipment are the same as the method previously
25 qualified, and that the equipment involved is in good repair and adjustment. Failure of
26 joints to meet the quality and accuracy requirements is cause for rejection. In the case of
27 repeated failures revise and/or requalify the method or discontinue its use.

28 At the time of qualification of an alternate method, submit for approval a written
29 procedure specification describing the procedures and equipment and giving upper and
30 lower value limits and tolerances for all pertinent variables. Accurately reflect the actual
31 procedures, equipment and values used in the qualification tests. In addition to the
32 certification on each subsequent project, the Engineer may request copies of the approved
33 procedure specification.

34 (H) Oversize, Short-Slotted, and Long-Slotted Holes

35 Where shown in the plans or permitted in writing, use oversize, short-slotted and long-
36 slotted holes with high strength bolts 5/8" and larger in diameter. Do not allow the
37 distance between edges of adjacent holes or edges of holes and edges of members to be
38 less than permitted under the AASHTO specification. Oversize, short-slotted and long-
39 slotted holes are defined as follows:

40 (1) Oversize holes are 3/16" larger than bolts 7/8" and less in diameter, 1/4" larger than
41 bolts 1" in diameter, and 5/16" larger than bolts 1 1/8" and greater in diameter.
42 When oversized holes are permitted, they are allowed in any or all plies of friction
43 type connections. Install hardened washers over exposed oversize holes.

44 (2) Short-slotted holes are 1/16" wider than the bolt diameter and have a length that does
45 not exceed the oversize diameter requirements of Subarticle 1072-16(H)(1) by more
46 than 1/16". When short-slotted holes are permitted, they are allowed in any or all
47 plies of friction-type or bearing-type connection. Locate holes without regard to
48 direction of loading in friction-type connections, but orient normal to the direction of
49 the load in bearing-type connections. Install hardened washers over exposed short-
50 slotted holes.

1 (3) Long-slotted holes are 1/16" wider than the bolt diameter and have a length more
2 than allowed in Sub-paragraph 2 but not more than 2 1/2 times the bolt diameter.
3 Structural plate washers or a continuous bar not less than 5/16" in thickness are
4 required to cover long slots that are the outer plies of joints. Ensure that these
5 washers have a size sufficient to completely cover the slot after installation. When
6 long-slotted holes are permitted, they are allowed in only one of the connected parts
7 of either a friction-type or bearing-type connection at an individual faying surface.

8 When used in friction-type connections, locate holes without regard to direction of
9 loading if one-third more bolts are provided than needed to satisfy the allowable unit
10 stresses except as herein restricted.

11 When used in bearing-type connections, orient the long diameter of the slot normal to the
12 direction of loading. No increase in the number of bolts over those necessary for the
13 allowable unit stress is required.

14 (I) Misfits

15 When misfits occur for any reason, enlargement of the holes by reaming is limited to
16 1/16" over the nominal size hole called for unless otherwise permitted in writing.

17 (J) Erection Bolt Holes

18 At field welded connections where erection bolts are used, provide holes 3/16" larger
19 than the nominal erection bolt diameter.

20 1072-17 INSTALLING BOLTS

21 Install high strength bolts in accordance with Article 440-8.

22 1072-18 WELDING

23 (A) Definition

24 The Bridge Welding Code referred to herein is the edition of the
25 ANSI/AWS/AASHTO Bridge Welding Code D 1.5 and any applicable interim that is
26 current on the date of advertisement for the project, and as modified by the *Standard*
27 *Specifications*.

28 (B) General

29 Commercially blast clean all steel used in girders, beams and connecting members to
30 SSPC-SP 6 before welding.

31 Weld all steel in the shop or in the field for bridges, whether permanent or temporary, and
32 perform all other work related to welding including, but not limited to, testing and
33 inspection of welds, preparation of material, oxygen cutting, electrodes, shielding and
34 shear studs, meeting the Bridge Welding Code. Weld other steel items in accordance
35 with AWS Welding Code.

36 Weld only where shown in the plans or where called for in the *Standard Specifications*
37 unless requesting and receiving written approval for additional welding.

38 Show all permanent and all temporary welds on the shop drawings. For groove welds,
39 indicate on the shop drawings the particular detail and process to be employed in
40 production of the work. For prequalified joints, use of the Bridge Welding Code letter
41 classification designation of the joint (B-L2b-S etc.) along with the appropriate symbol
42 satisfies this requirement. Tack welds that become part of a permanent weld are not
43 required on the shop drawings.

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1 Provide fillet welds, including seal welds, at least the minimum size allowed by the
2 Bridge Welding Code for the thickness of material welded or the size called for in the
3 plans, whichever is larger. For exposed, bare, unpainted applications of steel, the basic
4 requirements for weld filler metal with atmospheric corrosion resistance and coloring
5 characteristics similar to that of the base metal are mandatory. The variations from these
6 basic requirements listed in the Bridge Welding Code for single pass welds are not
7 permitted.

8 Use only Department approved electrodes for welding. The Department maintains a list
9 of approved brands of electrodes for which satisfactory reports of tests made within one
10 year are previously submitted. This list is available from the State Materials Engineer.
11 Designate an appropriate storage area for all welding consumables in accordance with the
12 Bridge Welding Code.

13 (C) Qualification of Personnel

14 Ensure that each welder, welding operator and tacker is qualified in accordance with the
15 Bridge Welding Code or other applicable AWS Welding Code as determined by the
16 Engineer. Employ welders that are qualified by the Department. Welders shall be
17 requalified by the Department every 5 years. Contact the Materials and Tests Unit to
18 schedule qualification tests. Permanent in-shop welders employed by a fabricator who
19 passed the appropriate welding tests and whose weldments are radiographically tested
20 with regularly acceptable results are exempt from additional testing when approved by
21 the Engineer. Ensure a representative of the testing agency witness all phases of the
22 qualification tests including preparation of the test plates and placing of welds. As
23 evidence of such qualification, furnish a satisfactory certificate, or a copy thereof, issued
24 by a testing agency which is approved by the Engineer, for each welder, welder operator
25 and tacker employed on the work. Submit certification for each welder, welding operator
26 or tacker, and for each project, stating the name and Social Security number of the
27 welder, welding operator or tacker; the name and title of the person who conducted the
28 examination; the kind of specimens; the position of welds; the AWS electrode
29 classification used; the results of the tests; and the date of the examination. Such
30 certifications are required for all persons performing shop or field welds of any kind on
31 the work, whether permanent or temporary. Ensure each welder provides a picture ID
32 upon request or other form of positive identification as required by the Engineer.

33 (D) Qualification of Welds and Procedures

34 Use welds, except as otherwise provided below, that are prequalified in accordance with
35 the details, limitations and procedures prescribed by the Bridge Welding Code or other
36 AWS Welding Code as determined by the Engineer. Substitute other such prequalified
37 welds for those shown in the plans, subject to the approval of the Engineer.

38 For all prequalified field welds, submit Welding Procedure Specifications (WPS) for each
39 joint configuration for approval at least 30 days before performing any welding. Instead
40 of this, use the WPS provided and preapproved by the Department. These preapproved
41 WPS are available from the Materials and Tests Unit. Use non-prequalified welds only if
42 approved by the Engineer. Submit WPS for all non-prequalified welds to the Engineer
43 for approval. At no cost to the Department, demonstrate their adequacy in accordance
44 with the Bridge Welding Code.

45 Include in procedure specifications, upper and lower value limits of all variables listed for
46 procedure qualification in the Bridge Welding Code for the process or processes used.
47 Written welding procedure specifications are required for prequalified welds also.

48 On all welding, include in the welding procedure continuous visual inspection by
49 welders, welding operator, tackers, welding supervisors and all personnel involved in
50 preparation of the material for welding.

1 Approval by the Engineer of the procedure specifications does not relieve the Contractor
2 of his responsibility to develop a welding procedure that produces weldments meeting the
3 required quality and dimensions.

4 If non-prequalified joints procedures are previously found acceptable to the Engineer on
5 another project, furnish the inspector with a copy of the joint details and procedure
6 specification approved at the time of qualification. Such documentation is required from
7 each fabricator employing a non-prequalified joint or procedure on the work. Failure to
8 produce such documentation results in the fabricator being required to requalify the joint
9 or procedure or to use prequalified joints, procedures, and procedure specifications.

10 On weldments where geometric shape prevents compliance with requirements to weld
11 a particular position, alternate procedures are considered for approval. Previously
12 qualified alternate procedures are considered for approval without further procedure
13 qualification tests. No separate payment is made for developing, demonstrating and
14 documenting for future use such alternate procedures, as such work is incidental to the
15 work of welding.

16 **(E) Requirements for Testing and Inspection**

17 Require the fabricator to make provisions for convenient access to the work for
18 inspection and cooperate with the inspector during the required inspection and testing.

19 Inspect welds in the presence of the Department's inspector unless otherwise approved by
20 the Department's inspector, using visual inspection and the nondestructive tests herein
21 prescribed in addition to the test requirements of the Bridge Welding Code and the
22 contract. Employ quality control inspectors and NDT technicians qualified in accordance
23 with the Bridge Welding Code and preapproved by the Engineer before the start of any
24 fabrication. Supply the appropriate certifications as required by the Bridge Welding
25 Code to the Department's inspector for all inspectors. Individuals assigned to production
26 welding activities or processes and their supervisors are not acceptable for performing
27 quality control testing. Ensure a qualified welding inspector presents any time welding is
28 in progress. No separate payment is made for inspection and testing. The entire cost of
29 this work is included in the unit contract price for the structural steel items involved.

30 Retest welds requiring repairs or replacement in the presence of the Department's
31 inspector after the repairs or replacements are made.

32 If the Engineer finds that acceptable repair to defective work is not feasible; the entire
33 piece is rejected.

34 Payment at the contract prices for the various items in the contract which include the
35 work of welding is full compensation for all costs resulting from the required
36 nondestructive testing of welds and from the required inspection of welds.

37 **(F) Nondestructive Test Required**

38 The extent of nondestructive testing required is as prescribed in the Bridge Welding Code
39 and by the contract except radiograph all flange splices for their full length. The term
40 "main members" in this regard means girders, beams, floor beams, stringers, truss
41 members, high strength bolts, columns, bearing stiffeners, bearing shoes, high mount
42 lighting standards and components of main member carrying stress, including the end
43 connections for such members. Nondestructive testing of other complete welds or weld
44 passes is required when so noted in the plans or deemed necessary by the Engineer. Tests
45 other than those prescribed are also required when deemed necessary by the Engineer.
46 Perform all radiographic testing in accordance with procedures established by the
47 Engineer. Copies of these procedures are available from the State Materials Engineer.

48 Use edge blocks when radiographing butt welds greater than 1/2" in thickness. Use edge
49 blocks with a length sufficient to extend beyond each side of the weld centerline for
50 a minimum distance equal to the weld thickness, but not less than 2" and with a thickness

Section 1072

1 equal to or greater than the thickness of the weld. Use edge blocks with a minimum
2 width equal to half the weld thickness, but not less than 1". Center the edge blocks on the
3 weld with a snug fit against the plate being radiographed allowing no more than
4 1/16" gap. Produce edge blocks from radiographically clean steel and provide a surface
5 finish of ANSI 125 or smoother.

6 High mount lighting standards longitudinal groove welds and fillet welds are
7 radiographically tested as specified by the contract. Other nondestructive test methods
8 are sometimes deemed necessary by the Engineer to determine the quality of the welds.
9 No separate payment is made for inspection and testing. The entire cost of this work is
10 included in the unit contract price involved.

11 (G) Welded Structural Shapes

12 Produce butt welds of flanges and webs, and fillet welds of web to flanges of plate
13 girders and haunched beams using the submerged arc process. Produce other structural
14 shapes built up from plates and bars using the submerged arc process unless another
15 process is qualified for these joints in accordance with the Bridge Welding Code and is
16 subject to the approval of the Engineer.

17 After all shop welded splices in the flanges and webs for the full length of the field
18 section are made, tested and approved, fit the flange plates tight and square against the
19 web to leave no gap and to not bow the web. Brace one side of each flange against the
20 web with gussets or struts and tack weld securely to the web at the stiffener locations.
21 Upon removal of the welds, grind any nicks or gouges, preheat, weld and test or
22 incorporate into the stiffener fillet weld.

23 Connect the flanges to the web by starting the fillet weld at one end of the girder and
24 proceeding to the other ends.

25 As an option, make adjacent welds simultaneously.

26 The sequence for making the flange to web fillet welds is subject only to the provisions
27 for control of shrinkage and distortion and to the position requirements of the Bridge
28 Welding Code.

29 After flange to web welds are complete, shift bracing gussets or struts if necessary, then
30 remove all temporary gussets or struts. Remove tack welds by grinding flush with parent
31 metal.

32 Straighten any transverse warpage of the flanges if necessary by heating along the
33 centerline of the outside face.

34 Fit tight, square and tack weld stiffeners securely to the web. With the girder in the flat
35 position (web horizontal), weld the stiffeners to the web. Do not weld or tack weld
36 stiffeners to the flanges except where noted in the plans.

37 After all parts are welded into place, trim the girder to detail length with adjustments for
38 slope and end rotation exceeding 1/4" net.

39 1072-19 SHOP ASSEMBLING

40 (A) General

41 Assemble the field connections of main members of continuous beam spans, plate girders
42 and rigid frames in the shop with milled ends of compressing members in full bearing,
43 and then ream their sub-size holes to specified size while the connections are assembled.
44 Assembly shall be either Full Girder Assembly or Progressive Girder Assembly unless
45 Full Girder Assembly or Special Complete Structure Assembly is required by the
46 contract.

1 Furnish a camber diagram to the Engineer showing the camber at each panel point of
 2 each continuous beam line, plate girder or rigid frame. When the shop assembly is Full
 3 Girder Assembly or Special Complete Structure Assembly, ensure the camber diagram
 4 shows the camber measured in assembly. When any of the other methods of shop
 5 assembly is used, show the calculated camber in the camber design.

6 Clean surfaces of metal in contact before assembling. Assemble the parts of a member,
 7 pin well and firmly draw together with bolts before reaming. Take assembled pieces
 8 apart, if necessary, for removal of burrs and shavings produced by the reaming operation.
 9 Ensure that the member is free from twists, bends and other deformation.

10 Drift during assembling only to bring the parts into position, and not sufficient to enlarge
 11 the holes or distort the metal. If any holes are enlarged to admit the fasteners, ream them.

12 Match-mark those connecting parts assembled in the shop for the purpose of reaming
 13 holes in field connections and provide a diagram showing marks furnished by the
 14 Engineer.

15 **(B) Full Girder Assembly**

16 Full Girder Assembly consists of assembling all members of each continuous beam line,
 17 plate girder or rigid frame at one time.

18 **(C) Progressive Girder Assembly**

19 Progressive Girder Assembly consists of assembling initially for each continuous beam
 20 line or plate girder at least 2 contiguous shop sections or all members in at least
 21 2 contiguous shop panels but not less than the number of panels associated with
 22 3 contiguous section lengths (i.e., length between field splices) and not less than 150 ft in
 23 the case of structures longer than 150 ft. Add at least one shop section at the advancing
 24 end of the assembly before removing any member from the rearward end, so the
 25 assembled portion of the structure is never less than the specified above.

26 **(D) Special Complete Structure Assembly**

27 Special Complete Structure Assembly consists of assembling the entire structure,
 28 including the floor system.

29 Ensure each assembly, including camber, alignment, accuracy of holes and fit of milled
 30 joints, is approved by the Engineer before reaming.

31 **1072-20 PAINTING AND OTHER PROTECTIVE COATINGS**

32 Shop paint in accordance with Section 442.

33 Repair galvanized surfaces that are abraded or damaged in accordance with Article 1076-7.

34 **1072-21 MARKING AND SHIPPING**

35 Paint or mark each member with an erection mark for identification and furnish an erection
 36 diagram with erection marks shown thereon.

37 Furnish to the Engineer as many copies of material orders, shipping statements and erection
 38 diagrams as the Engineer directs. Show the weights of the individual members on the
 39 statement. Mark the weights on members weighing more than 3 tons. Load structural
 40 members on trucks or cars in such a manner that they are transported, unloaded and stored at
 41 their destination without being excessively stressed, deformed or otherwise damaged.

42 Load and ship steel beams and girders in accordance with the Figures 1072-2 and 1072-3 and
 43 Table 1072-9 for all types of transportation. When the contractor wishes to place members on
 44 trucks not in accordance with these limits, to ship by rail, to attach shipping restraints to the
 45 members, to ship horizontally curved steel members, or to invert members, he shall submit
 46 a shipping plan before shipping. Refer to Article 1072-9.

Section 1072

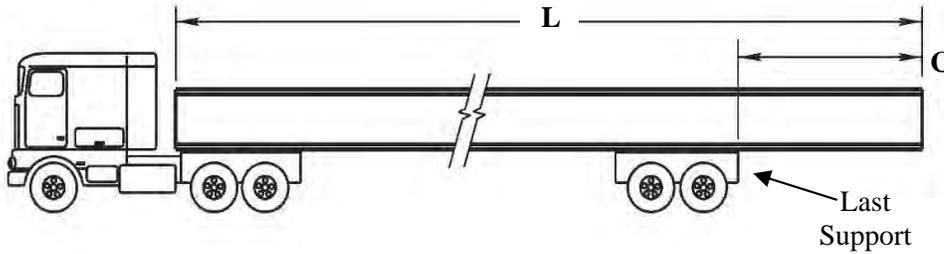
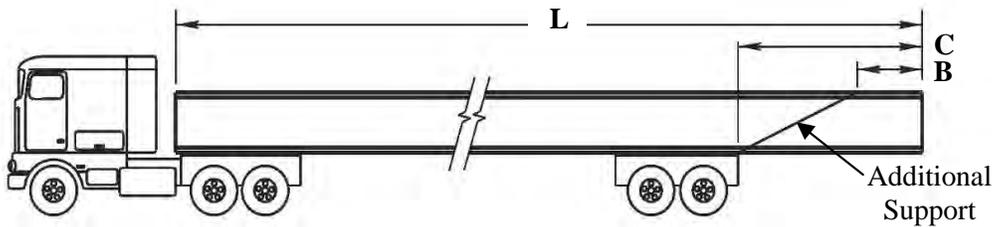


Figure 1072-2. Truck loading diagram for when the length past the last support, *C*, is 15 ft or less.



1

2 **Figure 1072-3.** Truck loading diagram for when the length past the last support, *C*, is
3 between 15 ft and 30 ft.

4 For truck loading with the length of the last support between 15 ft and 30 ft in Figure 1072-3,
5 use the following formulas to calculate truck loading limits or use the values given in
6 Table 1072-9:

7

$$B = 0.4C$$

8

$$C = 0.2L \text{ to } 0.3L, \text{ up to } 30 \text{ ft}$$

9 Where **B** is the length of the member past a required additional restraint, **C** is the length of the
10 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
<i>(L)</i>	<i>(C)</i>	<i>(C)</i>	<i>(B)</i>
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

1 Restrain overhanging ends of beams or girders both vertically and horizontally to prevent
2 excess movement. Chains are permitted to secure beams and girders during shipping only
3 when adequate measures are taken to prevent damage to the material by the use of approved
4 protective material. If necessary, use adequate bracing to prevent bending of the top flange.

5 Pack bolts of one length and diameter and loose nuts or washers of each size separately. Ship
6 pins, small parts and packages of bolts, washers and nuts in boxes, crates, kegs or barrels, but
7 do not allow the gross weight of any package to exceed 300 lb. Plainly mark a list and
8 description of the contained material on the outside of each shipping container.

9 Steel die stamped fabricator's identity, station number, girder number and span number of
10 main members into an unpainted area (if available) near the end of the member. Die stamp
11 members with painted ends outside the painted area but as close to the end as possible.

12 Ship anchor bolts, washers and other anchorage or grillage materials, in time to be
13 incorporated into the masonry portion of the structure.

14 SECTION 1074

15 MISCELLANEOUS METALS AND HARDWARE

16 1074-1 WELDING

17 Certify all welders performing any welding on any metals in accordance with the applicable
18 AWS welding code in the position and process required as approved by the Engineer.

19 1074-2 EXPANSION ANCHORS

20 Unless otherwise shown in the plans, provide expansion anchors consisting of 2 or more units
21 with a minimum of 2 hard metal conical ring wedges and 2 expandable lead sleeves of
22 an equally effective design that is approved by the Engineer. Use anchors providing
23 a minimum safe holding power of 3,000 lb for 3/4" bolts and 2,000 lb for 5/8" bolts, based
24 upon 1/4 of the actual holding power of the anchor in 3,000 psi concrete. Furnish satisfactory
25 evidence, based upon actual tests performed by a commercial testing laboratory, which
26 indicate that the anchors develop the minimum required safe holding power.

27 When it is proposed to use anchors that are previously accepted as meeting the above
28 requirements, the anchors are accepted on the basis of a certified statement indicating the
29 prior acceptance of the furnished anchors.

30 1074-3 PLAIN STEEL BARS WITH THREADED ENDS

31 Provide plain steel bars with threaded ends meeting ASTM A307, Grade A.

32 1074-4 HARDWARE FOR TIMBER STRUCTURES

33 Use machine bolts, drift-bolts and dowels that are either wrought iron or medium steel. Use
34 washers that are cast iron ogee, malleable iron castings or cut from medium steel or wrought
35 iron plate.

36 Use machine bolts with square heads and nuts. Use nails that are cut or round wire of
37 standard form. Use spikes that are cut, wire spikes or boat spikes.

38 Use black or galvanized nails, spikes, bolts, dowels, washers and lag screws for untreated
39 timber.

40 Galvanize or cadmium plate all hardware for treated timber bridges, except malleable iron
41 connectors.

Section 1074

1 1074-5 METAL BRIDGE RAILING

2 (A) General

3 As an option, use either aluminum or galvanized steel metal rail, provided that the same
4 material is used on all structures on the project.

5 Certified mill test reports are required for rails and posts.

6 Place a permanent identifying mark that identifies the fabricator on each post. Use
7 a method and location of the identifying mark such that it does not detract from the
8 appearance of the post.

9 Where it is necessary for rails to be curved, form the curvature in the shop or in the field.
10 Uniformly curve the rail without buckling or kinking. Perform all welding in accordance
11 with AWS D1.1 for steel railing and AWS D1.2 for aluminum railing.

12 Provide an anchor unit of sufficient strength to insure load anchoring capacity as
13 specified for rail loading in the *AASHTO LRFD Bridge Design Specifications*.

14 (B) Aluminum Rail

15 Supply material for posts, post bases, rails, expansion bars and clamp bars meeting
16 ASTM B221 for Alloy 6061 T6.

17 Use material for rivets meeting ASTM B316 for Alloy 6061 T6. Use rivets that are
18 standard button head and cone point cold driven.

19 Use material for nuts meeting ASTM B211 for Alloy 6061 T6.

20 Provide material for washers meeting ASTM B209 for Alloy Alclad 2024 T3.

21 Supply material for shims meeting ASTM B209 for Alloy 6061 T6.

22 Ensure that the handrails meet the dimensional tolerance requirements of ANSI H35.2.

23 (C) Galvanized Steel Rail

24 Use posts, post bases, rails, expansion bars and clamp bars meeting ASTM A36 and
25 galvanize in accordance with ASTM A123. Grind the cut ends of rail smooth and give
26 them 2 coats of organic zinc repair paint. Galvanize the posts and post bases after they
27 are riveted together.

28 Use rivets meeting ASTM A502 for Grade 1 rivets.

29 Use bolts meeting ASTM F593 Alloy 304.

30 Use nuts meeting ASTM F594 Alloy 304.

31 Use washers meeting ASTM F844 except made from Alloy 304 stainless steel.

32 Use materials for shims meeting ASTM A1011 for Grades 36, 40 or 45, or ASTM A1008
33 for Grade C, and galvanized in accordance with ASTM A123.

34 1074-6 STEEL PIPE

35 Steel pipe bent or welded in fabricating shall meet ASTM A53 for standard weight pipe. Use
36 galvanized pipe unless otherwise shown in the plans.

37 1074-7 IRON CASTINGS

38 (A) General

39 Comply with the Department's Iron Casting QA/QC program.

1 Boldly fillet castings at angles, and provide arrises that are sharp and perfect. No sharp,
2 unfilleted angles or corners are permitted. Provide castings that are true to pattern in
3 form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other
4 defects affecting their strength and value for the service intended. Sand blast or
5 otherwise effectively clean of scale and sand all castings to present a smooth, clean, and
6 uniform surface. Welding is not allowed for the purpose of making a casting structurally
7 sound. Welding for cosmetic or other purposes is not allowed without approval of the
8 Engineer.

9 **(B) Gray Iron Castings**

10 Supply gray iron castings meeting AASHTO M 306. Proof load testing will only be
11 required for new casting designs during the design process. Acceptance of production
12 castings will be based on test bars. Cast test bars, of size "B", attached to and integral
13 with the castings. Instead of this, cast test bars separate from the castings when approved
14 in writing by the Engineer. The Engineer reserves the right to require that a test bar be
15 machined from an actual casting if deemed necessary. Unless otherwise specified, do not
16 coat gray iron castings. Do not perform any welding on castings for any reason without
17 prior approval from the Engineer. Mark castings with the NCDOT Standard Number of
18 the casting design, the fabricator's ID and the day, month and year of production.

19 **1074-8 STEPS**

20 Fabricate steps for minor drainage structures from deformed reinforcing bars, use gray iron
21 castings meeting Subarticle 1074-7(B) or use composite plastic-steel construction as shown in
22 the plans.

23 The use of steps differing in dimension, configuration or materials from those shown in the
24 plans is allowed by furnishing the Engineer with details of the proposed steps and obtaining
25 written approval for the use of such steps.

26 **1074-9 FABRICATED STEEL GRATES**

27 Use fabricated steel grates made from bars that meet ASTM A36. Galvanize the grates after
28 fabrication in accordance with AASHTO M 111.

29 **1074-10 PINS**

30 Supply pins for bearing assemblies meeting either ASTM A36 or ASTM A108 for
31 Grades 1016 through 1030, unless otherwise required by the plans or specifications.

32 **1074-11 WASHERS**

33 Provide washers for use with fasteners meeting ASTM A436. Provide washers for high
34 strength bolts meeting Article 1072-5.

35 Ensure that the size and finish (plain, weathering or galvanized) of washers is compatible with
36 the fastener.

37 **1074-12 METAL STAY-IN-PLACE FORMS**

38 Provide metal stay-in-place forms for concrete floor slabs of zinc-coated (galvanized) steel
39 sheet conforming to ASTM A653, Structural Steel (SS) Grades 33 through 80 and Coating
40 Class G165 meeting all requirements relevant to steel stay-in-place forms as noted on the
41 contract plans. Do not use material thinner than 20 gauge.

Section 1076

**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 the *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" 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).

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 or brush-apply the paint to the cleaned areas with 2 coats of organic zinc repair paint meeting Article 1080-9. Ensure that the total thickness of the 2 coats is not less than 3 dry mils. Allow adequate curing time before subjecting repaired items to service conditions in accordance with the manufacturer's printed instructions.

- 1 Application conditions shall be 40°F Air/Steel temperature and rising, steel temperature shall
 2 be 5°F above the dew point and relative humidity shall be 85% or less. Follow paint
 3 manufacturers recommendation if more restrictive than above requirements.
- 4 Follow paint manufacturers written instructions on storage temperatures, mixing application,
 5 continuous agitation and pot life. No thinners are to be used when applying organic zinc
 6 repair paint by brush or roller.
- 7 Instead of repairing by painting with organic zinc repair paint, other methods of repairing
 8 galvanized surfaces that are abraded or damaged are allowed provided the proposed method is
 9 acceptable to the Engineer.
- 10 Excessive damage to galvanized surfaces as determined by the Engineer is cause for rejection.
 11 Replace or re-galvanize rejected galvanized material.

SECTION 1077 PRECAST CONCRETE UNITS

1077-1 GENERAL

- 15 Use precast concrete units from sources participating in the Department's Precast Concrete
 16 QC/QA Program. A list of participating sources is available from the Materials and Tests
 17 Unit. The Department will remove a manufacturer of precast concrete units from this
 18 program if the monitoring efforts indicated that non-specification material is being provided
 19 or test procedures are not being followed.
- 20 This section covers the materials for and the production of precast reinforced concrete units
 21 produced in accordance with the contract. Where precast reinforced concrete circular
 22 manhole sections are used, they shall meet AASHTO M 199.

1077-2 PLAN REQUIREMENTS

- 24 The plans for precast units will be furnished by the Department in the *Roadway Standard*
 25 *Drawings* or details shown in the project plans.
- 26 When the Department does not make precast plans available and the Contractor chooses to
 27 precast, submit drawings to the Engineer for the items proposed to precast. Submit one
 28 complete set of drawings for review, at least 40 calendar days before beginning production.
 29 After acceptance, submit 7 complete sets of drawings. Acceptance by the Engineer of
 30 contractor drawings will not be considered as relieving the Contractor of any responsibility
 31 for precast units. When precast units are load bearing and require structure design, have the
 32 plans prepared and certified by an engineer licensed by the State of North Carolina.
 33 Contractor furnished drawings shall show complete design, installation and construction
 34 information in such detail as to enable the Engineer to determine the adequacy of the
 35 proposed units for the intended use. Contractor drawings shall include details of steel
 36 reinforcement size and placement and a schedule that lists the size and type of precast units at
 37 each location where the precast units are to be used. Produce precast units in accordance with
 38 the approved drawings.

1077-3 MATERIALS

- 40 Refer to Division 10.

Item	Section
Air Entraining Agent	1024-3
Chemical Admixtures	1024-3
Coarse Aggregate	1014-2
Curing Agents	1026
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6

Section 1077

Item	Section
Miscellaneous Metals	1074
Portland Cement	1024-1
Reinforcing Steel	1070
Silica Fume	1024-7
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Water	1024-4

1 1077-4 INSPECTION

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

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

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

14 (A) Storage

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

18 (B) Transporting

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

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

24 1077-5 PORTLAND CEMENT CONCRETE

25 (A) Composition and Design

26 Portland cement concrete is composed of Portland cement, coarse aggregate (#67 or
27 78M), fine aggregate, water and unless otherwise permitted by the Engineer, an air
28 entraining agent. If other cementitious materials and/or chemical admixtures are used,
29 use these materials in the proper proportions to obtain the optimum effect. Do not use
30 calcium chloride or other admixtures containing calcium chloride.

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

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

Section 1077

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

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

10 (B) Testing

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

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

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

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

24 For the purpose of testing for the required 28 day compressive strength, furnish, at no
25 cost to the Department, at least 4 concrete cylinders for each class of concrete, each
26 structure and each day that precast units are produced for the Department. If the
27 contractor anticipates an early break request, furnish the Department with 2 concrete
28 cylinders for each early break request. These cylinders are in addition to the 4 concrete
29 cylinders required for each day of production. Make and cure cylinders in accordance
30 with AASHTO T 23 unless, by permission of the Engineer, the units are cured by one of
31 the methods in Article 1077-9 for the full time required to meet the specified compressive
32 strength requirements. In such case, cure the cylinders with the members and in the same
33 manner as the members. Test cylinders in accordance with AASHTO T 22. If the
34 average of 2 cylinders tested to determine compressive strength at the age of 28 days fails
35 to indicate a compressive strength as shown in Table 1077-1, or such compressive
36 strength as is required by the approved drawings, such failure is cause for the rejection of
37 the members represented.

38 (C) Temperature Requirements

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

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

42 (D) Use of Water Reducing Admixtures

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

1 **1077-6 FORMS**

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

12 **1077-7 REINFORCEMENT**13 **(A) Steel Reinforcement**

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

16 **(B) Macro Synthetic Fiber Reinforcement**

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

20 (1) Materials

21 Refer to Division 10.

Item	Section
Portland Cement Concrete	1077-5

22 Substitute macro-synthetic fibers only for steel reinforcement with an area of steel of
 23 0.12 sq.in./ft or less in the following items:

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

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

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

30 (2) Submittal

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

34 (3) Macro-Synthetic Fibers

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

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

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(4) Fiber Reinforced Concrete

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

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

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

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

1077-8 PLACING CONCRETE

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

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

1077-9 CURING CONCRETE

(A) General

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

(B) Curing at Elevated Temperatures

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

(C) Water Curing

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

(D) Curing Compound

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

1 1077-10 LIFT HOLES, HANDLING

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

6 1077-11 FINAL FINISH

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

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

12 1077-12 EXPOSED AGGREGATE FINISH FOR PRECAST CONCRETE PANELS

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

20 Use aggregate and cement from the same source as was used for the test panel and accepted
21 sample panels to produce panels with an exposed aggregate finish. Provide access to visually
22 inspect the entire finish of each completed panel and compare it to the test panel appearance
23 before stacking panels. Replace the test panel with a new test panel every 3 months during
24 production or when fly ash or cement source changes.

25 1077-13 STEPS FOR PRECAST DRAINAGE STRUCTURES

26 Supply steps meeting AASHTO M 199 for design, materials and dimensions. Incorporate
27 steps in all drainage structures over 3.5 ft in height. Do not detail the lowest step more than
28 16" from the bottom.

29 1077-14 MARKING

30 Clearly show the following information on each precast member:

31 (A) Date of manufacture,

32 (B) Name of the manufacturer,

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

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

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

37 1077-15 DIMENSIONS

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

41 1077-16 INCIDENTAL PRECAST ITEMS

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

Section 1078

**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 girders, submit complete working drawings to the Engineer for approval. The 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

Item	Section
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
Type IP Blended Cement	1024-1
Type IS Blended Cement	1024-1
Silica Fume	1024-7
Structural Steel	1072
Water	1024-4

1 Do not make changes in the source of aggregates, cements or admixtures during the casting of
 2 members in any one span or substructure unit unless approved by the Engineer.

3 **1078-3 INSPECTION**

4 The Department reserves the right to place a duly authorized inspector in the plant at any or
 5 all times work related to the production of members for the Department is performed. Notify
 6 the Engineer at least 7 days in advance when such work is scheduled. Provide an office area
 7 with an approximate floor space of 100 sf, a desk or drafting table, 2 chairs, telephone,
 8 separate dial-up or faster internet access, facilities for proper heating and cooling and
 9 adequate lighting at the plant for the exclusive use of the inspector. The inspector has the
 10 authority to reject any or all members not manufactured in accordance with these *Standard*
 11 *Specifications*. Approval of any member by the inspector at the plant is in no way final, and
 12 further inspection is made at the structure site both before and after the member is placed in
 13 the final position. Any member found to be defective in any manner at any time is rejected
 14 and requires replacement by an acceptable member or repair in a manner approved by the
 15 Engineer.

16 Do not transport any member from the plant to the job site before approval of that member by
 17 the plant inspector. Provide access to all surfaces of the member so the plant inspector has the
 18 opportunity to properly inspect the member before approval. This approval is stamped on the
 19 member by the plant inspector.

20 **1078-4 PORTLAND CEMENT CONCRETE**

21 **(A) Composition and Design**

22 Supply Portland cement concrete composed of Portland cement, coarse aggregate, fine
 23 aggregate, water and an approved air-entraining agent. Add other cementitious materials
 24 and/or chemical admixtures if approved by the Engineer. When admixtures are used, use
 25 them in the proper proportions to obtain the optimum effect. Do not use set accelerating
 26 admixtures, calcium chloride or admixtures containing calcium chloride. If approved,
 27 high range water reducer may be used at a rate not to exceed the manufacturer's
 28 recommended dosage.

Section 1078

- 1 Supply concrete with a minimum compressive strength of 5,000 psi at the age of 28 days,
- 2 unless otherwise required by the plans or Specifications. Ensure that all coarse aggregate
- 3 used in prestressed concrete passes a 1" sieve. Maintain a cement content of at least
- 4 564 lb/cy but no more than 752 lb/cy. As an option, reduce the cement content of the mix
- 5 design and replace with fly ash or ground granulated blast furnace slag in accordance
- 6 with Article 1024-1. For concrete with a 28 day design strength greater than 6,000 psi, if
- 7 approved, substitute microsilica for cement, in conformance with Article 1024-1.
- 8 Supply concrete meeting Table 1078-1, unless otherwise approved by the Engineer.

TABLE 1078-1 REQUIREMENTS FOR CONCRETE		
Property	28 Day Design Compressive Strength 6,000 psi or less	28 Day Design Compressive Strength greater than 6,000 psi
Maximum Water/Cementitious Material Ratio	0.45	0.40
Maximum Slump without HRWR	3.5"	3.5"
Maximum Slump with HRWR	7"	7"
Air Content (upon discharge into forms)	5 + 2%	5 + 2%

9 Submit to the Engineer proposed concrete mix designs for each strength of concrete used
 10 in the work. Determine quantities of fine and coarse aggregates necessary to provide
 11 concrete in accordance with the *Standard Specifications* by the method described in
 12 ACI 211 using the absolute volume basis.

13 Submit mix designs, stated in terms of saturated surface dry weights, on
 14 M&T Form 312U at least 35 days before using the proposed mix. Adjust batch
 15 proportions to compensate for surface moisture contained in the aggregates at the time of
 16 batching. Changes in the saturated dry mix proportions are not permitted unless revised
 17 mix designs are submitted to the Engineer and are determined to be acceptable for use.

18 Provide with M&T Form 312U a listing of laboratory test results of aggregate gradation,
 19 air content, slump and compressive strength. List the compressive strength of at least
 20 three 6" x 12" or 4" x 8" cylinders. Show the age of the cylinders at the time of testing
 21 and a detailed description of the curing procedure. Perform laboratory tests in
 22 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 23 and T 22

23 If the design 28 day compressive strength is greater than 6,000 psi, submit the
 24 compressive strength of at least 6 cylinders. Ensure that the average strength of the
 25 6 cylinders is at least 1,500 psi above the minimum 28 day compressive strength required
 26 by the plans.

27 When the combination of materials is such that the required strength and/or a workable
 28 slump is not obtained at the minimum specified cement content with the maximum
 29 allowable water-cement ratio, increase the cement content at no cost to the Department
 30 by whatever amount is required to produce the required strength and/or slump without
 31 exceeding the allowable water-cement ratio.

1 The Engineer reviews the mix design only to ascertain general compliance with the
2 *Standard Specifications*. The Engineer notifies the Contractor, in writing, that the mix
3 design is either acceptable or unacceptable. Do not use a mix until notified by the
4 Engineer that the mix design is acceptable. Acceptance of the mix design does not
5 relieve the Contractor of responsibility to furnish an end product meeting specification
6 requirements. Upon request, a mix design accepted and used satisfactorily on any
7 Department project may be accepted for use on other projects.

8 (B) Testing

9 Employ a certified concrete technician to perform all testing required by this subarticle at
10 the bed site in the presence of the plant inspector unless otherwise approved.
11 Certification of technicians is awarded upon satisfactory completion of examinations
12 prepared and administered by the Department or other approved agency.

13 (1) Air Content

14 Before allowing placement of the first load in a bed, determine the air content by
15 a calibrated Chace indicator in accordance with AASHTO T 199. During the
16 placement of the first load, determine the air content by AASHTO T 152, T 196 or
17 T 121. Determine the air content in each subsequent 10 cy by the Chace indicator in
18 accordance with AASHTO T 199 before allowing placement. Determine the air
19 content by AASHTO T 152, T 196 or T 121 from all loads from which cylinders are
20 made. If the air content as determined by the Chace indicator, AASHTO T 199, fails
21 to meet the specification requirements, a second test is run on material from the same
22 load and the results of the 2 tests averaged. If the average does not meet the
23 *Standard Specifications*, a test on the same load is conducted using AASHTO T 152,
24 T 196 or T 121. Acceptance or rejection of the load is based on the results of this
25 test.

26 (2) Slump

27 Determine slump in accordance with AASHTO T 119.

28 (3) Strength

29 For the purpose of testing for the required 28 day compressive strength and also for
30 the required compressive strength for the transfer of load, furnish, at no cost to the
31 Department, cylinders made from a sample of concrete placed near the live end of
32 the bed and additional cylinders made from a sample of concrete placed near the
33 dead end of the bed. Make cylinders in accordance with AASHTO T 23, except cure
34 the cylinders in the same manner as the members represented until the strands are
35 released. Place cylinders in clusters at random points along the casting bed. After
36 the strands are released, air cure the cylinders in an approved common area near the
37 testing apparatus for the remainder of the 28 day curing period. Test the cylinders in
38 accordance with AASHTO T 22. Provide approved apparatus for testing the transfer
39 strength of the cylinders. Maintain this apparatus to within 1.0% accuracy and
40 calibrate at intervals not to exceed 12 months by an approved testing company at no
41 cost to the Department. The Engineer reserves the right to require verification
42 immediately after a testing machine is relocated and whenever there is reason to
43 doubt the accuracy of the indicated load, regardless of the time interval since the last
44 verification.

Section 1078

1 The testing requirements vary according to the 28 day compressive strength required
2 by the plans as follows:

3 (a) Compressive Strength (28 day) of 6,000 psi or Less

4 Test 2 cylinders, one from each end of the bed, for the purpose of determining
5 whether the concrete has reached the required strength for transfer of load.
6 Ensure that the average of the strength tests on the 2 cylinders meets or exceeds
7 the required strength and the lowest cylinder is not more than 200 psi below the
8 required strength.

9 Test 2 cylinders to determine compressive strength at the age of 28 days. The
10 strength from these 2 cylinders is averaged. Ensure that this average is at least
11 5,000 psi or such 28 day compressive strength required by the plans or *Standard*
12 *Specifications*. Ensure that no cylinder indicates a compressive strength less
13 than 400 psi below the required 28 day compressive strength. Failure to meet
14 the above requirements is cause for rejection of the members represented.

15 (b) Compressive Strength (28 day) of Greater Than 6,000 psi

16 Test 4 cylinders, 2 from each end of the bed, for the purpose of determining
17 whether the concrete has reached the required strength for transfer of load. The
18 strengths from the dead end cylinders are averaged and the strengths from the
19 live end cylinders are averaged. Ensure that both of these averages meet or
20 exceed the required release strength and the lowest cylinder is not more
21 than 200 psi below the required strength.

22 Test 3 cylinders from each end to determine the 28 day compressive strength.
23 The strengths from the dead end cylinders are averaged and the strengths from
24 the live end cylinders are averaged. Ensure that both of these averages meet or
25 exceed the 28 day compressive strength. Ensure that no cylinder indicates
26 a compressive strength less than 400 psi less than the required 28 day
27 compressive strength. Failure to meet the above requirements is cause for
28 rejection of the members represented.

29 **(C) Temperature Requirements**

30 Maintain a concrete temperature at the time of placing in the forms between 50°F
31 and 95°F.

32 Do not place concrete when the air temperature, measured at the location of the
33 concreting operation in the shade away from artificial heat, is below 35°F.

34 **(D) Elapsed Time for Placing Concrete**

35 Ensure that the elapsed time for placing concrete is in accordance with
36 Subarticle 1000-4(E). The requirements of Subarticle 1000-4(E) pertaining to
37 Class AA concrete apply to prestressed concrete.

38 **(E) Use of Set Retarding Admixtures**

39 By permission of the Engineer, use an approved set retarding admixture if choosing to
40 take advantage of the extended time interval between adding mixing water and placing
41 the concrete.

42 Use a quantity of set retarding admixture per 100 lb of cement within the range
43 recommended on the current list of approved set retarding admixtures issued by the
44 Materials and Tests Unit.

45 **(F) Use of Water Reducing Admixtures**

46 Use water-reducing admixtures in accordance with Subarticle 1000-4(G).

(G) 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 5.1 lb/cy Nitrite (NO₂) 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 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.

(H) Measuring Materials

Measure materials in accordance with Article 1000-8.

(I) Mixers and Agitators

Use mixers and agitators meeting Article 1000-10.

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1 (J) Mixing and Delivery

2 (1) General

3 Mix and deliver concrete to the site of the work by one of the following methods,
4 except where other methods are approved by the Engineer. The Engineer approves
5 the mixing of concrete by methods other than those listed below provided the
6 proposed method is capable of satisfying job requirements and there is adequate
7 evidence that the proposed method produces concrete complying with the *Standard*
8 *Specifications*. Assume responsibility for controlling the materials and operations so
9 as to produce uniform concrete meeting the *Standard Specifications*.

10 Have present during all batching operations at the concrete plant a certified concrete
11 technician employed by the Contractor, prestressed concrete producer or concrete
12 supplier while concrete is batched and delivered to the site of the work. The sole
13 duty of this employee is to have charge of and exercise close supervision of the
14 production and control of the concrete. Ensure the technician performs moisture
15 tests, adjusts mix proportions of aggregates for free moisture, completes batch tickets
16 on M&T Form 903 or approved delivery tickets, signs batch tickets or approved
17 delivery tickets and assures quality control of the batching operations. Delivery
18 tickets are permitted instead of batch tickets on M&T Form 903 provided they are
19 reviewed and approved by the Materials and Tests Unit. Certification of technicians
20 is awarded upon satisfactory completion of examinations prepared and administered
21 by the Department or other approved agency.

22 (a) Central Mixed Concrete

23 Mix completely in a stationary mixer and transport the mixed concrete to the
24 point of delivery in a truck agitator or in a truck mixer operating at agitating
25 speed or in non-agitating equipment approved by the Engineer. Mix within the
26 capacity and at the mixing speeds recommended by the equipment
27 manufacturer.

28 (b) Transit Mixed Concrete

29 Mix completely in a truck mixer while at the batching plant, in transit or at the
30 work site.

31 (2) Mixing Time for Central Mixed Concrete

32 The mixing time starts when all the solid materials are in the mixing compartment
33 and ends when any part of the concrete begins to discharge. Charge the ingredients
34 into the mixer such that some of the water enters in advance of cement and
35 aggregate, and substantially all the water is in the drum before 1/3 of the specified
36 mixing time elapses. Transfer time in multiple drum mixers is counted as part of the
37 mixing time.

38 Establish the minimum mixing time by one of the following:

39 (a) Mixer performance tests as described herein,

40 (b) The manufacturer of the equipment, or

41 (c) The requirement of one minute for mixers of 1.0 cy capacity or less with
42 an increase of 15 seconds for each cubic yard or fraction thereof in increased
43 capacity.

44 The Engineer reserves the right to require a mixer performance test at any time. The
45 minimum mixing time as determined by the mixer performance test is that which
46 produces concrete in accordance with Table 1078-2.

1 Sample and test for mixer performance as provided below. Charge the mixer to its
 2 rated capacity with the materials and proportions used in the work and mix at the
 3 recommended mixing speed to the target time. Stop mixing then and begin
 4 discharging. Take 2 samples of sufficient size to make the required tests after
 5 discharge of approximately 15% and 85% of the load by an appropriate method of
 6 sampling which provides representative samples of the concrete.

7 Separately test each of the 2 samples of concrete for the properties listed in
 8 Table 1078-2. Conduct tests in accordance with the standard methods shown in
 9 Table 1078-2 or procedures established by the Materials and Tests Unit.

10 Perform the mixer performance test described above on at least 2 batches of
 11 concrete. For the performance test to be acceptable, ensure that all tests in each
 12 batch meet the requirements listed above.

13 The Engineer rechecks mixer performance at any time when in his judgment
 14 acceptable mixing is not accomplished.

15 Where acceptable mixing cannot be accomplished in the established mixing time, the
 16 Engineer increases the mixing time or requires that the mixer be repaired or replaced
 17 before any further mixing.

18 (3) Truck Mixers and Truck Agitators

19 Use truck mixers and truck agitators meeting Subarticle 1000-11(C). For concrete
 20 with a design 28 day compressive strength greater than 6,000 psi, load trucks to
 21 within 1 cy of rated capacity and mix at a speed of 16 to 18 rpm.

22 (4) Delivery

23 For central mixed concrete delivered in truck agitators, truck mixers, or transit mixed
 24 concrete, use a ticket system for recording the transportation of batches from the
 25 proportioning plant to the site of the work. Fill out the tickets on M&T Form 903 or
 26 approved delivery tickets in accordance with the instructions issued by the Engineer.
 27 Issue the tickets to the truck operator at the proportioning plant for each load and
 28 have them signed by the certified concrete technician, which signifies that the
 29 concrete in the truck is inspected before departure. Show on each ticket the time
 30 batching is complete and if transit mixed, the number of revolutions at mixing speed,
 31 if any, at the plant. Deliver the tickets to the inspector at the site of the work. For
 32 central mixed concrete delivered in non-agitating equipment, alternate methods of
 33 documenting batch proportions are considered by the Engineer. Loads that do not
 34 arrive in satisfactory condition within the time limits specified are not acceptable for
 35 use in the work.

36 (K) Ready Mixed Concrete Plant

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 T23

37 **A.** Obtain tentative approval pending 7 day compressive strength tests.

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1 Ensure ready mixed concrete plants are inspected and approved by the Department before
2 they are used to produce concrete for the project. Ensure that plants meet all applicable
3 requirements of the *Standard Specifications* and in addition have at least 2 acceptable
4 concrete delivery vehicles that are in working condition. Plants approved by the
5 Department are placed on a list of approved plants that is made available. All plants are
6 subject to reinspection at intervals selected by the Engineer. Reapproval after each
7 inspection is contingent on continuing compliance with the *Standard Specifications*

8 **1078-5 CASTING BED AND FORMS**

9 Use metal forms, including headers or end forms, except where other materials are approved
10 by the Engineer. Use forms of adequate thickness, braced, stiffened, anchored and aligned
11 adequately to consistently produce members within the limits of dimensional tolerances.
12 Design and align the forms so they do not restrict longitudinal movement of the casting when
13 the prestressing force is transferred. Provide corners and angles that are chamfered or
14 rounded. Provide joints in forms that are smooth and tight enough to prevent leakage of
15 mortar. Plug holes and slots in forms, pallets, headers and bulkheads neatly to prevent
16 leakage of mortar. Make the inside surfaces of forms accessible for cleaning. Thoroughly
17 clean the beds and forms after each use. Before casting, clean the inside surfaces of the forms
18 from rust, grease or other foreign matter. Remove all foreign substances from inside the
19 forms, including any standing water. Do not allow coatings used for release of members to
20 build up. Do not use forms that do not present a smooth surface.

21 When casting holes through the top flange of Bulb Tee Girders for overhang or interior bay
22 falsework hanger rods, use rigid PVC conduits with a wall thickness of approximately 1/8".
23 Do not use thin wall material. Secure conduits in the forms so they do not migrate out of the
24 proper location. Other methods of forming holes may be proposed but are subject to the
25 Engineer's approval.

26 When casting dowel rod holes in cored slab or box beam members, use material that creates
27 round, vertical holes of the specified diameter and in the correct location. Do not use material
28 that deforms, collapses or shifts position during casting of the member.

29 Apply form release agents to the forms either before or after stringing of strands. If applied
30 before stringing, provide a release agent of a type that dries to a degree so it cannot
31 contaminate any strand that comes in contact with it. If the release agent is applied after
32 stringing, exercise great care and provide a sheet metal or similar type shield for protection of
33 the strands.

34 **1078-6 TENSIONING DEVICES**

35 Use tensioning devices adequate to produce and maintain the required tension in all strands
36 until the concrete reaches the required transfer strength. Equip all jacks with accurate and
37 calibrated gauges for registering jacking loads. Calibrate gauges with the jacks with which
38 they are used. Calibrate all jacks and gauges by an approved testing company at no cost to the
39 Department at intervals not to exceed 12 months. During progress of the work, if gauge
40 readings and elongations indicate materially differing loads, recalibrate as required. Use
41 gauges with a full load capacity of 1 1/2 to 2 times their normal working load, unless
42 otherwise approved. Do not use loads less than one-fourth or more than 3/4 of the total
43 graduated gauge capacity unless calibration data clearly establishes consistent accuracy over
44 a wider range. Use gauges with indicating dials at least 6" in diameter and gauge pointers that
45 do not fluctuate, preventing an accurate reading, but remain steady until the jacking load is
46 released. Ensure that all gauges have an accuracy of reading within 2%. Provide means for
47 measuring the elongation of strands within 1/4".

1 1078-7 PLACING STRANDS, TIES AND REINFORCING STEEL

2 Position strands, ties, supports, reinforcing bars of the sizes shown in the plans and bearing
3 plates in accordance with the detailed dimensions shown in the plans and effectively secure
4 against displacement from their correct positions. The use of previously tensioned strands is
5 not permitted. For prestressing strands, do not allow deflections or displacements of any kind
6 between the end anchorages unless shown in the plans. Place the steel reinforcing in final
7 position after tensioning of the strands. Bend all tie wires to the inside of the member so the
8 ends are farther from the edge than the material tied. Support bottom strands spacings not to
9 exceed 20 ft by supports meeting Article 1070-4 or by other approved means. Plastic
10 supports may be used when approved.

11 Strands with kinks, bends, nicks, scale, excessive rust or other defects are not permitted. No
12 more than one broken wire per casting bed is permitted. Slight rusting is not cause for
13 rejection, provided it is not sufficient to cause visible pits. Take precautions to prevent
14 contamination of strands and reinforcing steel. Clean the strands and reinforcing steel to an
15 acceptable condition before pouring concrete. Do not place concrete in the forms until the
16 strand and reinforcement condition and arrangement are inspected by the plant inspector.

17 Strand splices are only permitted at the end of a reel and when using a single strand jack.
18 Ensure that the strand lengths to be spliced together have the same lay of wire to avoid
19 unraveling and position the splice so it does not fall within a member. Do not torch cut the
20 ends of the spliced strand lengths. Cut by shears, abrasive grinders or other means approved
21 by the Engineer. No more than one strand splice per bed is allowed on an individual strand
22 and the use of previously tensioned strands for splicing is not permitted.

23 Where debonding of strands is required, accomplish by encasing the strand in a tubular
24 conduit capable of resisting the pressure exerted by the concrete. Do not use slit conduit. Use
25 a conduit of HDPE or polypropylene with a minimum wall thickness of 0.025". Ensure that
26 the inside diameter of the conduit is of sufficient size to allow free movement of the encased
27 strand but not greater than the diameter of the strand plus 1/8". Secure the conduit so
28 longitudinal movement along the strand is prevented, and bonding of the strand is prevented
29 at the required location ± 1 ". Prevent concrete from entering the conduit by taping. Use tape
30 manufactured from a non-corrosive material compatible with the concrete, conduit and steel.

31 1078-8 TENSIONING PROCEDURE

32 A producer quality control representative shall be present during strand tensioning. Tension
33 each strand to the load shown in the plans before placing the concrete.

34 Measure the load induced in the prestressing strand both by jacking gauges and strand
35 elongations on at least the first 5 strands and every third strand thereafter on each pour.
36 Measure loads on all other strands by either jacking gauges or strand elongations. When both
37 methods of measurement are used, if a discrepancy between gauge and elongation of more
38 than 5% is apparent, carefully check the entire operation and determine the source of error
39 before proceeding. Make appropriate allowances in the computed elongation and jacking
40 loads for load losses due to friction and all possible slippage or relaxation of the anchorage.
41 Establish references periodically at each strand anchorage to indicate any yielding or slippage
42 that may occur between the time of initial tensioning and final release of the strands.

43 In determining the applied load by measuring the elongation of the strand, use a modulus of
44 elasticity taken from the typical stress-strain curve for the brand, size and type of strand
45 tensioned. Submit stress-strain curve data for the actual heats of material used in the strands
46 to the plant inspector before using the strands. Identify each reel or strand by tagging in
47 accordance with AASHTO M 203. Mark the outer layer of each reel pack of strand with a
48 wide color band as follows: white for 270K stress relieved strand, green for low relaxation
49 strand and a double marking of green and red for special low relaxation strand. In addition,
50 attach a metal tag to each reel pack labeled in accordance with AASHTO M 203.

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1 Tension strands in a group or individually. Before full tensioning, bring each strand to
2 an initial tension of 2,000 lb for all beds under 150 ft in length, 3,000 lb for all beds 150 ft to
3 300 ft in length and 4,000 lb for all beds longer than 300 ft in length. Measure this initial
4 tension by a calibrated gauge or other approved means, and then compute the elongation due
5 to initial tensioning. Use the difference between the required final tension and the initial
6 tension to compute the expected additional elongation.

7 For precast prestressed deck panels, use a final prestressing force of 14,000 lb per strand for
8 Grade 250 strand and 16,100 lb per strand for Grade 270 strand.

9 After initial tensioning, tension the strands until the required elongation and jacking load are
10 attained and reconciled within the limits specified above. Keep a permanent record of the
11 initial jacking load, the final jacking load, and the elongation produced thereby.

12 In single strand tensioning, rotation of the jacking ram is not allowed.

13 When draped strands are used, submit 6 sets of the bed layout showing the method of draping
14 and tensioning the draped strands and also calculations determining the loads required for
15 tensioning the draped strands. Drape the strands for all members to be cast in any one
16 tensioning operation before casting any beam. Have end templates or bulkheads at ends of
17 beams remain vertical or as otherwise shown in the plans. Perform draping for all members
18 either simultaneously or in single or incremental lifts beginning at the center of the bed and
19 working outward toward each end of the bed. Complete tensioning in the fully draped
20 position is not allowed unless approved in writing.

21 Use round steel rollers of a type and dimensions approved by the Engineer for deflecting the
22 draped strands. Round the part in contact with the strand to a diameter of not less than 3/4".
23 Use support and hold-down devices of sufficient rigidity with adequate support so the final
24 position of the strands is as shown in the plans.

25 With strands tensioned in accordance with the above requirements and with other
26 reinforcement in place, cast the concrete members so as to achieve the required lengths.
27 Maintain strand load between anchorages until the concrete reaches the required compressive
28 strength for transfer of load from the anchorages to the members.

29 For personnel engaged in the tensioning operation, provide protection by effective shields
30 adequate to stop a flying strand. Provide shields produced from steel, reinforced concrete,
31 heavy timbers and other approved material at both ends of the bed.

32 **1078-9 PLACING CONCRETE**

33 Place concrete in accordance with Article 1077-8 and the additional requirements of this
34 article.

35 Upon completion of stressing strand, place concrete within a reasonable time to prevent
36 contamination of the strands and reinforcing steel.

37 Place concrete for girders 54" or less in height, and concrete for all cored slabs and box
38 beams, in 2 or more equal horizontal layers. Place concrete for girders over 54" in height in
39 3 horizontal layers. When placing concrete in 3 layers locate the top of the first layer
40 approximately at the top of the bottom flange and locate the top of the second layer
41 approximately at the top of the web. To prevent separation of surfaces between layers, do not
42 allow the time between successive placements onto previously placed concrete to exceed
43 20 minutes, unless the previously placed concrete has not yet stiffened, as evidenced by the
44 continuous effective use of vibration. Should shrinkage or settlement cracks occur, the
45 Engineer reserves the right to require additional layers and/or vibration.

46 The requirement of the above paragraph may be waived with the permission of the Engineer if
47 self consolidating concrete is used.

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

- 1 Place concrete in cold weather in accordance with Article 420-7.
- 2 Place concrete in daylight unless an adequate lighting system meeting the approval of the
3 Engineer is provided.
- 4 Do not exceed a temperature of 95°F in the freshly mixed concrete when placed in the forms.
- 5 Place the concrete in the bed in one continuous operation, finishing each member before
6 proceeding to the next one. If the pour stops before the concrete in all the members in the bed
7 is placed, start curing immediately. Do not place concrete in any remaining members in that
8 bed setup once curing at elevated temperatures has begun.
- 9 When cored slabs and box beams are cast, employ an internal hold-down system to prevent
10 the voids from moving. At least 6 weeks before casting cored slabs or box beams, submit to
11 the Engineer for review and comment, detailed drawings of the proposed void material and
12 hold-down system. In addition to structural details, indicate the location and spacing of the
13 holds-downs. Submit the proposed method of concrete placement and of consolidating the
14 concrete under the void.

15 **1078-10 CURING CONCRETE**

16 **(A) General**

17 Cure concrete by steam curing, radiant heat curing or water curing, as set forth below.
18 As an option, cure concrete for prestressed piles with membrane curing compound as set
19 forth below. Use a method or methods that prevent the concrete from losing moisture at
20 any time before curing is complete. Use methods that do not deface or injure the
21 concrete. Use curing procedures that prevent cracks from occurring in the members.
22 Cure all members in any one bed by the same method.

23 Continue the curing period until the concrete reaches sufficient strength to permit transfer
24 of load from the anchorage to the members. As soon as the concrete attains release
25 strength, immediately release all forms in a continuous operation, without delay for other
26 activities such as the cleaning of forms. Immediately following the removal of the forms,
27 de-tension the members.

28 **(B) Curing at Elevated Temperatures**

29 Perform radiant heat curing under a suitable enclosure that contains the heat and prevent
30 moisture loss. Apply moisture by a cover of moist burlap, cotton matting, or similar
31 approved material. Retain moisture by covering the member with an approved
32 waterproof sheeting in combination with an insulating cover. Support the cover at
33 a sufficient distance above the member being cured to allow circulation of the heat.

34 Provide steam curing enclosures essentially free of steam leakage to minimize moisture
35 and heat losses. Do not allow the enclosure to come in contact with the members or
36 forms for the members. Do not direct steam jets on the forms so as to cause localized
37 high temperatures.

38 After placing and vibrating, allow the concrete to attain its initial set before the
39 application of heat or steam. The concrete is considered to obtain its initial set when it
40 has a penetration resistance of at least 500 psi when tested in accordance with
41 AASHTO T 197. Take the sample of concrete tested for penetration resistance from the
42 last load cast in the bed. Store the sample of concrete with the precast member and
43 maintain in the same condition and environment as the member except for the periods of
44 time necessary to prepare the test specimen and to perform the penetration resistance test.
45 Conduct the penetration resistance test.

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1 As an option, submit data indicating that an approved concrete mix attains its initial set
2 after some particular time period. Different periods may be required for different weather
3 conditions. If such data is submitted, consideration is given to permitting heat or steam
4 introduced after the time indicated by such data instead of having to perform the
5 penetration resistance test. Consideration is given to determining the time of initial set by
6 methods other than AASHTO T 197 provided data supporting such other methods is
7 submitted.

8 When the ambient air temperature is below 50°F, cover the forms after the placement of
9 concrete and apply sufficient heat to maintain the temperature of the air surrounding the
10 unit between 50° and 70°F.

11 When the ambient air temperature is above 70°F, start a water cure as set forth below or
12 other approved method as soon as the concrete is able to receive the water without
13 physical damage to its surface. Discontinuation of the cure is allowed upon introduction
14 of steam, provided that a relative humidity of 100% is maintained.

15 Cure at elevated temperatures at a temperature of not more than 160°F.

16 Maintain a relatively uniform rate of increase of the temperature within the curing
17 enclosure of approximately 40°F per hour, not to exceed 15°F per 15 minutes. Ensure
18 that the temperature increase is relatively uniform throughout the length and on both
19 sides and top of the concrete unit. Place recording thermometers within 50 ft of each end
20 of the bed and at points not to exceed 100 ft between the end thermometers. Provide at
21 least 2 thermometers for bed lengths of 100 ft or less. Calibrate recording thermometers
22 at intervals not to exceed 6 months. Ensure that the temperature differential within the
23 curing enclosure does not exceed 15°F. Submit complete temperature records for all
24 cures before final approval of the members.

25 Continue steam curing until the concrete reaches the required transfer strength.

26 (C) Water Curing

27 Keep the concrete continuously wet by the application of water as soon as possible
28 without damage to the concrete surface, and before the concrete obtains an initial set of
29 500 psi. Apply the water using soaker hoses and wet burlap or other approved means for
30 the full length of each member. Apply water evenly along the entire length of the bed.

31 When the ambient air temperature is below 50°F cover the forms after the placement of
32 the concrete and apply sufficient heat in an approved manner to maintain the temperature
33 of the air surrounding the member between 50°F and 70°F. After the concrete obtains
34 an initial set of 500 psi, the air temperature surrounding the member is allowed to
35 increase to 100°F while continually maintaining moisture on the surface of the concrete.
36 Whenever heat is applied to the member, place temperature recording clocks on the bed
37 as required when curing at elevated temperatures. The requirements for rate of
38 temperature increase apply.

39 Maintain the application of heat (if used) and water until the concrete obtains release
40 strength.

41 (D) Curing with Membrane Curing Compound

42 As an option, cure prestressed concrete piles with a membrane curing compound. Spray
43 the entire surface of the concrete uniformly with a wax-free, resin-base curing compound
44 conforming to Article 1026-2. Use clear curing compound to which a fugitive dye is
45 added for color contrast.

1 Apply the membrane curing compound after the surface finishing is complete, and
2 immediately after the free surface moisture disappears. In the event the application of
3 curing compound is delayed, start another curing method immediately and continue until
4 the application of the curing compound is started or resumed or until the concrete reaches
5 the required detensioning strength.

6 Seal the surface with a single uniform coating of the specified type of curing compound
7 applied at the rate of coverage recommended by the manufacturer or as directed by the
8 Engineer, but not less than one gallon per 150 sf of area.

9 At the time of use, thoroughly mix the compound in a condition with the pigment
10 uniformly dispersed throughout the vehicle. If the application of the compound does not
11 result in satisfactory coverage, stop the method and apply water curing, as set out above,
12 until the cause of the defective work is corrected.

13 At locations where the coating shows discontinuities, pinholes, or other defects, or if rain
14 falls on the newly coated surface before the film dries sufficiently to resist damage, apply
15 an additional coat of the compound immediately after the rain stops at the same rate
16 specified herein.

17 When the ambient air temperature is below 50°F, cover the forms after the application of
18 the curing compound and apply sufficient heat in an approved manner to maintain the
19 temperature of the air surrounding the member between 50°F and 70°F. Whenever heat
20 is applied to the members, place recording thermometers on the bed as required when
21 curing at elevated temperatures. The requirements for rate of temperature increase also
22 apply.

23 Completely remove any curing compound adhering to a surface to which new concrete is
24 bonded by sandblasting, steel wire brushes, bush hammers or other approved means.

25 Protect the concrete surfaces to which the compound is applied from abrasion or other
26 damage that results in perforation of the membrane film until the concrete achieves
27 design strength and the members are de-tensioned.

28 **1078-11 TRANSFER OF LOAD**

29 A producer quality control representative or equivalent qualified personnel shall be present
30 during removal of forms and during transfer of load.

31 Transfer load from the anchorages to the members when the concrete reaches the required
32 compressive strength shown in the plans. Loosen and remove all formwork in one continuous
33 operation as quickly as possible as soon as release strength is obtained. As soon as the forms
34 are removed, and after the Department's Inspector has had a reasonable opportunity to inspect
35 the member, transfer the load from the anchorages to the members as quickly as possible in
36 one continuous operation using the approved detensioning sequence.

37 For any particular group of members cast in the same bed, do not transfer the load to any
38 concrete until the test cylinder breaks indicate that the concrete in all these members has
39 reached the required strength as outlined in Subarticle 1078-4(B)(3). If these conditions are
40 not met, delay the transfer of the prestressing load to the concrete until tests of additional
41 cylinders show that the required strength is reached.

42 When curing at elevated temperatures, begin the procedures for transferring prestressing load
43 immediately after curing is discontinued and the forms are released, and while the concrete is
44 still hot to prevent cooling shrinkage and cracking. If so directed by the Engineer, cover
45 members or otherwise protect so as to cool the concrete slowly after release to prevent
46 thermal shock and the evaporation of moisture in the members.

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1 Transfer load to not cause cracks in members. Transfer load by gradual release of the strands
2 as a group, by gradual release of part of the group, or by burning the fully tensioned strands at
3 the ends of the members. If intending to release the strands by a method other than gradual
4 release of the entire group, submit 6 copies of the proposed method and pattern of release, if
5 not so shown in the plans, for approval. Rigidly follow the approved method and pattern of
6 release. When the fully tensioned strands are burned, burn each strand or group of strands
7 simultaneously at each end of the bed in its indicated order in the pattern and at each end of
8 each member before proceeding to the strands in the next group in the pattern at any point.
9 Because of the critical nature of the bond development length in prestressed concrete panel
10 construction, if transferring of stress by burning the fully tensioned strands at the ends of the
11 member, burn each strand first at the ends of the bed and then at each end of each member
12 before proceeding to the next strand in the burning pattern.

13 When detensioning all girders, box beams, cored slabs, piles, and panels do not burn strands
14 quickly but heat with a low oxygen flame played along the strand for at least 5" until the
15 metal gradually loses its strength. Apply heat at such a rate that failure of the first wire in
16 each strand does not occur until at least 5 seconds after heat is first applied. When
17 detensioning other members, follow the above procedure unless an alternate procedure is
18 approved. Detensioning by arc welder is not allowed.

19 Incorporate the following in the method for single strand detensioning of members having
20 draped strands:

21 (A) Release the pair of straight strands located in the uppermost position in the lower flange
22 first.

23 (B) Then release the tension in the draped strands at the ends and uplift points in accordance
24 with an approved pattern.

25 (C) Disengage all hold-down devices for draped strands and release the hold-downs.

26 (D) Then release the pair of straight strands located in the upper flange.

27 (E) Release the remaining straight strands of the pattern in accordance with an approved
28 sequence.

29 (F) Release all strands in a manner meeting the Engineer's approval that will cause
30 a minimum shock and lateral eccentricity of loading.

31 Failure to follow the above procedures for transfer of load is ground for rejection of the
32 members involved.

33 **1078-12 VERTICAL CRACKS IN PRESTRESSED CONCRETE GIRDERS BEFORE** 34 **DETENSIONING**

35 This section addresses prestressed concrete members that have vertical casting cracks before
36 strand detensioning. Certain types of these cracks have been determined by the Department to
37 render the girders unacceptable.

38 Unacceptable cracked members are those with 2 or more vertical cracks spaced at a distance
39 less than the member depth which extend into the bottom flange. Such members are not
40 serviceable and will be rejected. Members with 2 or more vertical cracks spaced at a distance
41 less than the member depth but do not extend into the bottom flange are subject to
42 an engineering assessment. Such members may not be serviceable and may be rejected.

43 Members with one or more vertical cracks that extend into the bottom flange and are spaced
44 at a distance greater than the member depth are subject to an engineering assessment to
45 determine their acceptability. If this engineering assessment is required, submit, at no
46 additional cost to the Department, a proposal for repairing the member and a structural
47 evaluation of the member prepared by an engineer licensed by the State of North Carolina.

1 In the structural evaluation, consider the stresses under full service loads had the member not
 2 cracked and the effects of localized loss of prestress at the crack as determined by methods
 3 acceptable to the Department.

4 All members, except those defined as unacceptable, which exhibit vertical cracks before
 5 detensioning, shall receive a 7 day water cure as directed by the Engineer. The water cure
 6 shall begin within 4 hours after detensioning the prestressing strands and shall be at least 3 ft
 7 beyond the region exhibiting vertical cracks.

8 The Department has the final determination regarding acceptability of any members in
 9 question.

10 **1078-13 PRESTRESSED CONCRETE GIRDER WEB SPLITTING**

11 After detensioning of certain girders with draped strands, cracks occasionally occur in the
 12 webs at the ends of the girders. If such cracks occur, employ a method to remedy this
 13 condition on all subsequent girders of the same type and strand pattern. If debonding of
 14 strands is used, satisfy the following criteria:

15 (A) Do not debond the 2 straight strands in the top of the girder. Debond 1/2 of the straight
 16 strands, as nearly as possible, in the bottom flange. As nearly as possible, debond 1/4 of
 17 the straight strands in the bottom of girder 4 ft from each end of the girder and debond
 18 1/4 of the straight strands 2 ft from each end of the girder.

19 (B) Use a debonding pattern that is symmetrical about the vertical axis of the girder.

20 (C) Debond strands so the center of gravity of the strands in the bottom of the girder remain
 21 within 1" of their original location at the end of the girder.

22 (D) Debond strands by encasing the strand in a conduit meeting the approval of the Engineer.
 23 Conduit may be rigid one-piece or rigid 2-piece split sheathing. Do not use flexible
 24 conduit or sheathing.

25 No separate payment is made for debonding strands as payment is included in the contract
 26 unit price bid for prestressed concrete girders.

27 **1078-14 HANDLING, TRANSPORTING AND STORING**

28 Members damaged while being handled or transported are rejected or require repair in
 29 a manner approved by the Engineer. All members are allowed to be handled immediately
 30 after transfer of load from the anchorages to the members is complete.

31 Store all prestressed members on solid, unyielding, storage blocks in a manner to prevent
 32 torsion or objectionable bending. In handling prestressed concrete girders 54" or less in
 33 height, including cored slabs and box beams, maintain them in an upright position at all times
 34 and pick them up within 5 ft of the points of bearing and transport and store supported only
 35 within 3 ft of points of bearing. In handling prestressed concrete girders greater than 54" in
 36 height, maintain them in an upright position at all times and submit for approval the proposed
 37 method of lifting, transporting, and storing the girders. When requested, provide calculations
 38 to confirm girders are not overstressed by such operations.

39 Prestressed concrete panels are weak in the direction perpendicular to the prestressing strands,
 40 therefore, they are subject to breakage during handling, storing or transporting. Provide
 41 adequate blocking during all of these construction phases.

42 In handling, transporting, and storing prestressed members, use the number and location of
 43 supports in accordance with the plan requirements for the sizes, lengths and types of members
 44 involved, or as approved.

45 When handling the prestressed concrete members, a temporary stress of $5\sqrt{f_{ci}}$ is permitted,
 46 where f_{ci} is the strength of concrete at release, in pounds per square inch.

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- 1 Do not transport members away from the casting yard until the concrete reaches the minimum
2 required 28 day compressive strength and a period of at least 5 days elapses since casting,
3 unless otherwise permitted.
- 4 Do not transfer any member from the plant to the job site before approval of that member by
5 the plant inspector. This approval is stamped on the member by the plant inspector.
- 6 **1078-15 FINAL FINISH**
- 7 Finish prestressed concrete members that are intended for composite action with subsequently
8 placed concrete or asphalt with a roughened surface for bonding. Make sure that no laitance
9 remains on the surfaces to be bonded.
- 10 Rough float the tops of girders. Broom finish the top surface of the cored slab and box beam
11 sections receiving an asphalt overlay. Rake the top surface of cored slab and box beam
12 sections receiving a concrete overlay to a depth of 3/8". No surface finish is required for sides
13 and bottom of the slab and beam sections except the exposed side of the exterior unit as noted
14 below. Provide a resulting surface finish essentially the same color and surface finish as the
15 surrounding concrete.
- 16 Provide a 3/4" chamfer along the bottom edges on ends and sides of all box beam and cored
17 slab sections, top outside edges of exterior sections and acute corners of sections. Round the
18 top edges on ends of all sections with a 1/4" finishing tool. Provide square corners along top
19 edges on all sections along shear keys. Do not chamfer vertical edges at ends of sections.
- 20 Fill all voids in the diagonal face of the bottom flange of prestressed concrete girders and the
21 outside face of exterior cored slabs and box beams with a sand-cement or other approved
22 grout. Fill all voids in piles greater than 1/2" in diameter or depth as above. Provide
23 a resulting surface finish essentially the same color and surface finish as the surrounding
24 concrete. Repair voids greater than 1/4" in diameter or depth in other faces of these and other
25 members except piles in a like manner. Where an excessive number of smaller voids exist in
26 any member, the Engineer requires a similar repair.
- 27 Repair honeycomb, excessively large fins, and other projections as directed. Submit, at no
28 additional cost to the Department, a proposal for repairing members with honeycomb, cracks
29 or spalls. Do not repair members containing honeycomb, cracks, or spalls until a repair
30 procedure is approved and the member is inspected by the Engineer. Any appreciable
31 impairment of structural adequacy that cannot be repaired to the satisfaction of the Engineer is
32 cause for rejection.
- 33 Clean and fill holes caused by strand hold downs upon removal from the casting bed. Use
34 patches of materials approved by the Engineer that develop strength at least equal to the
35 minimum 28 day strength requirement for the concrete before approval of the member.
36 Ensure that members are clean and surfaces have a uniform appearance.
- 37 Give the top surface of prestressed concrete panels a raked finish or other approved finish to
38 provide an adequate bond with the cast-in-place concrete. As soon as the condition of the
39 concrete permits, rake the top surface of the concrete making depressions of approximately
40 1/4". Take care when raking not to catch and pull the coarse aggregate.
- 41 Clean reinforcing bars exposed on the tops of girders and exterior cored slabs or box beams of
42 mortar build up and excessive rust.
- 43 Apply epoxy protective coating to the ends of prestressed members as noted in the plans.

1 **1078-16 ALIGNMENT AND DIMENSIONAL TOLERANCES**

2 **(A) Piles**

3 Manufacture piles within the tolerances indicated in Table 1078-3 and Figure 1078-1.

4 **(B) Cored Slabs**

5 To ensure a good, neat field fit, assemble cored slab spans in the yard and have pieces
6 matchmarked. Ensure that pieces fit together neatly and in a workmanlike manner.

7 Manufacture cored slabs within the tolerances indicated in Table 1078-4 and
8 Figure 1078-2.

9 **(C) Girders**

10 Manufacture girders within the tolerances indicated in Table 1078-5 and Figure 1078-3.

11 **(D) Prestressed Concrete Panels**

12 Manufacture prestressed concrete panels within the tolerances indicated in Table 1078-6.

13 **(E) Box Beams**

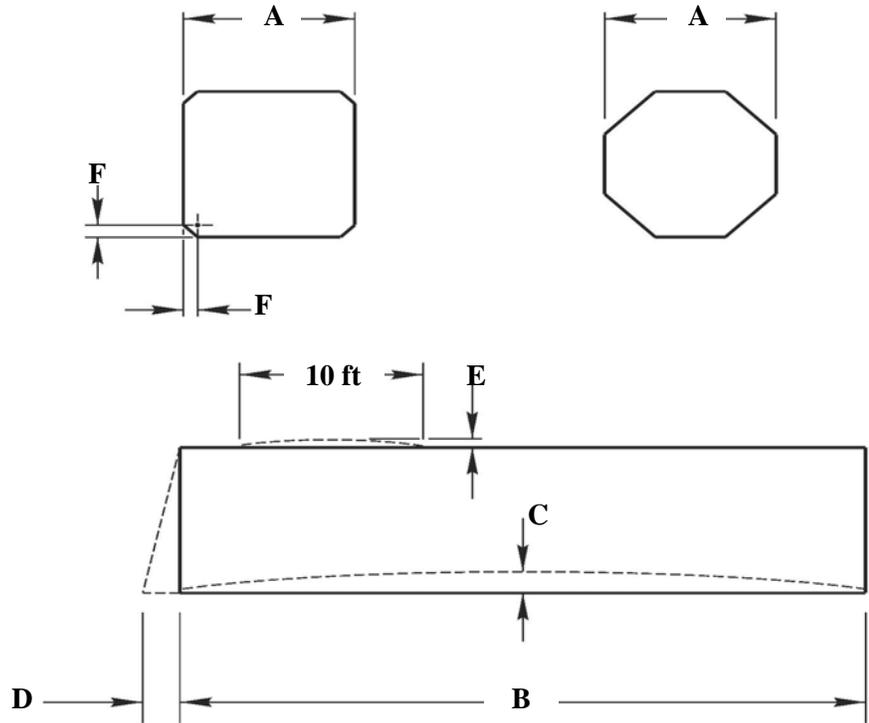
14 To ensure a good, neat field fit, assemble box beam spans in the yard and have pieces
15 match-marked. Ensure that pieces fit together neatly and in a competent manner.

16 Manufacture box beams within the tolerances indicated in Table 1078-7 and
17 Figure 1078-4.

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1 1078-17 IDENTIFICATION OF MEMBERS

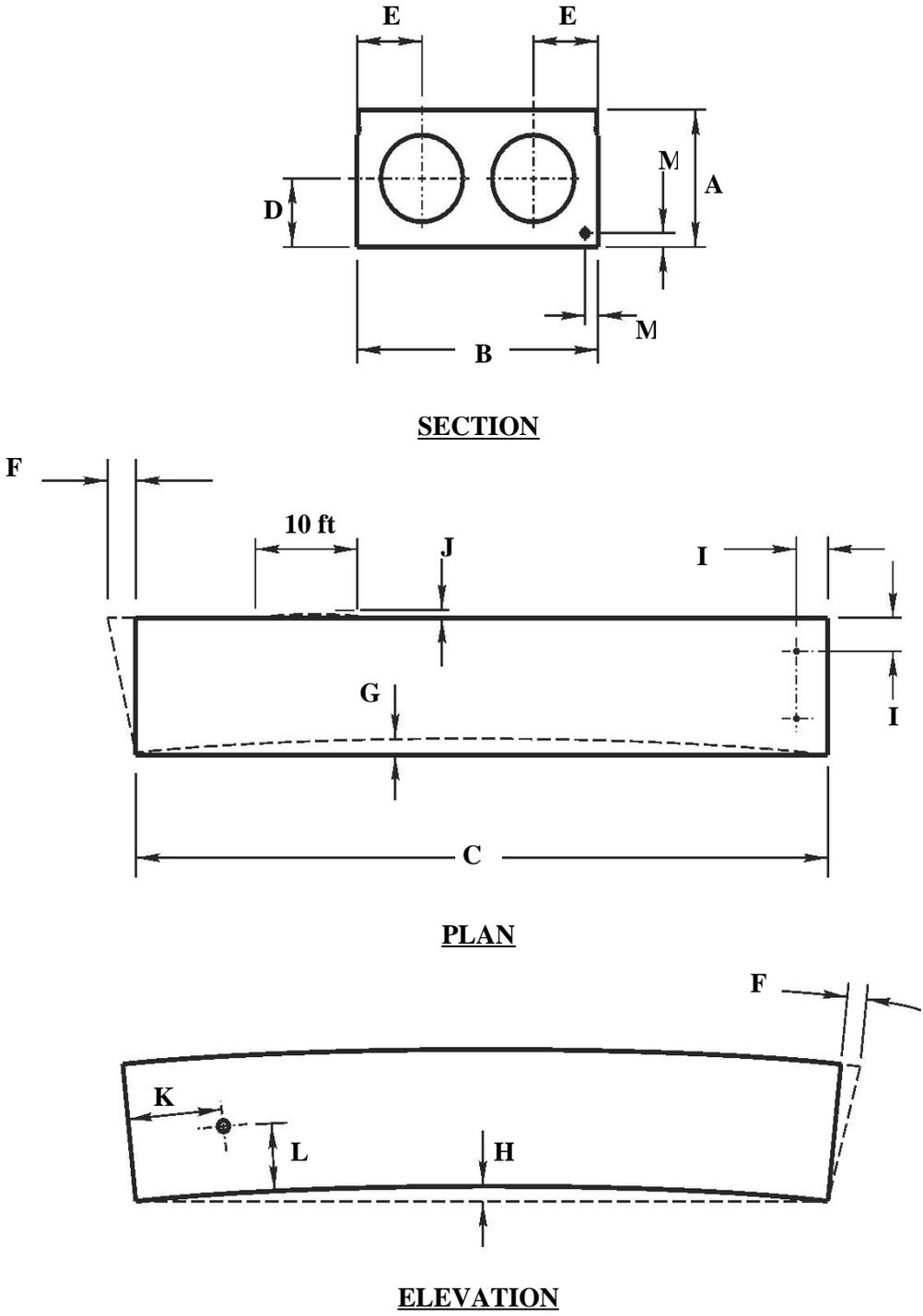
- 2 Permanently identify each prestressed member by number and date of manufacture, and paint
- 3 this information, or otherwise mark as approved by the Engineer, on at least one end of the
- 4 member as soon as practical after manufacture. In the case of girders or cored slabs, paint
- 5 other identification as to station, span and position within the span on at least one end of the
- 6 member.



7 **Figure 1078-1. Prestressed Piles.** Dimensions shown are in Table 1078-3.

TABLE 1078-3
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"

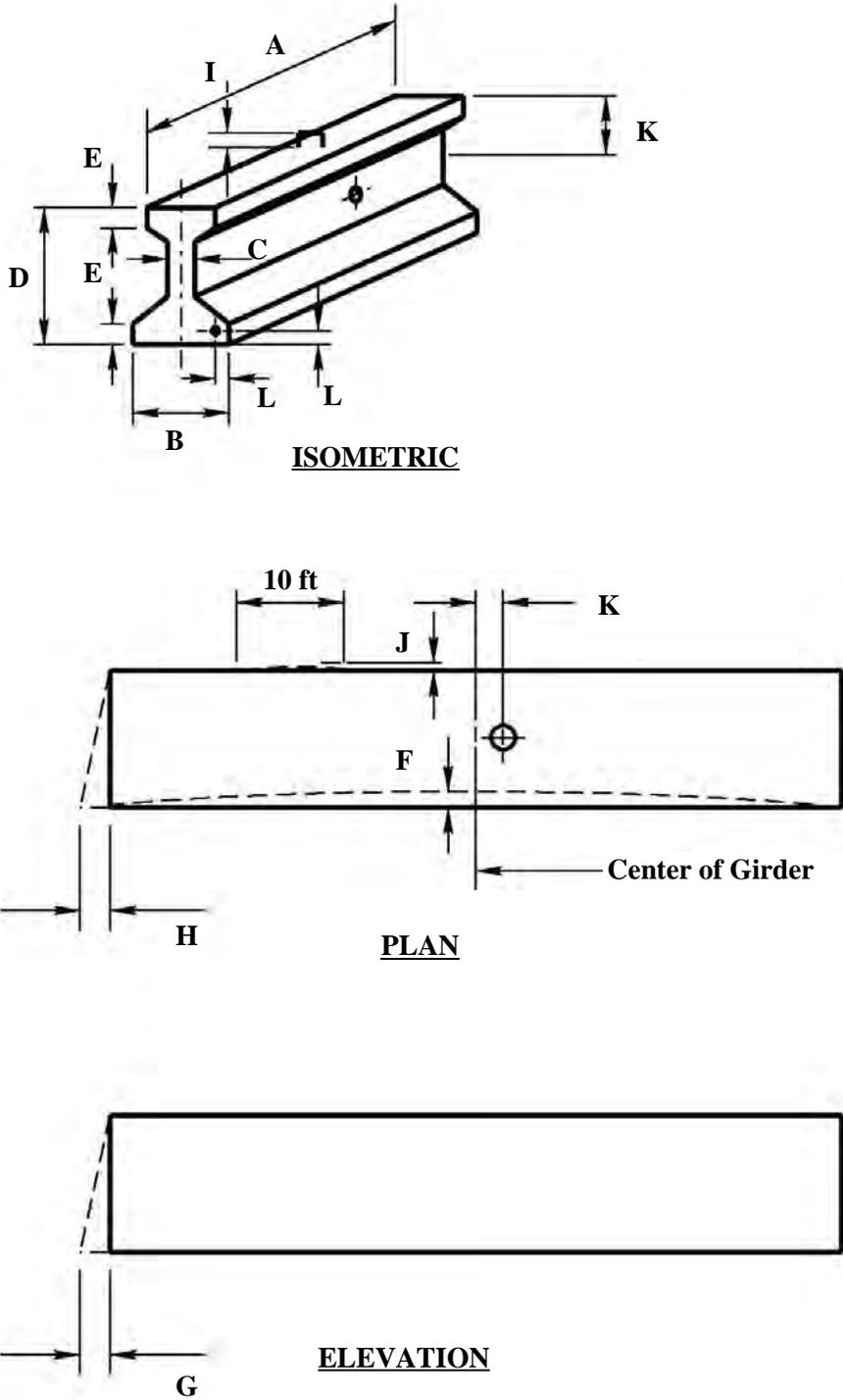


1 Figure 1078-2. Prestressed cored slabs. Dimensions shown are in Table 1078-4.

TABLE 1078-4 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"

1 **1078-18 QUALITY CONTROL**

- 2 Maintain a daily quality control record form approved by the Engineer including pertinent
3 information concerning tensioning, concrete quality and placement, curing and detensioning.
4 Have this form signed and dated by a certified concrete technician. Furnish a copy of the
5 completed or up-to-date form to the Materials and Tests Unit upon request and before any
6 members are approved. A sample form, indicating the minimum required information, is
7 available from the Materials and Tests Unit.



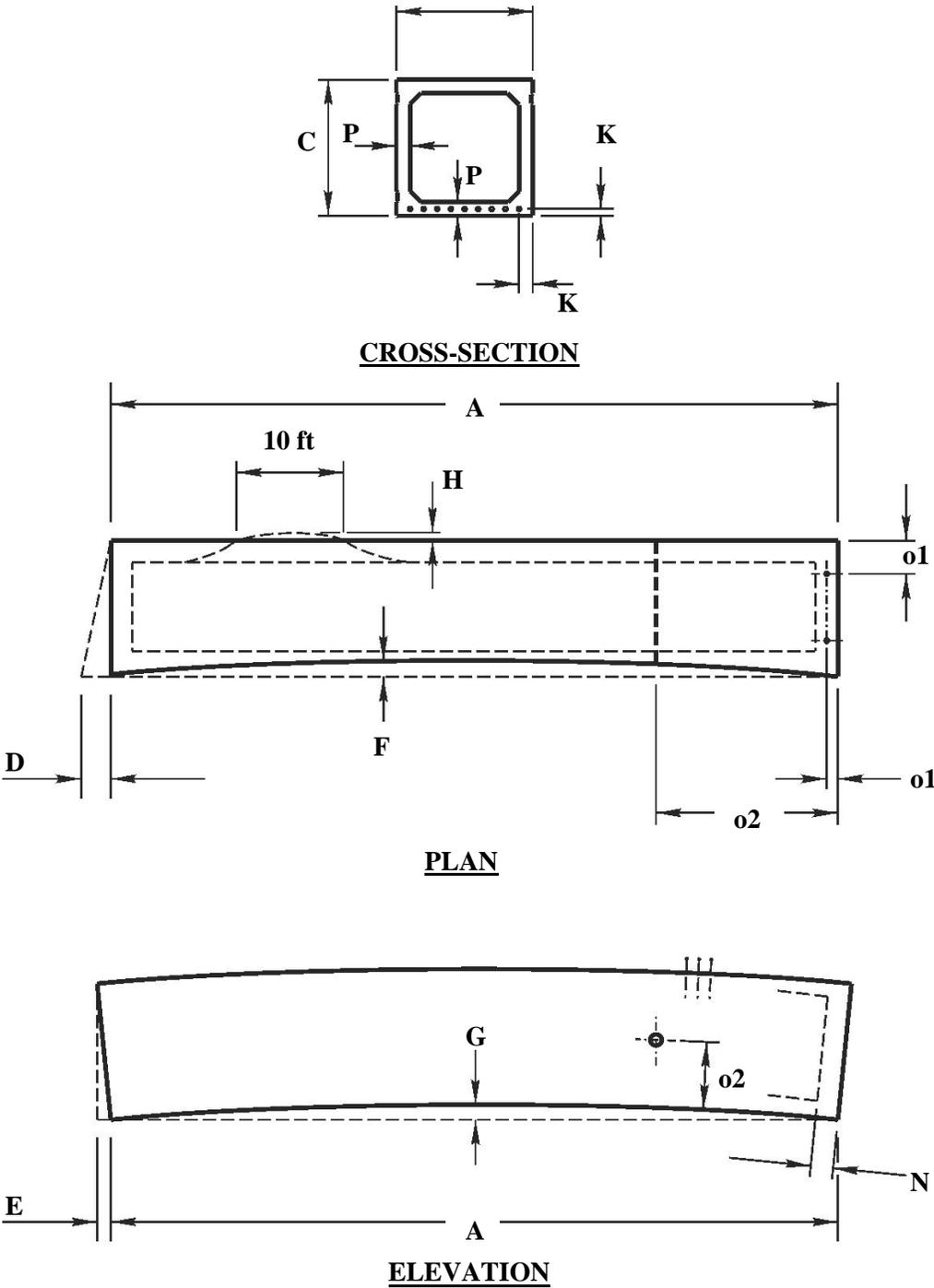
1 Figure 1078-3. Prestressed Girders. Dimensions shown are in Table 1078-5.

TABLE 1078-5 TOLERANCES FOR PRESTRESSED GIRDERS (Refer to Figure 1078-3)	
Dimension	Tolerance
Length (A) Girders 80 ft. or shorter	$\pm 1/8$ " per 10 ft
Length (A) Girders longer than 80 ft.	$\pm 1/8$ " 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)	$\pm 1/4$ "
Horizontal alignment (top or bottom flange) Deviation from a straight line parallel to the centerline of beam (F)	$\pm 1/8$ " per 10 ft Not to exceed 1"
Bearing plate Deviation from plane surface	1/16"
Girder ends Deviation from square or designated skew (G and H)	Vertical (G): $\pm 1/8$ " per 12" of girder height Horizontal (H): $\pm 1/2$ "
Position of stirrups - Projection above top of girder (I)	$\pm 1/2$ "
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)	$\pm 1/4$ "
Position of strands (L)	$\pm 1/4$ "

- 1 Dimensions followed by an alphabetical suffix are shown in Figure 1078-3. The length (A) is
 2 measured along the top of the top flange. The tolerances at girder ends (G and H) are
 3 increased to 1" if the girder end is to be encased in a full depth concrete diaphragm.

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TABLE 1078-6 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	$\pm 1/8$ "
Vertical Dimension	$\pm 1/2$ "



1 **Figure 1078-4. Prestressed Box Beams.** Dimensions shown are in Table 1078-7.

TABLE 1078-7 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 blackout (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"

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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" with a tolerance of $\pm 1/16"$. Use cotton duck that meets Military Specification MIL-C882-D 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.

Manufacturers shall be pre-qualified by the Department and shall submit working drawings for approval. Refer to Subarticles 1079-2(D) and 1079-2(E). Furnish a Type 3 certification in accordance with Article 106-3 certifying that elastomeric bearings satisfy this Specification and all design criteria. Include the lot number, description and test results in the certification.

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1 (B) Elastomer Properties

2 The elastomer for all bearings shall be classified as Grade 3.

3 The shear modulus of the elastomer for laminated (reinforced) bearings shall be 160 psi,
4 unless otherwise noted in the plans.

5 Provide Grade 50 or Grade 60 durometer hardness elastomer in all (unreinforced)
6 bearings, unless otherwise noted in the plans.

7 (C) Testing

8 The optional test procedures of AASHTO M 251 are not required, except as specified
9 herein.

10 Determine the shear modulus of the elastomer for laminated (reinforced) bearings in
11 accordance with ASTM D4014.

12 At the Manufacturer's option, plain (unreinforced) bearings may be tested using the
13 methods of Appendices X1 and X2 of AASHTO M 251.

14 Test at least 2 bearings per lot or as directed by the Engineer. Define a "lot" as a group
15 of 100 or less bearings with or without holes or slots, which are:

16 (1) Manufactured in a reasonably continuous manner from the same batch of elastomer
17 and cured under the same conditions, and

18 (2) Of the same type (plain or laminated) and of similar size (no dimensions shall vary
19 by more than 40%).

20 A lot may include bearings from multiple projects and purchasers.

21 (D) Working Drawings

22 Submit 6 sets of detailed fabrication drawings of laminated (reinforced) bearings to the
23 Engineer for review, comments and acceptance. Show complete details and all material
24 specifications. Clearly identify any proposed deviations from details shown in the plans
25 or requirements of the Standard Specifications. Obtain drawing approval before
26 manufacturing of the bearings.

SECTION 1080

PAINT AND PAINT MATERIALS

27

28 1080-1 GENERAL

29 Deliver all paints except 2 component products to the project completely mixed and ready for
30 use without additional oil or thinner. Mix 2 component paints in accordance with the
31 manufacturer's printed instructions and shall not need additional oil or thinner upon mixing,
32 except where necessitated by weather conditions. Mixed paints or paint components that
33 harden or curdle in the container and will not break up with a paddle to form a smooth,
34 uniform consistency will be rejected. Any thinning necessitated by weather conditions shall
35 be approved in writing and use only those thinners approved by the manufacturer. Store all
36 paint materials in a moisture free environment between 40°F and 110°F or at such
37 temperatures within this range recommended by the manufacturer.

38 1080-2 PAINT VEHICLES, THINNERS AND DRIERS

39 Paint vehicles, thinners and dryers shall meet the requirements for these ingredients that are
40 included in the *Standard Specifications* for the paint being used. Only ingredients
41 recommended by the manufacturer which have a history of compatibility with each other may
42 be used.

1 1080-3 PACKING AND MARKING

2 Ship paint and paint materials in strong, substantial containers that are properly labeled and
3 plainly marked with the weight, color and volume in gallons of the paint content; a true
4 statement of the percentage composition of the pigment; the proportions of pigment to
5 vehicle; and the name and address of the manufacturer. Any package or container not so
6 marked as described above or exceeding 5 gallons total volume will not be accepted for use.

7 1080-4 INSPECTION AND SAMPLING

8 All paint will be sampled, either at the point of manufacture or at the point of destination.
9 Inspection and sampling will be performed at the point of manufacture wherever possible.
10 The Contractor shall not begin painting until the analysis of the paint has been performed, and
11 the paint has been accepted by the Engineer.

12 Use only pre-qualified inorganic zinc paint manufactured in accordance with the requirements
13 shown below.

14 Ensure the paint manufacturer submit the following at the same time to the State Materials
15 Engineer:

16 **(A)** A minimum one quart sample of each component of paint including the manufacturer's
17 name, location, product name, mixing instructions, batch number and MSDS.

18 **(B)** At least 3 panels prepared as specified in 5.5.10 of AASHTO M 300.

19 **(C)** A certified test report from an approved independent testing laboratory as specified in
20 5.5.8 and 5.5.9 of AASHTO M 300.

21 **(D)** A certified report from an approved independent testing laboratory that the product has
22 been tested for slip coefficient and meets AASHTO M 253, Class B.

23 Use the same batch of paint for all samples and panels. The independent testing laboratory
24 Report may be for a typical batch of the same product. Submit samples and reports for
25 qualification at least 30 days in advance of anticipated need. Once qualified, a product will be
26 placed on North Carolina's approved list for 5 years unless the formulation of the product or
27 manufacturing process is changed, in which case the product shall be requalified before use.

28 The Materials and Tests Unit will conduct all tests of paints in accordance with the latest
29 ASTMs, Federal Test Method Standard No. 141 and various other methods in use.

30 1080-5 RED PRIMER PAINT**31 (A) Scope**

32 This Specification covers a long oil-alkyd primer paint for use on steel surfaces blast-
33 cleaned to a SSPC-SP 6 finish. The paint may be applied by brushing or spraying to
34 a wet film thickness of approximately 3 wet mils per coat.

35 (B) Materials

36 Materials shall be as specified herein. Materials not specified shall be selected by the
37 supplier and will be subject to all of the requirements of this Specification. Use paint
38 made of materials that are not toxic to personnel under normal conditions of use.

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**TABLE 1080-1
PROPERTIES OF FOR RED PRIMER PAINT**

Property	Minimum	Maximum
Pigment % by Weight	53%	55%
Vehicle % by Weight	-	47%
Weight per Gallon	12.9 lb	-
Solids % by Volume	67.0%	-
Fineness of Grind Hegman Units	4.5	-
Moisture Content % by Weight	-	0.5
Skinning hrs (3/4 vol. in Closed Container)	48	-
Viscosity	85 KU	95 KU
Drying Time, Set to Touch	-	6 hrs
Drying Time, Dry Through	-	18 hrs
Adhesion ^A at 14 days (ASTM D3359)	3B	-
Volatile Organic Compounds per Gallon	-	2.8 lb

- 1 A. Prepare the specimen for the adhesion test by applying 2 dry mils of the coating
2 to a standard Q panel.

**TABLE 1080-2
COMPOSITION OF PIGMENTS FOR RED PRIMER PAINT, % BY WEIGHT**

Pigment	Minimum	Maximum
Zinc Hydroxy Phosphite	73%	-
Red Iron Oxide (86% Fe ₂ O ₃)	24%	-
Organo Montmorillonite	-	1%

**TABLE 1080-3
COMPOSITION OF VEHICLES FOR RED PRIMER PAINT, % BY WEIGHT**

Vehicle	Minimum	Maximum
Non-Volatile	62%	-
Alkyd Resin Solids Fed. Spec TT-4-266, Type 1, Class A	40%	-
Linseed Oil (ASTM D234)	20%	-
Linseed Oil to Alkyd Ratio	1.2%	-
Thinner and Dryer Thinner: Fed. Spec. TT-T291, Type 2 Gr. A Dryer: Fed. Spec. TT-D-643B	38%	-

3 **1080-6 ALKYD FINISH PAINT**

4 **(A) Scope**

5 This article covers a gray, long oil-alkyd primer paint for use over surfaces coated with
6 Red Alkyd Primer Paint. The paint may be applied by brushing or spraying to a wet film
7 thickness of approximately 3 wet mils per coat.

8 **(B) Materials**

9 Materials shall be as specified herein. Materials not specified will be selected by the
10 supplier and be subject to all of the requirements of this Specification. Use paint made of
11 materials which are not toxic to personnel under normal conditions of use.

**TABLE 1080-4
PROPERTIES OF ALKYD FINISH PAINT**

Property	Minimum	Maximum
Pigment % by Weight	47%	-
Vehicle % by Weight	-	54%
Weight per Gallon	11.0 lb	-
Solids % by Volume	54.0%	-
Fineness of Grind Hegman units	6.0	-
Moisture Content % by Weight	-	0.5
Skinning hrs (3/4 vol. in Closed Container)	48	-
Viscosity	90 KU	100 KU
Drying Time, Set to Touch	-	6 hrs
Drying Time, Dry Through	-	18 hrs
Adhesion ^A at 14 days (ASTM D3359)	3B	-
Volatile Organic Compounds per Gallon	-	3.5 lb
Lead Content % by Weight Dry Film	-	0.05%
Color (Federal Color Standard 595)	26622 (Gray)	-

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- A.** Prepare the specimen for the adhesion test by applying 2 dry mils of the coating to a standard Q panel.

**TABLE 1080-5
COMPOSITION OF PIGMENTS FOR ALKYD FINISH PAINT,
% BY WEIGHT**

Pigment	Minimum	Maximum
Zinc Hydroxy Phosphite ASTM D4462	20%	-
Titanium Dioxide ASTM D476 TY-II	50%	-
Magnesium Silicate	15%	-
Tinting and Inert Pigments	-	12%

**TABLE 1080-6
COMPOSITION OF VEHICLES FOR ALKYD FINISH PAINT,
% BY WEIGHT**

Vehicle	Minimum
Non-Volatile	62%
Alkyd resin solids	40%
Fed. Spec TT-4-266, Type 1, Class A	40%
Linseed oil (ASTM D234)	20%
Linseed oil to Alkyd ratio	1.2%
Thinner and Dryer	38%
Thinner: Fed. Spec. TT-T291, Type 2 Gr. A	38%
Dryer: Fed. Spec. TT-D-643B	38%

3 **1080-7 SELF-CURING INORGANIC ZINC PAINT**

4 Use a self curing inorganic zinc paint meeting the Type I Inorganic Zinc Primer paint
5 specified in AASHTO M 300 and the following:

6 **(A)** Use mixed paint with zinc content of not less than 72% by mass of the total solids.

7 **(B)** The slip coefficient meets AASHTO M 253, Class B.

8 **(C)** The adhesion shall be no less than 400 psi in accordance with ASTM D4541.

9 **(D)** Cure the paint to meet the solvent rub requirements in ASTM D4752.

10 **(E)** Formulate the paint to produce a distinct contrast in color with the blast cleaned metal
11 surfaces and with the finish paint.

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1 **1080-8 COAL TAR EPOXY PAINT**

2 Use coal tar epoxy paint meeting SSPC-Paint 16.

3 **1080-9 ORGANIC-ZINC REPAIR PAINT**

4 Use organic-zinc repair paint meeting SSPC-Paint 20 Type II or Federal
5 Specification TT-P-641. Organic-zinc repair paint is not tinted and is applied 3 to 4 wet mils
6 of paint per coat. Do not use zinc paint in aerosol spray cans.

7 **1080-10 WASH PRIMER PAINT**

8 Use wash primer paint meeting SSPC-Paint 27.

9 **1080-11 WATERBORNE PAINTS**

10 **(A) Paints**

11 (1) Waterborne Primer Paints

12 The chemical requirements of the brown and white primer paints are specified in
13 Tables 1080-7 through 1080-10. Use primer paints on roughened steel surfaces
14 cleaned to an SSPC-SP 6 finish. Two coats of paint are required to form an effective
15 primer coat. The first coat is brown and the second is white. Each coat is applied at
16 a wet film thickness of approximately 6 mils.

17 (2) Waterborne Finish Paints

18 The chemical requirements of the gray and green finish paints are specified in
19 Tables 1080-11 through 1080-14. Apply finish paints over compatible primer paints.
20 Apply either one or 2 coats at a wet film thickness of approximately 6 mils each to
21 produce an effective finish coat.

22 **(B) Description**

23 The acrylic paints furnished in accordance with this Specification are one component
24 products made from acrylic resins with sufficient additives, coalescing agents, solvents
25 and pigmentation to produce a durable paint.

26 These products are intended for brush, roller or spray application applied in accordance
27 with SSPC-PA 1.

28 **(C) Composition**

29 Use ingredients and proportions as specified in Tables 1080-7 through 1080-14. Do not
30 use Chrome Green.

31 Provide raw materials based on the specified ingredients that are uniform, stable in
32 storage, and free from grit and coarse particles. Do not use rosin or rosin derivatives.
33 Beneficial additives such as anti-skinning agents, suspending agents or wetting aids are
34 allowed.

35 **(D) Properties**

36 (1) General

37 Use both Type I and II paints that meet Tables 1080-7 through 1080-14.

38 (2) Odor

39 Normal for the materials permitted in accordance with ASTM D1296.

- 1 (3) Color
- 2 (a) Waterborne Primer Paint
- 3 The color before and after weathering when compared with Federal Test Method
4 Standard No. 595B is Brown #30045 for Type I. There are no color
5 requirements for the white primer.
- 6 (b) Waterborne Finish Paint
- 7 The colors before and after weathering when compared with Federal Test
8 Method Standard No. 595B are Green #24108 for Type I and Gray #26622 for
9 Type II.
- 10 (4) Working Properties
- 11 Use a paint that is easily applied by brush, roller or spray when tested in accordance
12 with Federal Test Method Standard No. 141, Methods 4321, 4331 and 4541. Ensure
13 that the paint shows no streaking, running or sagging during application or while
14 drying.
- 15 (5) Condition In Container
- 16 Ensure that the paint shows no thickening, curdling, gelling or hard caking when
17 tested as specified in Federal Test Method Standard No. 141, Method 3011, after
18 storage for 6 months from the date of delivery, in a full, tightly covered container, at
19 a temperature of 50°F to 110°F.
- 20 (6) Skinning
- 21 No skinning is allowed in a 3-quarters filled closed container after 48 hours when
22 tested in the standard manner specified in Federal Test Method Standard No. 141,
23 Method 3021.
- 24 (7) Salt Contamination
- 25 Minimize the content of salt contamination by the incorporation of only high purity
26 materials. Ensure that the specific resistance of the aqueous leachate of the
27 composite of the pigments in required proportions is at least 5,000 ohm-cm when
28 tested in accordance with ASTM D2448.
- 29 (8) Early Rust Resistance
- 30 Provide each type of paint that meets the early rust requirements specified in
31 Materials and Tests Standards CLS-P-1.0.
- 32 (9) Directions For Use
- 33 Supply the following directions for use with each container of paint:
- 34 Waterborne primer paint is intended for use as a primer over rough, bare structural
35 steel. It is not intended for use over other paint systems. Waterborne finish paint is
36 intended for use as a topcoat over a compatible primer in atmospheric exposure. Mix
37 the paint thoroughly before use. For roller, brush or airless spray application, no
38 thinning should be necessary. A minimum amount of thinning may be necessary for
39 conventional air spray. Apply by brush or spray to the specified film thickness, or if
40 none is specified, to at least 2 mils dry or approximately 6 mils wet. Dry the surface
41 to be painted and ensure that the surface temperature is at least 5°F above the dew
42 point, the humidity is less than 85%, and the temperature of the air is over 50°F. Do
43 not paint outdoors in rainy weather or if freezing temperatures are expected before
44 the paint dries. Allow the paint at least 24 hours drying time before recoating.

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1 (E) Inspection

2 All materials supplied under this Specification are subject to random inspection by the
3 Department.

4 Supply samples of any or all ingredients used in the manufacture of this paint, along with
5 the supplier's name and identification for the material when requested.

6 (F) Volatile Organic Compound (VOC) Content

7 Ensure that the VOC content after formulation, but before thinning, complies with the
8 VOC limit for the applicable coatings category per Federal regulations. Notify the
9 coating specifier if State or local regulations reduce the maximum VOC content
10 permitted for coatings applied in a specific locality.

11 (G) Color Variation

12 A color variation of 5 ΔE units from the specified color will be acceptable. After
13 3 months weathering, the color shall not vary more than 5 ΔE units from the original color
14 value.

**TABLE 1080-7
COMPOSITION OF PIGMENTS FOR WATERBORNE PRIMER PAINTS,
% BY WEIGHT**

Characteristics	Minimum	Maximum	Test Method
<u>PIGMENT CONTENT:</u>			
Type I (Brown)	20%	25%	ASTM D3723
Type II (White)	35%	40%	ASTM D3723
<u>VOLATILES:</u>			
Type I (Brown)	-	2.0 lb/gal	ASTM D2369
Type II (White)	-	2.0 lb/gal	ASTM D2369
Coarse Particles and Skins, as Retained on Std. 325 Mesh Screen	-	0.5%	ASTM D185
Rosin or Rosin Derivatives	-	0	ASTM D1542

**TABLE 1080-8
COMPOSITION OF PIGMENTS FOR WATERBORNE PRIMER PAINTS,
% BY WEIGHT**

Pigments	Type I (Brown)		Type II (White)		Test Method
	Minimum	Maximum	Minimum	Maximum	
<u>MAJOR PIGMENTS:</u>					
Pigments	20%	25%	35%	40%	ASTM D3723
Calcium Carbonate	-	-	30%	-	ASTM D1159
Magnesium Silicate	-	-	-	12%	ASTM D605
Titanium Dioxide	-	-	45%	-	ASTM D476, Type II
Zinc Phosphate	10%	-	10%	-	NCDOT M&T P-10
Iron Oxide	45%	-	-	-	ASTM D3721
<u>TINTING PIGMENTS:</u>					
Lamp Black	-	-	2%	-	ASTM D209
Phthalocyanine Pigments	-	-	-	2%	ASTM D1135 and D3256
Acid Soluble Pigments ^A	-	-	-	0	-
Lead	-	0.005%	-	0.005%	-

1

A. Use a 5% acetic acid solution with a pH 4 + 2 to determine solubility.

**TABLE 1080-9
COMPOSITION OF VEHICLES FOR WATERBORNE PRIMER PAINTS,
% BY WEIGHT**

Vehicle	Type I (Brown)		Type II (White)		Test Methods
	Minimum	Maximum	Minimum	Maximum	
Total Vehicle	73%	80%	60%	65%	NCDOT M&T P-10
HG-56 ^A Solids	30%	-	30%	-	-
Water	-	55%	-	55%	-
Methyl Carbitol	5%	-	5%	-	-
Texanol	2%	-	2%	-	-

2

A. Or approved equivalent.

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TABLE 1080-10 PROPERTIES OF WATERBORNE PRIMER PAINTS			
Property	Minimum	Maximum	Test Method
Consistency ^A Shear Rate 200 rpm, Ounces	255	350	ASTM D562
Consistency ^A Shear Rate 200 rpm, Krebs units	3.2	3.5	ASTM D562
Density, lb/US gal, Type I (Brown)	9.7	-	ASTM D1475
Density, lb/US gal., Type II (White)	11.0	-	ASTM D1475
Fineness of Grind, Hegman Units	5.0	-	ASTM D1210
Drying Time, Hours, Tack Free	-	3	ASTM D1640
Drying Time, Hours, Dry Hard	-	24	ASTM D1640
Flash Point, °F	Report Value	Report Value	ASTM D3278
Early Rust	9	-	NCDOT M&T CLS-P-1.0
Leneta Sag Test	10+	-	-
Gloss, Specular @ 60°	Report Value	Report Value	-
pH	8.0	8.5	-
Adhesion ^B	4B	-	ASTM D3359
Color, Fed. Std. 595B, Type I (Brown)	30045	-	ASTM D2244
Color, Fed. Std. 595B, Type II (White)	NA	-	ASTM D2244

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4

- A.** Consistency 48 hours or more after manufacture.
- B.** Prepare the specimen for adhesion by applying 2 dry mils of coating to a 3" x 5" x 0.25" steel panel cleaned to a minimum SSPC-SP 6 finish with a 1.7 + 0.5 mil profile.

Characteristics	Minimum	Maximum	Test Method
<u>PIGMENT CONTENT:</u>			
Type I (Green)	13%	17%	ASTM D3723
Type II (Gray)	13%	17%	ASTM D3723
<u>VOLATILE:</u>			
Type I (Green)	-	2.0 lb/gal	ASTM D2369
Type II (Gray)	-	2.0 lb/gal	ASTM D2369
Coarse Particles and Skins, as Retained on Std. 325 Mesh Screen	-	0.5%	ASTM D185
Rosin or Rosin Derivatives	-	0%	ASTM D1542-93

Pigment	Type I(Green)		Type II (Gray)		Test Method
	Minimum	Maximum	Minimum	Maximum	
<u>MAJOR PIGMENTS:</u>					
Pigments	13%	17%	13%	17%	ASTM D3723
Calcium Carbonate	-	-	-	-	ASTM D1159
Magnesium Silicate	-	-	-	-	ASTM D605
Titanium Dioxide	5%	-	70%	-	ASTM D476, Type II
Zinc Phosphate	10%	-	10%	-	NCDOT M&T P-10
<u>TINTING PIGMENTS:</u>					
Lamp Black	-	-	-	-	ASTM D209
Phthalocyanine Green	0%	-	0%	-	ASTM D3021
Red Iron Oxide	-	-	-	-	ASTM D3721
Yellow Iron Oxide	-	-	-	-	ASTM D768
Acid Soluble Pigments ^A	-	-	-	0%	-
Lead	-	0.005%	-	0.005%	-

1

A. Use a 5% acetic acid solution with a pH 4 + 2 to determine solubility.

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TABLE 1080-13 COMPOSITION OF VEHICLES FOR WATERBORNE FINISH PAINTS, % BY WEIGHT					
Vehicle	Type I	Green	Type II	Gray	Test Method
	Minimum	Maximum	Minimum	Maximum	
Total Vehicle	83%	87%	83%	87%	NCDOT M&T P-10
HG-56 ^A Solids	30%	-	30%	-	-
Water	-	58%	-	58%	-
Methyl Carbitol	5%	-	5%	-	-
Texanol	4%	-	4%	-	-

1 A. Or approved equivalent.

TABLE 1080-14 PROPERTIES OF WATERBORNE FINISH PAINTS			
Property	Minimum	Maximum	Test Methods
Consistency ^A Sheer Rate 200 rpm, Ounces	255	350	ASTM D562
Consistency ^A Sheer Rate 200 rpm, Krebs Units	90	100	ASTM D562
Density, lb/US gal, Type I (Brown)	9.35	-	ASTM D1475
Density, lb/US gal, Type II (White)	9.35	-	ASTM D1475
Fineness of Grind, Hegman Units	5.0	-	ASTM D1210
Drying Time, Hours, Tack Free	-	3	ASTM D1640
Drying Time, Hours, Dry Hard	-	24	ASTM D1640
Flash Point, °F	Report Value	Report Value	ASTM D3278
Early Rust	9	-	NCDOT M&T CLS-P-1.0
Leneta Sag Test	10+	-	-
Gloss, Specular @ 60°	40	-	-
pH	8.0	8.5	-
Adhesion ^B	4B	-	ASTM D3359
Color, Fed. Std. 595B, Type I (Green)	24108	-	ASTM D2244
Color, Fed. Std. 595B, Type IB (NC Green)	24272	-	ASTM D2244
Color, Fed. Std. 595B, Type II (Gray)	26622	-	ASTM D2244

2 A. Consistency 48 hours or more after manufacture.

3 B. Prepare the specimen for adhesion by applying 2 dry mils of coating to
4 a 3" x 5"x 0.25" steel panel cleaned to at least a SSPC-SP 6 finish with
5 a 1.7 + 0.5 mil profile.

1 **1080-12 PAINT FOR VERTICAL MARKERS**

2 For vertical markers, use a waterborne acrylic or alkyd type material meeting Table 1080-15.
 3 Apply sufficient paint to completely cover the color of the underlying substrate along with
 4 any surface imperfections.

TABLE 1080-15		
PROPERTIES OF PAINT FOR VERTICAL MARKERS		
Property	Requirement	Test Method
Color	# 27040 Black or # 13538	Federal Color Std. 595
Adhesion to Substrate	3A Min.	ASTM D3359

5 **1080-13 ABRASIVE MATERIALS FOR BLAST CLEANING STEEL**

6 Select the gradation of the abrasive to impart the anchor profile specified.

7 **(A) Expendable Abrasive**

8 Use blasting abrasives with a suitable steel or mineral abrasive containing no more than
 9 100 ppm of any corrosive compound such as sulfate or chloride or 100 ppm of any
 10 EPA characteristic waste compound such as lead, chromium or arsenic.

11 **(B) Recyclable Steel Grit**

12 Use abrasives that when sampled at any time during the blasting process, contain no more
 13 than 100 ppm of any corrosive compound such as sulfate or chloride or 1,000 ppm of any
 14 EPA characteristic waste compound such as lead, chromium or arsenic. Maintain the size
 15 and shape of the abrasive to impart the specified profile.

16 **1080-14 FIELD PERFORMANCE AND SERVICE**

17 Do not use paint products inspected by the Engineer and found to exhibit poor performance in
 18 similar North Carolina environments. Poor performance is defined as any coating failing to
 19 meet ASTM D610, Grade 5, or having greater than 3% rusting or disbonding before attaining
 20 5 years of service.

21 **SECTION 1081**
 22 **EPOXY AND ADHESIVES**

23 **1081-1 EPOXY RESIN SYSTEMS**24 **(A) Classification**

25 The types of epoxies and their uses are as shown below:

26 **Type 1** - A low-modulus, non-sag gel adhesive used to bond or repair damp, vertical or
 27 overhead surfaces. Typical applications include walls, concrete foundations, concrete
 28 pipe, conduit and ceilings.

29 **Type 2** - A low-modulus, general-purpose adhesive used in epoxy mortar repairs and
 30 broadcast sand sealing operations. Bridge Maintenance uses it as both a primer coat and
 31 thickness-building second coat in 2-stage sand broadcast operations to seal and skid-
 32 proof bridge decks. As a repair material, it may be used to patch spalled, cracked or
 33 broken concrete where vibration, shock or expansion and contraction is expected.
 34 Feather-edged patching is not recommended with this material; instead, the adjacent
 35 concrete perimeter should be sawed at least 1/4" to 1/2" deep and any remaining concrete
 36 chipped away to provide a vertical interface between the epoxy mortar and concrete.

37 **Type 3** - A high-modulus general-purpose adhesive used to bond plastic concrete or
 38 hardened concrete to hardened concrete or other structural materials. It may be used to
 39 produce a high-strength epoxy mortar grout bed for equipment or to patch interior spalls,
 40 cracks or broken concrete. It is not recommended for exterior patching because its rate of

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1 thermal expansion and contraction differs too greatly from concrete. It may be used for
2 anchoring bolts where a flowable adhesive is required.

3 **Type 3A** - A gel-like version of Type 3, used specifically for embedding dowel bars,
4 threaded rods, rebars and other fixtures in hardened concrete. The manufacturer shall
5 submit test results showing that the bonding system will obtain 125% of the specified
6 yield strength of the anchor fixture in concrete with a minimum compressive strength of
7 3,000 psi. Plans may call for field testing of adhesively anchored fixtures.

8 **Type 4A** - A gray protective coating for concrete, wood, steel and other structural
9 materials. It is typically used as a topcoat in waterproofing concrete exposed to splash
10 zones and tidal water.

11 **Type 4B** - A red primer coating used with Type 4A.

12 **Type 5** - A high modulus, low viscosity adhesive suitable for pressure injection into
13 cracks in concrete. For some non-structural crack repairs, Type 5 epoxy may be poured
14 on the surface to penetrate cracks by gravity. This may be beneficial before
15 waterproofing and skid proofing.

16 **Type 6A** - An adhesive for bonding raised traffic markers to concrete or asphalt surfaces.
17 Part A shall be pigmented white, Part B black so when the components are combined
18 a uniform gray color results.

19 **Type 6B** - A normal-setting self-leveling adhesive for bonding traffic markers in recessed
20 areas on concrete and asphalt. Type 6A color requirements apply.

21 **Type 6C** - A rapid-setting adhesive for bonding traffic markers to concrete and asphalt
22 surfaces. Type 6A color requirements apply.

23 (B) Requirements

24 Epoxies shall conform to the requirements shown in Table 1081-1 using the test methods
25 described in Article 1081-3.

26 For epoxy resin systems used for embedding dowel bars, threaded rods, rebar and other
27 fixtures in hardened concrete, the manufacturer shall submit test results showing that the
28 bonding system will obtain 125% of the specified yield strength of the anchor fixture in
29 concrete with a compressive strength of at least 3,000 psi. Plans may call for field-testing
30 of adhesively anchored fixtures.

31 (C) Properties of Epoxy Resin Systems

32 (1) All integral fillers, pigments and thixotropic agents shall be fine enough to not
33 separate, settle or cause skinning during storage of the epoxy components. Do not
34 use abrasive fillers such as alumina and silica flour. Do not use solvents. When
35 mineral fillers are to be added during mixing, they shall be inert, readily dispersible
36 and except for sand, have fineness such that 99% of the material will pass
37 a No. 325 sieve.

38 (2) The coefficient of expansion of cured epoxy is 6 times greater than that of concrete.
39 Therefore, to reduce spalling and peeling during temperature changes, avoid thick
40 layers of pure epoxy. A 4:1 by weight sand-epoxy mortar has approximately the
41 same coefficient of expansion as concrete.

42 (3) The shelf life of parts A and B shall be at least one year from the date of
43 manufacture.

44 (4) Types 1 through 5 epoxy resin systems are moisture insensitive and can be applied
45 on clean, dry or damp surfaces free of standing water.

Table 1081-1
Properties of Mixed Epoxy Resin Systems

Property	Type 1	Type 2	Type 3	Type 3A	Type 4A	Type 4B	Type 5	Type 6A	Type 6B	Type 6C
Viscosity-Poises at 77°F ± 2°F	Gel	10-30	25-75	Gel	40-150	40-150	1-6	1,500-3,000	400-800	1,500-3,000
Spindle No.	-	3	4	--	4	4	2	T-D	6	T-D
Speed (RPM)	-	20	20	--	10	10	50	5	10	5
Pot Life (Minutes)	20-50	30-60	20-50	5-50	40-80	40-80	20-60	8-13	8-13	7-10
Minimum Tensile Strength at 7 days (psi)	1,500	2,000	4,000	4,000	1,500	1,500	4,000	-	-	-
Tensile Elongation at 7 days (%)	30 min.	30 min.	2-5	2-5	5-15	5-15	2-5	-	-	-
Min. Compressive Strength of 2" mortar cubes at 24 hours	3,000 (Near)	4,000-	6,000-	6,000 (Near)	3,000	3,000	6,000	-	-	-
Min. Compressive Strength of 2" mortar cubes at 7 days	5,000 (Near)	-	-	-	-	5,000	-	-	-	-
Maximum Water Absorption (%)	1.5	1.0	1.0	1.5	1.0	1.0	1.0	-	-	-
Min. Bond Strength Slant Shear Test at 14 days (psi)	1,500	1,500	2,000	2,000	1,500	1,500	1,500	-	-	□

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1 (D) Test Methods for Epoxies

2 (1) Viscosity

3 Determine the viscosity of the mixture in accordance with AASHTO T 237 using
4 Brookfield viscometer model RVT. Use the spindle number and speed shown in
5 Table 1081-1.

6 (2) Pot Life

7 Determine the pot life of the mixture in accordance with AASHTO T 237 except use
8 a mass of 60 ± 0.4 g.

9 (3) Compressive Strength of Epoxy Mortar

10 Determine the compressive strength of epoxy mortar in accordance with
11 ASTM C109 except as follows:

12 Use mortar consisting of one part epoxy and 3 parts standard graded Ottawa sand
13 except for Types 1 and 3A, which shall be tested neat. Mix epoxy
14 components A and B at the recommended proportions for 2 minutes, add the sand,
15 and mix for 3 minutes. Pour the mortar into the cube molds in 2 layers, and tamp
16 each layer 50 times with a spatula and 25 times with a hammer handle. Make
17 6 specimens, and cure all in air at $77^{\circ}\text{F} \pm 2^{\circ}\text{F}$ for 24 hours. Test 3 specimens for
18 compressive strength at the end of this curing period. Immerse the remaining
19 3 specimens in water at $+ 77^{\circ}\text{F}$ for 6 days, after which immediately test them for
20 compressive strength in the wet condition.

21 (4) Tensile Strength and Tensile Elongation

22 Determine the tensile strength and tensile elongation of the mixture in accordance
23 with ASTM D638.

24 (5) Absorption

25 Determine the water absorption of the mixture in accordance with ASTM D570.

26 (6) Bond Strength

27 Determine the bond strength of the moist-cured mixture at 14 days by the slant shear
28 test in accordance with ASTM C882.

29 (E) Prequalification

30 All epoxy resin systems shall be on the NCDOT Approved Products List before use.
31 Manufacturers choosing to supply material for Department jobs must submit an Epoxy
32 Submittal Form to the Materials and Tests Physical Testing Laboratory with the
33 following information for each type and brand name:

34 (1) Contact information, including name, address and telephone number of the
35 manufacturer,

36 (2) Brand/Trade name of the material,

37 (3) Type of the material in accordance with Article 1081-1,

38 (4) Technical data sheet stating at a minimum product description, yield, technical
39 information, mixing directions, finishing directions, curing, clean-up and
40 precautions/limitations,

41 (5) Material Safety Data Sheets,

1 (6) Certified test data showing the product meets AASHTO M 237, including evidence
 2 that the testing laboratory is regularly inspected by the Cement and Concrete
 3 Reference Laboratory (CCRL) of the National Institute of Standards Technology or
 4 other approved reference laboratory, and

5 (7) A sample of the product for testing (4 injection tubes or 1/2 gallon of each
 6 component is required for testing).

7 Products will remain on the NCDOT Approved Products List as long as the formulation
 8 and manufacturing process remain unchanged, and the product performs as intended in
 9 the field. The manufacturer is required to submit an annual letter to the Materials and
 10 Tests Physical Testing Laboratory certifying the formulation and manufacturing process
 11 have not changed.

12 (F) Acceptance

13 When materials on the NCDOT Approved Products List are furnished to a project, submit
 14 to the Engineer a Type 1 material certification in accordance with Article 106-3 for each
 15 lot or batch delivered.

16 When materials are furnished to the Bridge Maintenance Unit, the terms of acceptance
 17 will be listed in the bid solicitation. The Engineer reserves the right to reject any epoxy
 18 that does not perform adequately in the field.

19 (G) Supply

20 Supply epoxy resin in 2 components, labeled as “Component A - Contains Epoxy Resin”
 21 and “Component B - Contains Curing Agent”, for combining immediately before use in
 22 accordance with the manufacturer’s instructions. Mark each container with the
 23 manufacturer’s name, NCDOT type, lot or batch number, quantity, date of manufacture,
 24 shelf life or expiration date, color, mixing instructions, usable temperature range and
 25 hazards or safety precautions.

26 Furnish the 2 components in separate non-reactive containers. Provide containers of such
 27 size that the proportions of the final mix can be obtained by combining a single container
 28 of one component with one or more whole containers of the other component.

29 (H) Notes on Use of Epoxies

30 (1) Safety

31 Epoxies can irritate the eyes, skin and respiratory tract. Therefore, wear chemical
 32 splash goggles, chemically-resistant gloves and protective clothing and boots when
 33 handling epoxies. Respiratory protection is usually not needed if epoxies are mixed
 34 and applied in well-ventilated areas, but avoid prolonged breathing of vapors.
 35 Follow all MSDS instructions for proper use of these materials.

36 (2) Mixing

37 Stir parts A and B individually until each component is homogeneous. Use
 38 a separate stirrer for each component.

39 Combine parts A and B, either by weight or volume, as specified in the
 40 manufacturer’s instructions. Stir the mixture vigorously, periodically scraping the
 41 sides and bottom of the container. Small quantities of epoxy usually require 2 to
 42 3 minutes to mix homogeneously; 5-gallon quantities can take up to 10 minutes of
 43 mixing.

44 Temperature affects the viscosity and pot life of epoxies. Most laboratory tests are
 45 conducted at 77°F. Higher temperatures render epoxies thinner and faster setting;
 46 lower temperatures induce higher viscosities and longer pot lives.

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1 Add sand or other fillers to liquid epoxies only after parts A and B have been
2 thoroughly mixed. Stir in the sand or filler until all particles are completely coated.

3 (3) Storage and Substrate Temperature

4 Store epoxies at temperatures between 50°F and 90°F. Epoxy components exposed
5 to the extremes of this range or outside this range should be conditioned to 77°F
6 before mixing and blending. If heat is necessary, always use indirect methods such
7 as hot water, a heated room or a microwave oven to condition components.

8 When applying epoxy to a cold substrate, preheat the components approximately 1°F
9 above 77°F for every 2°F of substrate temperature below 77°F.

10 Seal previously opened containers to be airtight. Unsealed containers can absorb
11 moisture from the atmosphere, which can alter the chemical reaction of the mixture.

12 1081-2 POLYESTER RESIN EPOXY ADHESIVE

13 (A) General

14 Polyester resin is used specifically for embedding dowel bars, threaded rods, rebars and
15 other fixtures in hardened concrete.

16 Have the manufacturer submit test results showing that the bonding system will obtain
17 125% of the specified yield strength of the anchor fixture in concrete with a minimum
18 compressive strength of 3,000 psi. Field testing may be required for adhesively anchored
19 fixtures.

20 (B) Materials

21 Package components of the adhesive in containers of such size that one whole container
22 of each component is used in mixing one batch of adhesive. Use containers of such
23 design that all of the contents may be readily removed, and are well sealed to prevent
24 leakage. Furnish adhesive material that requires hand mixing in 2 separate containers
25 designated as Component A and Component B. A self-contained cartridge or capsule
26 will consist of 2 components which will be automatically mixed as they are dispensed, as
27 in the case of a cartridge, or drilled into, as in the case of a capsule.

28 Clearly label each container with the manufacturer's name; date of manufacture; batch
29 number; batch expiration date; all directions for use and such warning of precautions
30 concerning the contents as may be required by Federal or State laws and regulations.

31 (C) Mixing of Adhesive

32 Mix adhesive in conformance with the manufacturer's instructions.

33 1081-3 HOT BITUMEN

34 Mix the adhesive asphaltic material with the filler homogeneously.

35 (A) Physical Requirements

36 Supply materials meeting Tables 1081-2 or 1081-3 and 1081-4.

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 1081-4(B)	-	0.2	ASTM D5329
Viscosity, 400°F, poises or ASTM D4402 as modified in Subarticle 1081-4(B)	30	75	ASTM D2669
Flash Point, C.O.C., °F.	550	-	ASTM D92

TABLE 1081-17
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 1081-18
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%	-	

1 **(B) Test Methods**

2 (1) Flow

3 Determine flow according to Section 6 of ASTM D5329 with the exception that the
 4 oven temperature shall be 158°F ± 2°F and sample preparation done according to
 5 Section 7.1 of ASTM D5.

6 (2) Viscosity

7 Viscosity is to be determined according to ASTM D2669 or ASTM D4402 using
 8 a spindle speed of 10 rpm. Heat the adhesive to approximately 410°F and allowed to
 9 cool. Determine viscosity at 400°F ± 1°F.

10 (3) Asphalt Properties

11 Properties of the base asphalt are to be determined on the material obtained from the
 12 following extraction and Abson recovery methods. Extract the asphalt by heating the
 13 adhesive just to the point where it will easily flow and then transfer 125 to 150 g into
 14 400 ml of trichloroethylene with a temperature of 125°F to 150°F. Thoroughly stir
 15 this mixture to dissolve the asphalt. Decant the trichloroethylene-asphalt mixture
 16 decanted and the asphalt recovered using the Abson recovery method, ASTM D1856
 17 as modified by the following. The extraction methods of ASTM D2172 do not apply
 18 and there will be no filtration of the solvent asphalt mixture. The extraction solution
 19 of trichloroethylene and asphalt shall be centrifuged for at least 30 minutes at
 20 770 times gravity in a batch centrifuge. Decant this solution in the distillation flask,
 21 taking care not to include any filler sediment. Apply heat and bubble carbon dioxide
 22 solution slowly to bring the solution temperature to 300°F. At this point the carbon
 23 dioxide flow is increased to 800 ml to 900 ml per minute. The solution temperature
 24 is maintained at 320°F to 335°F with this carbon dioxide flow for at least 20 minutes
 25 and until the trichloroethylene vapors have been completely removed from the
 26 distillation flask. Repeat the above extraction-recovery method as necessary to
 27 obtain the desired quantity of asphalt. Use the asphalt recovered to determine
 28 penetration, 275°F viscosity, and 275°F viscosity ratio.

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(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 $160^{\circ}\text{F} \pm 5^{\circ}\text{F}$ 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

Bituminous adhesives are required to be pre-qualified by the Department's Transportation-Traffic Engineering Branch. 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. For more information on the pre-qualification process, contact the Work Zone Traffic Control Unit.

(D) Packaging and Labeling

Pack the adhesive in self-releasing cardboard containers which will stack properly. Containers shall have a net weight of 50 lb to 60 lb and contain 2 to 4 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 insure 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 conforming to Federal Specifications TT-T-291 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.

(G) Anchor Bolt Adhesives

Before application, test the adhesive for a tensile strength of 125% of the specified required yield load (42 kips) of the anchor bolt. Furnish certification that, for the particular bolt grade, diameter and embedment depth required, the anchor system will not fail by adhesive failure and that there is no movement of the anchor bolt. For certification and anchorage, use 3,000 psi as the minimum Portland cement concrete compressive strength used in this test.

Use adhesives that meet Section 1081.

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.

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1 Package components of the adhesive in containers of such size that one whole container
2 of each component is used in mixing one batch of adhesive. Design the containers to
3 allow for all of the contents to be readily removed and be well sealed to prevent leakage.
4 Furnish adhesive material that requires hand mixing in 2 separate containers marked as
5 Component A and Component B. A self contained cartridge or capsule consists of
6 2 components that will automatically be mixed as they are dispensed.

7 Clearly label each container with the manufacturer's name, date of manufacture, batch
8 number, batch expiration date, all directions for use and such warning of precautions
9 concerning the contents as required by Federal or State laws and regulations.

SECTION 1082 STRUCTURAL TIMBER AND LUMBER

1082-1 GENERAL

13 Use Southern Pine timber and lumber graded in accordance with the current grading rules of
14 the Southern Pine Inspection Bureau unless otherwise specified or approved by the Engineer.
15 Use stress rated grades equal to or higher than the grades specified. For temporary crossings,
16 the use of stress rated lumber having stress ratings below those specified may be used if
17 approved by the Engineer.

18 Have all timber and lumber, including any preservative treatment, inspected and/or tested at
19 no cost to the Department by an approved commercial inspection company before it is
20 delivered to the project. Provide industry standard commercial inspection reports for each
21 shipment of untreated timber or lumber before its use on the project. Provide industry
22 standard commercial inspection reports and treatment test reports for each shipment of treated
23 timber or lumber before its use on the project. Perform all timber and lumber treatment
24 inspections in accordance with Standard M2 (Part A) of the AWPA Specifications. In
25 addition, brand, hammer mark, ink stamp or tag each piece of timber or lumber with the
26 approved commercial inspection company's unique mark to indicate it has been inspected.

1082-2 UNTREATED TIMBER AND LUMBER

28 Lumber that is 2" to 4" thick and 2" to 4" wide shall conform to Structural Light Framing,
29 Grade No. 1 Dense MC19. Lumber that is 2" to 4" thick and 6" wide or wider shall conform
30 to Structural Joists and Planks, Grade No. 1 Dense MC19. Lumber that is 5" and thicker
31 along the least dimension shall conform to Structural Lumber, Grade Dense Structural 72.
32 Rough lumber will be acceptable except where surfacing is called for by the contract. Rough
33 lumber may vary $\pm 1/4$ " from the dimensions shown on the contract or bill of material.

1082-3 TREATED TIMBER AND LUMBER

(A) General

36 Grade marked lumber will not be required. Brand or ink stamp each piece of treated
37 lumber in accordance with the AWPA Standard M6.

(B) Bridges, Fender Systems and Piles

39 Lumber for bridges that is 2" to 4" thick and 2" to 4" wide shall conform to Structural
40 Light Framing, Grade No. 1 Dense. Lumber for bridges that is 2" to 4" thick and 6" wide
41 and wider shall conform to Structural Joists and Planks, Grade No. 1 Dense. Lumber for
42 bridges that is 5" and thicker along the least dimension shall conform to Structural
43 Lumber, Grade Dense Structural 65. Lumber for fender systems shall conform to
44 Structural Lumber, Grade Dense Structural 65.

45 Timber for piles shall meet ASTM D25 except that the timber shall be Southern Pine, and
46 have at least a 2" sap ring or a 3" sap ring where called for by the contract or where the
47 preservative is creosote and the retention is greater than 18 lb/cf.

1 Rough lumber will be acceptable except where surfacing is called for by the contract or
2 bills of material. Rough lumber may vary $\pm 1/4$ " from the dimensions shown in the plans
3 or bill of material. Dressed lumber may be $1/8$ " scant from the dimensions shown in the
4 plans or bill of material. A $1/4$ " tolerance in length will be permitted.

5 **(C) Guardrail Posts**

6 Lumber for guardrail posts shall conform to Timbers, Grade No.1. Rough lumber will be
7 acceptable. An allowable tolerance of $3/8$ " scant will be permitted from nominal
8 dimensions.

9 **(D) Fence Posts and Braces**

10 Sawed fence posts and braces no larger than 4" x 4" shall conform to Structural Light
11 Framing, Grade No. 2. Sawed fence posts and braces larger than 4" x 4" shall conform to
12 Timbers, Grade No. 1.

13 Round lumber shall meet Subarticle 1050-2(A).

14 Use fully dressed S4S lumber for fence posts.

15 An allowable tolerance of $1/2$ " scant will be permitted from nominal dimensions of
16 sawed and dressed lumber.

17 **(E) Sign Posts and Battens**

18 Lumber for sign posts no larger than 4" x 4" shall conform to Structural Light Framing,
19 Grade No. 1 MC19. Lumber for sign posts larger than 4" x 4" and lumber for sign
20 battens shall conform to Timbers, Grade No. 1. Use fully dressed S4S lumber for sign
21 posts and battens.

22 An allowable tolerance of $1/2$ " scant will be permitted from nominal dimensions of sign
23 posts. A tolerance of 1" under and 3" over will be permitted in the length of the post.

24 **(F) Poles**

25 Timber for poles shall meet ANSI O5.1 except the timber shall be treated Southern Pine
26 or treated Douglas Fir. Use 40 ft Class 3 poles unless otherwise specified in the contract.

27 **1082-4 PRESERVATIVE TREATMENT**

28 **(A) General**

29 Give all timber and lumber required to be treated a preservative treatment in accordance
30 with AWPAs Standards. The required retention of chromated copper arsenate is specified
31 on the oxide basis. Preservative retention will be determined by the assay method.

32 After treatment, handle the timber and lumber carefully with rope slings, without sudden
33 dropping, breaking of the fibers, bruising or penetrating the surface with tools or hooks.

34 Treated timber and lumber will not be accepted for use unless it has been inspected and
35 found satisfactory, both before and after treatment, and shall be delivered to the project
36 site in a condition acceptable to the Engineer.

37 Use treating plants that have laboratory facilities at the plant site for use of the inspector
38 in accordance with AWPAs Standard T1.

39 **(B) Timber Preservatives**

40 Use timber preservatives conforming to AWPAs Standard T1.

41 **(C) Bridges, Fender Systems and Piles**

42 Treat timber and lumber for bridges and fender systems in accordance with
43 AWPAs Standard U1, except the type of preservative and the retention of preservative will
44 be as required by the contract.

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1 Treat piles in accordance to AWPA Standard U1, except the type of preservative and the
2 retention of preservative will be as required by the contract.

3 **(D) Guardrail Posts**

4 Treat guardrail posts in accordance to AWPA Standard U1, except require retention of
5 preservative as below.

6 Give all guardrail posts a preservative treatment of creosote, pentachlorophenol or
7 chromated copper arsenate. The same type of preservative is to be used throughout the
8 entire length of the project.

9 Minimum retention for creosoted timber will be 12 lb of preservative per cubic foot of
10 wood. Minimum retention for timber treated with pentachlorophenol will be 0.6 lb of dry
11 chemical per cubic foot of wood. Minimum retention for timber treated with chromated
12 copper arsenate will be 0.6 lb of dry chemical per cubic foot of wood.

13 **(E) Fence Posts and Braces**

14 Treat sawed posts and braces in accordance with AWPA Standard U1, except require
15 retention of preservative as below.

16 Treat round posts and braces in accordance with AWPA Standard U1, except require
17 retention of preservative as below.

18 Before treatment, peel round posts and braces cleanly for their full length, remove all
19 bark and innerskin, and trim all knots and projections flush with the surface of the
20 surrounding wood. Machine peeling will be permitted. Cut the ends to the proper length
21 before treatment.

22 Give all fence posts and braces a preservative treatment of either creosote,
23 pentachlorophenol, or chromated copper arsenate. The same type of preservative shall be
24 used throughout the entire length of the project.

25 Minimum retention for creosoted sawed timber will be 10 lb of preservative per cubic
26 foot of wood. Minimum retention for sawed timber treated with pentachlorophenol will
27 be 0.5 lb of dry chemical per cubic foot of wood. Minimum retention for sawed timber
28 treated with chromated copper arsenate will be 0.5 lb of dry chemical per cubic foot of
29 wood.

30 Minimum retention for creosoted round timber will be 8 lb of preservative per cubic foot
31 of wood. Minimum retention for round timber treated with pentachlorophenol will be
32 0.4 lb of dry chemical per cubic foot of wood. Minimum retention for round timber
33 treated with chromated copper arsenate will be 0.4 lb of dry chemical per cubic foot of
34 wood.

35 **(F) Sign Posts and Battens**

36 Treat sign posts and battens in accordance with AWPA Standard U1, except require
37 retention of preservative as below.

38 Give all sign posts and battens a preservative treatment of either pentachlorophenol or
39 chromated copper arsenate. The same type of preservative shall be used throughout the
40 entire length of the project.

41 Minimum retention for timber treated with pentachlorophenol will be 0.6 lb of dry
42 chemical per cubic foot of wood. Minimum retention for timber treated with chromated
43 copper arsenate will be 0.6 lb of dry chemical per cubic foot of wood.

44 All timber shall have moisture content of not greater than 19% before treatment. Redry
45 timber treated with chromated copper arsenate after treatment until it has moisture
46 content of not greater than 25%.

1 **(G) Poles**

2 Treat poles in accordance with AWWA Standard U1, except require retention of
3 preservative as below.

4 Give all poles a preservative treatment of either pentachlorophenol, or chromated copper
5 arsenate. The same type of preservative shall be used throughout the entire length of the
6 project.

7 Minimum retention for poles treated with pentachlorophenol will be 0.45 lb by assay of
8 dry chemical per cubic foot of wood. Minimum retention for poles treated with
9 chromated copper arsenate will be 0.6 lb by assay of dry chemical per cubic foot of
10 wood.

11 **SECTION 1084**
12 **PILES**

13 **1084-1 PILES**14 **(A) Treated Timber Piles**

15 Timber for treated timber piles shall meet Article 1082-3. Give treated timber piles
16 a preservative treatment in accordance with Article 1082-4.

17 **(B) Steel Piles**

18 See Section 1076 for galvanized steel piles. Before incorporating steel piles into the
19 work, obtain all applicable certified mill test reports clearly identifiable to the lot of
20 material by heat numbers, submit these reports to the Engineer for review and analysis
21 and receive approval of such test reports from the Engineer. These requirements apply to
22 both domestic and foreign produced steel piles. Transfer the heat number of each painted
23 pile to the newly painted surface with a permanent marker of a color contrasting to the
24 paint once the paint has fully cured.

25 **(1) Steel H-Piles**

26 Steel H-piles shall meet ASTM A572 Grade 50 or ASTM A588.

27 **(2) Steel Pipe Piles**

28 Steel pipe piles shall be of uniform diameter and conform to ASTM A252 Grade 3
29 modified (50,000 psi). Make all joints and seams in the pipe pile watertight. Unless
30 otherwise indicated by the contract, the ends of pipe pile may be flame cut. Square
31 flame cut ends with axis of the pile to provide a full uniform bearing over the entire
32 end area when the pile is being driven. Pipe piles under 24" in diameter shall be
33 spliced by a certified pipe welder.

34 **(C) Prestressed Concrete Piles**

35 Prestressed concrete piles shall meet Section 1078.

36 **1084-2 STEEL SHEET PILES**

37 Steel sheet piles detailed for permanent applications shall be hot rolled and meet ASTM A690
38 unless otherwise required by the plans.

39 Steel sheet piles detailed for temporary applications shall be hot rolled and meet ASTM A328.

Section 1086

**SECTION 1086
PAVEMENT MARKERS**

1086-1 TEMPORARY RAISED PAVEMENT MARKERS

(A) General

Use raised pavement markers evaluated by NTPEP.

Use raised pavement markers of the prismatic reflector type, or better as approved. 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 Federal Standard No. 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.

The 2 types of epoxy adhesive which may be used are Type 6A, Standard Setting, and Type 6C, Rapid Setting. Use Type 6A when the pavement temperature is above 60°F. Use Type 6C when the pavement temperature is between 50°F and 60°F or when a fast set is desirable. Epoxy adhesive Type 6C, Cold Set, may be used to attach temporary pavement markers to the pavement surface when the pavement temperature is between 32°F and 50°F.

(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 evaluated by NTPEP. 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 (1) Potted Markers

2 Potted marker shells shall be made of molded methyl methacrylate conforming to
 3 Federal Specification L P 380C, Type I, Class 3. Filling material shall be an inert
 4 thermosetting compound selected for strength, resilience, and adhesion adequate to
 5 meet physical requirements of the *Standard Specifications*. Sand or other inert
 6 granulars shall be embedded in the surface of the inert thermosetting compound and
 7 filler material before its curing to provide a surface, which will readily bond to the
 8 adhesive.

9 (2) Injection-molded Markers

10 Injection-molded markers shall consist of polymer materials selected for strength and
 11 resilience adequate to meet the physical requirements of the *Standard Specifications*.
 12 The bottom surface of the marker shall contain grooves or nonsmooth structure
 13 designed to increase bonding with the adhesive.

14 **(B) Optical Requirements**

15 All optical performance for permanent raised pavement markers shall conform to
 16 ASTM D4280.

17 **(C) Physical Properties**

18 All physical properties for permanent raised pavement markers shall conform to
 19 ASTM D4280.

20 **(D) Hot Bitumen Adhesives**

21 Use hot bitumen adhesive for mounting the pavement markers to asphalt concrete
 22 roadways. The hot bitumen adhesive shall meet the requirements of Article 1081-3.
 23 Other adhesives such as epoxy or cold bituminous adhesive pads are not acceptable on
 24 asphalt concrete roadways for permanent applications.

25 **(E) Epoxy Adhesives**

26 Use epoxy adhesive for mounting the pavement markers to concrete roadways. The
 27 epoxy adhesive shall comply with Section 1081. Other adhesives such as hot and cold
 28 bituminous or adhesive pads are not acceptable on concrete roadways for permanent
 29 applications.

30 **(F) Material Certification**

31 Furnish a Type 2 material certification in accordance with Article 106-3 for all raised
 32 pavement markers before use.

33 **1086-3 SNOWPLOWABLE PAVEMENT MARKERS**34 **(A) General**

35 Use snowplowable pavement markers evaluated by NTPEP. The snowplowable
 36 pavement marker shall consist of a cast iron housing with one or more glass or plastic
 37 face lens type reflective lenses to provide the required color designation. Shape the
 38 casting to deflect a snowplow blade upward in both directions without being damaged.
 39 Incorporate into the casting 2 parallel keels and a connecting web designed to fit into
 40 slots cut into the road surface. Plastic lens faces shall use an abrasion resistant coating.

41 Use recycled snowplowable pavement markers that meet all the requirements of
 42 new snowplowable pavement markers except Subarticle 1086-3(B)(1). Recycled
 43 snowplowable pavement markers with minimal variation in dimensions are acceptable
 44 only when the reflector fits in the casting of the recycled snowplowable pavement marker
 45 as originally designed.

Section 1086

1 (B) Castings

2 (1) Dimensions

3 The dimension, slope and minimum area of reflecting surface shall conform to
4 dimensions as shown in the plans. The minimum area of each reflecting surface
5 shall be 1.44 sq.in.

6 (2) Materials

7 Use nodular iron in accordance with ASTM A536.

8 (3) Surface

9 The surface of the keel and web shall be free of scale, dirt, rust, oil, grease or any
10 other contaminant which might reduce its bond to the epoxy adhesive.

11 (4) Identification

12 Mark the casting with the manufacturer's name and model number of marker.

13 (C) Reflectors

14 (1) General

15 Laminate the reflector to an elastomeric pad and attach with adhesive to the casting.
16 The thickness of the elastomeric pad shall be 0.04".

17 (2) Reflector Type

- 18 (a) One-direction, one color (crystal)
- 19 (b) Bidirectional, one color (yellow and yellow)
- 20 (c) Bidirectional, two colors (red and crystal)
- 21 (d) Bidirectional, two colors (red and yellow)

22 All pavement marker reflective lenses shall be in close conformance with the Federal
23 Standard No. 595 colors as listed below when viewed during night situations.

Crystal: Color No. 17886 (White)

Yellow: Color No. 13538

Red: Color No. 11302

24 (3) Reflector Optical Requirements

25 (a) Definitions

26 Define "horizontal entrance angle" as the angle in the horizontal plane between
27 the direction of incident light and the normal to the leading edge of the marker.

28 Define "observation angle" as the angle, at the reflector, between observer's line
29 of sight and the direction of the light incident on the reflector.

30 Define "specific intensity (S.I.)" as candlepower of the returned light at the
31 chosen observation and entrance angles for each footcandle of illumination at
32 the reflector.

$$\mathbf{S.I.} = \mathbf{RL} \times (\mathbf{D} \times \mathbf{D}) \times \mathbf{IL}$$

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" 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 lb 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 ft from a uniformly bright light source having an effective diameter of 0.2".

The photocell must be an angular ring 0.37" I.D. x 0.47" 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". If a test distance of other than 5 ft 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. Mix the epoxy adhesive rapidly by a 2 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 and resins shall be free from all skins, dirt and foreign objects.

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1 Use pavement marking materials capable of being fabricated into pavement markings of
2 specified dimensions and adhering to asphalt and Portland cement concrete pavements when
3 applied in accordance with their manufacturer's recommendation.

4 Pavement marking materials upon heating shall not exude fumes, which are toxic, or injurious
5 to persons or property.

6 Homogeneously mix all pavement marking materials.

7 **1087-2 COMPOSITION**

8 **(A) Paint Composition**

9 Pavement marking paint shall be a ready mixed type paint product conforming to Federal
10 Specification FP03 with spraying consistency suitable for use as a retroreflective
11 pavement marking. Glass beads are dropped by suitable pressurized means into the wet
12 paint as it is applied to the pavement.

13 **(B) Removable Tape Composition**

14 Removable tape pavement marking shall be composed of materials as specified by their
15 manufacturer.

16 Use removable tape markings capable of conforming to pavement contours, breaks,
17 faults, etc. through the action of traffic at normal pavement temperatures. The tape shall
18 have resealing characteristics such that it is capable of fusing with itself and previously
19 applied marking tape of the same composition under normal conditions of use. The
20 removable tape markings shall be patchable.

21 Use removable tape markings capable of adhering to the pavement by
22 a pressure-sensitive pre-coated adhesive or as directed by the manufacturer.

23 **(C) Thermoplastic Composition**

24 Use thermoplastic alkyd/maleic pavement markings composed of the materials in
25 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.
Yellow Pigment (For Yellow Marking Only) Silica Encapsulated Lead Chromate Pigment	4.0% Min.

26 Use white thermoplastic that does not contain anatase titanium dioxide pigment.

27 Provide yellow thermoplastic that contains only heat resistant silica encapsulated lead
28 chromate pigment. The lead chromate pigment shall contain at least 60% lead chromate.

29 Calcium carbonate and inert fillers may be as opted by the manufacturer, providing all
30 other qualifications are met.

31 The total silica content used in the formulation of the thermoplastic shall be the premixed
32 glass beads. Uniformly disperse the pigment, beads, and filler in the binder.

1 The Alkyd/maleic binder shall consist of a mixture of synthetic resins (at least one
 2 synthetic resin shall be solid at room temperature) and a high boiling point plasticizers.
 3 At least 1/2 of the binder composition shall be 100% maleic-modified glycerol of resin
 4 and be no less than 15% by weight of the entire material formulation. The binder shall
 5 contain no petroleum hydrocarbon resins. Use resins/rosins that are maleic-modified
 6 glycerol esters.

7 The thermoplastic material shall be free of contaminates and be homogeneously dry-
 8 blended or hot mixed from 100% virgin stock using no reprocessed materials, (excluding
 9 the requirement to use reprocessed glass).

10 The thermoplastic material shall not deteriorate or discolor when held at the application
 11 temperatures for at least 4 hours or upon repeated reheating (at least 4 times).

12 The color, viscosity and chemical properties versus temperature characteristics of the
 13 thermoplastic material shall remain constant for up to 4 hours at the application
 14 temperature and be the same from batch to batch.

15 The thermoplastic material shall be readily applicable at temperatures between 400°F and
 16 440°F from the approved equipment to produce lines and symbols of the required above
 17 the pavement thickness.

18 **(D) Cold Applied Plastic Composition**

19 The cold applied plastic pavement marking shall consist of a mixture of high quality
 20 polymeric materials, pigments and glass beads distributed throughout its base cross-
 21 sectional area, with a reflective layer of beads bonded to the top surface.

22 The cold applied plastic markings shall adhere to the pavement by a pressure-sensitive
 23 pre-coated adhesive.

24 The cold applied plastic shall conform to pavement contours, breaks, faults, etc. through
 25 the action of traffic at normal pavement temperatures. The film shall have resealing
 26 characteristics such that it is capable of fusing with itself and previously applied marking
 27 tape of the same composition under normal conditions of use. The cold applied plastic
 28 pavement marking shall be patchable.

29 **1087-3 COLOR**

30 All pavement markings, without drop-on beads, shall visually match the color chips that
 31 correspond to the Federal Standard Number 595b for the following colors:

Crystal: Color No. 17886 (White)

Yellow: Color No. 13538

Black: Color No. 37038

32 **1087-4 GLASS BEADS**

33 **(A) Composition**

34 The silica content of the glass beads shall be at least 60%.

35 Manufacture the beads from 100% recycled non-pigmented glass from a composition
 36 designed to be highly resistant to traffic wear and to the effects of weathering. All
 37 standard intermix and drop-on glass beads shall be manufactured using 100% North
 38 American recycled glass cullet.

39 Glass beads shall have no more than 75 ppm of arsenic as determined by the United
 40 States Environmental Protection Agency Method 6010B in conjunction with the United
 41 States Environmental Protection Agency Method 3052 modified.

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1 (B) Physical Characteristics

2 Use glass beads that are colorless, clean, transparent and free from milkiness, excessive
3 air bubbles, skins and foreign objects. Use glass beads with a minimum refractive index
4 of 1.50 when tested by the liquid immersion method at 77°F ± 9°F in accordance with
5 ASTM D1214 using the Becke Line Method or an equivalent method. Use glass beads
6 that are spherical in shape and essentially free of sharp angular particles or particles
7 showing surface scarring or scratching.

8 All intermixed and drop-on glass beads shall comply with NCGS § 136-30.2.

9 (C) Gradation & Roundness

10 Use drop-on and intermixed glass beads in all pavement markings with at least 80% true
11 spheres when tested in accordance with ASTM D1155. Drop-on and intermixed glass
12 beads used on any pavement markings shall meet Table 1087-2.

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%

13 (D) Chemical Resistance

14 Conduct the following chemical resistance test on all glass beads:

15 Place 3 to 5 g portions of the same glass bead batch to be tested in 3 separate glass
16 beakers or 3 porcelain dishes. Cover one sample with distilled water, cover the second
17 sample with 3N solution of sulfuric acid and cover the third sample with 50% solution of
18 sodium sulfides. After one hour of immersion, examine the glass bead samples
19 microscopically for evidence of darkening or frosting. All 3 samples shall show no
20 evidence of darkening or frosting.

21 (E) Moisture Resistance

22 Conduct the following moisture resistance test on drop-on glass beads:

23 Place a 2 lb minimum sample of glass beads in a clean, washed cotton bag with a thread
24 count of 50 warp, 50 woof. Immerse the bag containing the sample in a container of
25 water for 30 seconds or until the water covers the spheres, whichever is longer. Remove
26 the bag from water and force excess water from the sample by squeezing the bag.
27 Suspend the bag and allow to drain for 2 hours at room temperature 70°F to 72°F. Then
28 mix the sample in the bag by shaking thoroughly. Transfer the sample slowly to a clean
29 dry glass funnel having a stem of 4" in length with 1/4" inside diameter. The entire
30 sample shall flow freely through the funnel without stoppage. When first introduced in
31 the funnel, if the spheres clog, it is permissible to lightly tap the funnel to start the flow.

32 1087-5 PACKAGING FOR SHIPMENT

33 Deliver all pavement marking and glass bead materials to the project in suitable containers
34 packaged by the manufacturer. Clearly and adequately mark each material container to
35 indicate the material, color, date of manufacture, process, batch or lot number, manufacturer's
36 name and location, temperature application range, shelf life and include the MSDS.

1 Thermoplastic pavement marking materials shall be in block or granular form packaged in
 2 either suitable corrugated containers or thermal degradable plastic bags to which it will not
 3 adhere during shipment or storage.

4 Package glass beads in moisture resistant packaging.

5 **1087-6 STORAGE LIFE**

6 All pavement marking materials shall meet this Specification for one year from the date of
 7 shipment from the manufacturer to the Contractor, or the project when stored properly by the
 8 manufacturer's recommendation. Replace any pavement marking materials not meeting these
 9 Specifications.

10 **1087-7 TESTS TO BE PERFORMED**

11 When independent test laboratory tests are required, perform them on samples taken by
 12 an agency certified by the Department from the same process, batch or lot number as the
 13 material shipped to the project. The test reports shall contain the lot number. Use
 14 Department approved independent test laboratories.

15 Perform the following tests on thermoplastic pavement marking materials, intermixed glass
 16 beads and drop-on glass beads unless prescribed otherwise by the Engineer:

17 **(A) Intermixed and Drop-on Glass Beads**

18 Use X-ray Fluorescence for the normal sampling procedure for intermixed and drop-on
 19 beads, without crushing, to check for any levels of arsenic. If any arsenic is detected, the
 20 sample shall be crushed and repeat the test using X-ray Fluorescence. If the test detects
 21 more than 75 ppm arsenic, perform tests as determined by the United States
 22 Environmental Protection Agency Method 6010B and 3052 modified. Drop-on glass
 23 beads or pavement markings containing glass beads with more than 75 ppm arsenic shall
 24 not be approved for use.

25 **(B) Thermoplastic Pavement Marking Material Composition**

26 (1) % Binder tested in accordance with ASTM D4797.

27 (2) % Titanium Dioxide Pigment tested in accordance with ASTM D3720 or D4764.

28 (3) % Lead Chromate Pigment tested in accordance with D4797.

29 (4) % Glass Beads tested in accordance with ASTM D4797.

30 Except ash, use a 100 gram sample rather than a 10 gram sample to allow for testing of
 31 gradation and percent of rounds. Provide the results of sieve analysis and % rounds.

32 **(C) Flash Point**

33 The thermoplastic shall have a flashpoint of no less than 500°F when tested in
 34 accordance with ASTM D92 COC.

35 **(D) Requirements**

36 The thermoplastic material after heating for 240 ± 5 minutes at $425 \pm 3^\circ\text{F}$ and cooled to
 37 $77 \pm 3^\circ\text{F}$ shall meet the following:

38 (1) Color

39 (a) White

40 Daylight reflectance 2° Standard observer and CIE illuminant

41 Using XYZ scale D65/10° - 80% minimum

42 ASTM E1349

43 Yellowness Index - The white thermoplastic shall not exceed a yellowness index
 44 of 0.12

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- 1 (b) Yellow
- 2 Daylight reflectance at 2° Standard observer and CIE illuminant
- 3 Using XYZ scale D65/10° - 45% minimum =Y
- 4 ASTM E1349
- 5 (2) Bond Strength
- 6 The bond strength shall be 200 psi or greater in accordance with ASTM D4796.
- 7 (3) Cracking Resistance at Low Temperatures
- 8 After applying a 4", 125 mil draw-down to concrete blocks and cooling to 15 ± 3°F,
- 9 the material shall show no cracks at an observation distance of 12".
- 10 (4) Specific Gravity
- 11 The specific gravity shall be 1.95-2.20 in accordance with ASTM D792.
- 12 (5) Softening Point
- 13 The softening point shall be 215 ± 15°F in accordance with ASTM D36.
- 14 (6) Drying Time
- 15 When applied at a thickness of 125 mils, the material shall set to bear traffic in no
- 16 more than 2 minutes when air and substrate temperature is 50°F ± 3°F (and no more
- 17 than 10 minutes when the air and substrate temperature is 90°F ± 3°F when applied
- 18 at temperature of 412.5 ± 12.5°F in accordance with AASHTO T 250.
- 19 (7) Alkyd Binder Determination
- 20 The thermoplastic material shall immediately dissolve in diacetone alcohol. Slow
- 21 dissolution is evidence of the presence of hydrocarbon binder components.
- 22 (8) Indentation Resistance
- 23 The Shore Type A2 Durometer with a 4.41 lb load applied shall be between 40 and
- 24 75 units after 15 seconds at 115°F in accordance with ASTM D2240.

1087-8 MATERIAL CERTIFICATION

26 Furnish the following pavement marking material certifications in accordance with
27 Article 106-3:

Glass Beads	Type 3 Material Certification and Type 4 Material Certification
Paint	Type 3 Material Certification
Removable Tape	Type 3 Material Certification
Thermoplastic	Type 3 Material Certification and Type 4 Material Certification
Cold Applied Plastic	Type 2 Material Certification and Type 3 Material Certification
Polyurea	Type 3 Material Certification

**SECTION 1088
DELINEATORS**

1088-1 REFLECTIVE UNIT REQUIREMENTS FOR DELINEATORS

(A) Definition

- 32 Refer to ASTM D4956.
- 33 Define “entrance angle” as the angle at the reflector between direction of light incident on
- 34 it and direction of reflector axis.

1 Define "observation angle" and "specific intensity" in accordance with
2 Subarticle 1086-3(C)(3)(a).

3 **(B) Reflective Elements**

4 (1) Prismatic Plastic Type

5 (a) General

6 Use an acrylic plastic prismatic reflector hermetically sealed to an acrylic plastic
7 back. The reflector shall consist of a clear and transparent face, herein referred
8 to as a lens, with an acrylic plastic back fused to the lens under heat pressure
9 around the entire perimeter of the lens. Where a central mounting hole is
10 required, permanently seal the unit against dust, water and water vapor.

11 The lens shall consist of a smooth front surface free from projections or
12 indentations except a central mounting hole and identification markings. Mold
13 the manufacturer's trademark legibly into the face of the lens.

14 (b) Specific Intensity

15 Refer to ASTM D4956.

16 The specific intensity of each prismatic plastic type reflector shall meet
17 Table 1088-1 measurements made with reflectors spinning. Failure to meet the
18 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)		
		<i>Crystal</i>	<i>Yellow</i>	<i>Red</i>
0.1°	0°	119	71	29
0.1°	15°	119	28	--
0.1°	20°	47	28	11
0.1°	35°	50	30	--

19 Locate the prismatic plastic type reflector to be tested at a distance of 100 ft
20 from a single light source having an effective diameter of 2" operate the light
21 source at approximately normal efficiency. Measure the return light from the
22 reflector by a photoelectric photometer having a minimum sensitivity
23 of 1 x 10 footcandles per mm scale division. The photometer shall have
24 a receiver aperture of 0.5" diameter, shielded to eliminate stray light. The
25 distance from light source center to aperture center shall be 2.1" for 0.1 degree
26 observation angle. During testing, spin the reflectors to average the orientation
27 effect.

28 If a test distance other than 100 ft is used, modify the source and aperture
29 dimensions, and the distance between source and aperture, in the same
30 proportion as the test distance.

31 (c) Durability

32 (i) Seal Test

33 Use the following test to determine if a reflector is adequately sealed
34 against dust and water:

35 Submerge 50 samples in water at room temperature. Subject the submerged
36 samples to a vacuum of 5" gauge for 5 minutes. Restore atmospheric
37 pressure and leave the samples submerged for 5 minutes, then examine the

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1 samples for water intake. Evidence of any water is a failure. Failure of
2 more than 2% of the number tested will be cause for rejection.

3 (ii) Heat Resistance Test

4 Test 3 reflectors for 4 hours in a circulating air oven at 175°+5°F. Place the
5 test specimens in a horizontal position on a grid or perforated shelf,
6 permitting free air circulation. At the conclusion of the test, remove the
7 samples from the oven and permit them to cool in air to room temperature.
8 The samples, after exposure to heat, shall show no change in shape and
9 general appearance when compared with unexposed control standards. Any
10 failures will be cause for rejection.

11 (2) High Performance Sheeting Grade

12 The reflective sheeting shall be Grade C retroreflective sheeting that conforms to
13 Article 1092-2.

14 1088-2 GUARDRAIL AND BARRIER DELINEATORS

15 (A) Brackets and Casings for Delineators

16 Make brackets for guardrail and barrier delineators out of 12 gauge galvanized steel,
17 0.063" thick aluminum alloy, or .080" thick polycarbonate. Use molded plastic type
18 guardrail and barrier delineators that consist of a plastic casing and a reflective element.

19 (B) Reflective Element Requirements

20 The reflective element shall meet Article 1088-1. In addition, guardrail delineators and
21 side mounted barrier delineators shall have a minimum reflective area of 7 sq.in. Top
22 mounted barrier delineators shall have a minimum reflective area of 28 sq.in.

23 (C) Material Certification

24 Furnish a Type 2 material certification in accordance with Article 106-3 for all guardrail
25 and barrier (permanent) delineators and a Type 7 material certification for all guardrail
26 and barrier delineators (temporary) before use.

27 (D) Approval

28 All materials are subject to the approval of the Engineer.

29 1088-3 GUARDRAIL END DELINEATION

30 (A) General

31 Use guardrail end delineation that is adhesive coated yellow reflective sheeting applied
32 with a pressure sensitive adhesive backing.

33 (B) Reflective Sheeting Requirements

34 Use Grade C yellow retroreflective sheeting which conforms to Article 1092-2 for all
35 guardrail end delineation. In addition, guardrail end delineation shall have a minimum
36 reflective area of 2 sf for curved end sections or cover the entire portion of square end
37 sections. See *Roadway Standard Drawings*.

38 (C) Material Certification

39 Furnish a Type 2 material certification in accordance with Article 106-3 for all guardrail
40 end delineation before use.

41 (D) Approval

42 All materials are subject to the approval of the Engineer.

1 1088-4 OBJECT MARKERS**2 (A) General**

3 Use 7 ft galvanized steel U-shaped channel posts as supports for delineators that are
4 fabricated from steel conforming to ASTM A36 or ASTM A409. Use 7 ft posts, which
5 weigh at least 1.12 lb/lf after fabrication and application of protective finish. Punch or
6 drill all posts with 3/8" diameter holes on the centerline, spaced on 1" centers, starting
7 1" from the top and extending at least 24" down the posts. Make sure that the holes are
8 clean and the posts are free of burrs. Hot dip galvanize the posts after fabrication for the
9 full length and total area in accordance with ASTM A123.

10 (B) Reflectors

11 Use 3" diameter prismatic plastic reflectors on object markers that meet
12 Subarticle 1088-1(B)(1).

13 (C) Reflective Sheeting Requirements

14 Use Grade C retroreflective sheeting on object markers that meet Article 1092-2.

15 (D) Panel Requirements

16 Use panels that meet Article 1092-1.

17 (E) Fasteners

18 Use fasteners that meet Article 1092-1.

19 (F) Material Certification

20 Furnish a Type 5 material certification in accordance with Article 106-3 for sheeting,
21 a Type 2 material certification for delineators and a Type 1 material certification for
22 U-channel posts before use.

23 (G) Approval

24 All materials are subject to the approval of the Engineer.

25 1088-5 TUBULAR MARKERS**26 (A) General**

27 Provide tubular markers that are made of ultraviolet stabilized plastic impact resistant
28 material and have been evaluated by NTPEP. Provide orange, yellow or white tubular
29 markers as shown in the plans.

30 Provide tubular markers that are flexible or have a flexible joint at the base, such that it
31 will return to its original shape and position if struck by a 5,000 lb vehicle at a velocity of
32 55 mph. When struck the tubular markers shall not permanently distort to a degree that
33 would prevent reuse.

34 Use tubular markers that are circular in shape and have a minimum height of 36" with
35 a broadened base. Use tubular markers that have a minimum height of 42" on roadways
36 with posted speed limits greater than 50 mph.

37 Design tubular markers that have white retroreflective collars or as shown in the contract.

38 Where retroreflective collars are required, provide Grade C retroreflective sheeting or
39 better that meets Article 1092-2. Use retroreflective sheeting bands with a minimum
40 width of 4" with 6" between the bands. Apply a continuous strip of sheeting completely
41 around the tubular marker to ensure 360° retroreflectivity.

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1 (B) Material Certification

2 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
3 tubular markers and retroreflective collars and a Type 7 material certification for all used
4 tubular markers and retroreflective collars before use.

5 (C) Approval

6 All materials are subject to the approval of the Engineer.

7 1088-6 FLEXIBLE DELINEATOR

8 (A) General

9 Provide flexible delineators evaluated by NTPEP.

10 (B) Retroreflective Sheeting

11 Use retroreflective sheeting that is a minimum area of 16 sq.in., with a minimum width
12 of 3". The reflective sheeting shall be Grade C retroreflective sheeting or better and shall
13 conform to Article 1092-2.

14 Use retroreflective sheeting which is yellow, red or crystal, as shown in the plans. Attach
15 the retroreflective sheeting on the front and back of the delineator post as required by the
16 contract.

17 (C) Post

18 Design a delineator post that is flexible and made of recycled material. Provide
19 a delineator post that is resistant to impact, ultraviolet light, ozone, hydrocarbons and
20 stiffening with age.

21 Provide a post that is not seriously affected by exhaust fumes, asphalt or road oils, dirt,
22 vegetation, soil, deicing salts or any other types of air contamination or materials likely to
23 be encountered. Upon weathering, the post shall not exhibit serious discoloration,
24 checking or cracking, peeling or blistering, swelling, shrinking or distortion, or any other
25 detrimental effects. Weathering shall not cause appreciable strength or flexibility loss.

26 Design a post with a smooth surface that is free from irregularities or defects. The
27 surface of the post shall not soil excessively. If soiling does occur, it shall be easily
28 cleaned using detergent and water, or solvent.

29 Use posts that have a convex shaped cross-section. The cord distance for the cross-
30 section shall be from 3.5" to 4.5" in length.

31 Design a post such that it can maintain straightness throughout its entire life. Straight is
32 defined as no point along its length any more than 1" away from a perfectly straight edge
33 placed longitudinally along any side of the post.

34 Provide a post in which both sides of the top of the post accepts, and holds securely,
35 retroreflectorized sheeting.

36 Design posts that are gray in color.

37 (D) Base Support

38 Provide a base support that is hot rolled rail steel or new billet steel meeting
39 Article 1088-5, the physical requirements of ASTM A499 and the chemical requirements
40 of ASTM A1.

41 Use a base support that is a uniform flanged U-channel post with a nominal weight of
42 3 lb/ft before holes are punched. Use base support posts that are 18" in length and have
43 sufficient number of 3/8" diameter holes on 1" centers to facilitate attachment of the
44 flexible post.

1 (E) Anchoring

2 Design a delineator post for a permanent installation to resist overturning, twisting and
3 displacement from wind and impact forces.

4 (F) Temperature

5 Design flexible delineators that do not bend, warp or distort and remain straight, when
6 stored or installed at temperatures up to + 120°F. Design all components of the flexible
7 delineator, post and reflective sheeting to remain stable and remain fully functional
8 within a temperature range of - 20°F to + 120°F.

9 (G) Impact Resistance, Wind Resistance

10 Design flexible delineators that meet the impact and wind resistance of the current
11 evaluation criteria of the NTPEP.

12 (H) Product Identification

13 Provide flexible delineator post that are permanently identified, on the rear side, with the
14 manufacturer's name and the month and year of fabrication in order to provide a tracking
15 method for ongoing outdoor evaluation, and specification quality control. The letters
16 shall be at least 1/4" in height and permanently affixed to the rear of the marker.

17 (I) Material Certification

18 Furnish a Type 2 and Type 3 material certification in accordance with Article 106-3 for
19 all flexible delineators before use.

20 (J) Approval

21 All materials are subject to the approval of the Engineer.

22 **SECTION 1089**
23 **TRAFFIC CONTROL**

24 1089-1 WORK ZONE SIGNS**25 (A) General**

26 Grade B fluorescent orange sheeting shall be used on rigid work zone sign substrates.
27 The sheeting shall conform to Article 1092-2. Cover the entire sign face of the sign
28 substrate with Department approved Grade B fluorescent orange reflective sheeting. No
29 bubbles or wrinkles will be permitted in the material.

30 Roll-up sign retroreflective requirements shall conform to Article 1092-2.

31 (1) Work Zones Signs (Stationary)

32 Use Grade B fluorescent orange retroreflective sheeting that meets the reflective
33 requirements in Article 1092-2. Use approved composite or aluminum substrate for
34 sign backing. Signs and sign supports shall meet NCHRP 350 requirements for
35 breakaway devices.

36 (2) Work Zones Signs (Barricade Mounted)

37 Use approved composite or roll-up signs for barricade mounted sign substrates. No
38 other type of sign substrate is allowed on portable sign stands. Approved composite
39 barricade mounted warning signs (black on orange) shall be Grade B sheeting that
40 meets the retroreflective requirements of Article 1092-2. Sign and barricade
41 assembly shall meet NCHRP 350 for Work Zone Category II devices.

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(3) 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.

(a) Composite

Use Grade B fluorescent orange retroreflective sheeting that meets the reflective requirements in Article 1092-2. Signs and sign supports shall meet NCHRP 350 requirements for breakaway devices.

(b) Roll-up Signs

Use fluorescent orange retroreflective roll-up signs that meet the reflective requirements of Grade B in Article 1092-2.

Use roll up signs that have a minimum 3/16" x 1 1/4" horizontal rib and 3/8"x 1 1/4" vertical rib and has been crash test to meet NCHRP 350 requirements and Traffic Control qualified by the Work Zone Traffic Control Unit.

(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 ASTM D4956.

(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 when measured in accordance with ASTM E2301.

Rigid and roll up fluorescent orange signs shall maintain a total luminance factor of 25 for 3 years and conform to Article 1092-2 when measured in accordance with ASTM D4956.

1089-2 WORK ZONE SIGNS SUPPORTS

(A) General

(1) Work Zone Signs (Stationary)

Provide work zone sign supports for work zone signs (stationary) that are sturdy, durable and crashworthy. Work zone signs (stationary) and their supports shall meet appropriate NCHRP 350 crash criteria for Category II work zone devices.

Use 3-lb U-channel steel posts, 4" x 4" wood posts or perforated square steel tubing posts for all work zone signs with surface areas greater than 16 sf. Dual mount signs with surface areas greater than 10 sf on either 3-lb U-channel steel posts, 4" x 4" 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.

1 Three-pound steel U-channel posts shall comply with Subarticle 1094-1(B) and may
2 be galvanized steel or painted green by the post manufacturer.

3 (2) Work Zone Signs (Portable)

4 Use work zone signs and portable work zone sign stands that are sturdy, durable and
5 crashworthy.

6 **(B) Material Certification**

7 Provide portable work zone signs and stands that are listed on the NCDOT Approved
8 Product List. Furnish a Type 3 material certification in accordance with Article 106-3 for
9 all new work zone sign (stationary) posts and a Type 7 material certification for all used
10 work zone sign (stationary) posts before use.

11 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
12 portable work zone sign stand assemblies and a Type 7 material certification for all used
13 portable work zone sign stand assemblies before use.

14 **(C) Approval**

15 All materials are subject to the approval of the Engineer.

16 **1089-3 BARRICADES**

17 **(A) General**

18 Construct barricades out of perforated square steel tubing, angle iron or other Department
19 approved materials that meet or exceed NCHRP 350 crash criteria for Category II work
20 zone devices.

21 Use barricade rails constructed of approved composite, hollow/corrugated extruded rigid
22 polyolefin, HDPE or other Department approved material that have a smooth face and
23 alternating orange and white retroreflective stripes that slope at an angle of 45°.
24 Barricade rails shall meet or exceed NCHRP 350 crash criteria for Category II work zone
25 devices.

26 **(B) Supports**

27 Support barricade rails in a manner that shall be visible to the motorist and provide
28 a stable support not easily blown over by wind or traffic.

29 **(C) Reflective Sheeting**

30 Use Grade B retroreflective sheeting that meets Article 1092-2. Flame treat rails before
31 applying the sheeting if required by the sign sheeting manufacturer. Apply the reflective
32 sheeting with a pressure sensitive adhesive to both sides of the rails.

33 Use the same color sheeting on each rail of any individual barricade.

34 **(D) Material Certification**

35 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
36 barricades and a Type 7 material certification for all used barricades before use.

37 **(E) Approval**

38 All materials are subject to the approval of the Engineer.

39 **1089-4 CONES**

40 **(A) General**

41 Use cones made of ultraviolet stabilized plastic impact resistant material meeting
42 MUTCD and this article. Orange will be the predominant color on cones.

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1 Use cones conical in shape with a minimum height of 28" or 36". The 28" cones shall
2 have a minimum base dimension of 13.75", and the 36" cones shall have a minimum base
3 dimension of 14.5" as shown in the *Roadway Standard Drawings*. The 28" and 36"
4 cones (excluding ballast) shall have a minimum weight of 7 lb and 10 lb respectively.
5 When in an upright position, have the cones display the same dimensions regardless of
6 their orientation to oncoming traffic.

7 (B) Ballast

8 Provide wind resistant cones that do not blow over under normal roadway conditions,
9 including high speed truck traffic in close proximity to the cones when properly ballasted.
10 Provide cones that do not permanently distort to a degree that would prevent reuse when
11 struck.

12 Achieve ballasting of the cones by using any of the following methods:

- 13 (1) Cones with bases that may be filled with ballast,
- 14 (2) Doubling the cones or using heavier weighted cones, or
- 15 (3) Cones with special weighted bases or weights such as rubber rings that can be
16 dropped over the cones and onto the base to provide increased stability.

17 Provide cones with 70% of the weight of the cone in the base. These added weights shall
18 not present a hazard if the devices are inadvertently struck.

19 (C) Retroreflective Sheeting

20 Where retroreflective cones are required, provide a cone with flexible, prismatic cone
21 sheeting having impact resistance and attached with precoated pressure sensitive
22 adhesive. The retroreflective sheeting shall meet or exceed the retroreflectivity
23 requirements of Grade B sheeting in Section 1092. Use 2 retroreflective bands, the top
24 one is 6" wide and the bottom one is 4" wide; see *Roadway Standard Drawings*.

25 (D) Material Certification

26 Furnish a Type 3 material certification in accordance with Article 106-3 for all new cones
27 with or without retroreflective sheeting and a Type 7 material certification for all used
28 cones with or without retroreflective sheeting before use.

29 (E) Approval

30 All materials are subject to the approval of the Engineer.

31 1089-5 CHANNELIZING DEVICES

32 (A) Drums

33 (1) General

34 Provide drums composed of a body, alternating orange and white 4 band pattern of
35 Type III-High Intensity or higher prismatic sheeting and ballasts evaluated by
36 NTPEP.

37 (2) Body

38 Provide a drum made of orange, impact resistant, ultraviolet plastic material capable
39 of maintaining its integrity upon impact throughout a temperature range of 20°F to
40 125°F. When struck, the drum shall not permanently distort to a degree that would
41 prevent reuse, nor roll excessively after impact. Design the drum to prevent water
42 from accumulating and freezing in the top or bottom.

1 Provide a drum that is cylindrical in shape with the following dimensions;
2 a minimum height of 36", a minimum top outer diameter of 18", a bottom outer
3 diameter of 21" to 24", and a minimum weight of 7 lb. The top outer diameter shall
4 not exceed the bottom outside diameter. Provide closed tops on drums to prevent
5 accumulation of debris.

6 (3) Retroreflective Stripes

7 Provide at least 4 retroreflective bands with 2 orange and 2 white alternating
8 horizontal circumferential bands. The top band shall always be orange. Use a 6" to
9 8" wide band Type III–High Intensity prismatic retroreflective sheeting or better that
10 meets Article 1092-2 for each band. Do not exceed 2" for any non-reflective spaces
11 between orange and white stripes. Do not splice the retroreflective sheeting to create
12 the 6" band. Apply the retroreflective sheeting directly to the drum surface. Do not
13 apply the retroreflective sheeting over a pre-existing layer of retroreflective sheeting.
14 Do not place bands over any protruding corrugations areas. No damage to the
15 reflective sheeting should result from stacking and unstacking the drums, or vehicle
16 impact.

17 (4) Ballast

18 Ballast drums using the sandbag ballast method, the tire sidewall ballast method or
19 by the preformed weighted base ballast method. When properly ballasted, the drums
20 shall be wind resistant to the extent of withstanding wind created by traffic under
21 normal roadway conditions, including high speed truck traffic in close proximity to
22 the drums. Do not place ballast on top of the drum.

23 (a) Sandbag Ballast Method

24 Supply a sandbag with 50 lb of sand with each drum. Place the sandbag inside
25 the body on top of the detachable base. Upon impact the main body of the drum
26 shall deform and become detached from the base, allowing vehicles to easily
27 pass over the remaining base.

28 (b) Tire Sidewall Ballast Method

29 Design the base of the drums to accommodate no more than 2 tire sidewalls that
30 when combined will have a weight of at least 30 lb and no more than 50 lb. Use
31 the manufacturer's required tire sidewall ballast. Upon impact the main body of
32 the drum shall deform and become detached from the tire sidewalls, allowing
33 vehicles to easily pass over the tire sidewall ballasts.

34 (c) Preformed Weighted Base Ballast Method

35 Supply a preformed base specifically designed for the model drum. The weight
36 of each drum's preformed base will be self-certified by the manufacturers. Each
37 drum with preformed bases shall be approved by the Work Zone Traffic Control
38 Unit. Upon impact, the main body of the drum shall deform and become
39 detached from the base allowing vehicles to easily pass over the remaining base.

40 (5) Material Certification

41 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
42 drums and a Type 7 material certification for all used drums before use.

43 (6) Approval

44 All materials are subject to the approval of the Engineer.

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1 (B) Skinny Drums

2 (1) General

3 Provide skinny drums composed of a body, reflective stripes and ballasts evaluated
4 by NTPEP.

5 (2) Body

6 Provide a skinny drum made of orange, impact resistant, ultraviolet plastic material
7 capable of maintaining its integrity upon impact throughout a temperature range of
8 - 20°F to 125°F. When struck, the skinny drum shall not permanently distort to
9 a degree that would prevent reuse, nor roll excessively after impact. Design the
10 skinny drum to prevent water from accumulating and freezing in the top or bottom.

11 Provide a skinny drum that is cylindrical in shape with the following dimensions;
12 a minimum height of 42", a minimum top outer diameter of 4" and a bottom outer
13 diameter of 7.5". The top outer diameter shall not exceed the bottom outside
14 diameter. Provide closed tops on drums to prevent accumulation of debris.

15 (3) Retroreflective Stripes

16 Provide at least 4 retroreflective bands with 2 orange and 2 white alternating
17 horizontal circumferential bands for each skinny drum. The top band shall always be
18 orange. Use a 6" to 8" wide band Type III–High Intensity or higher prismatic
19 retroreflective sheeting that meets Article 1092-2 for each band. Do not exceed 2"
20 for any non-reflective spaces between orange and white stripes. Do not splice the
21 retroreflective sheeting to create the 6" band. Apply the retroreflective sheeting
22 directly to the skinny drum surface. Do not apply the retroreflective sheeting over
23 a pre-existing layer of retroreflective sheeting. Do not place bands over any
24 protruding corrugation areas. No damage to the reflective sheeting should result
25 from stacking and unstacking the skinny drums, or vehicle impact.

26 (4) Ballast

27 Ballast skinny drums using a preformed base specifically designed for the model
28 skinny drum. Each base shall be at least 15 lb and circular or polygonal with equal
29 sides. When properly ballasted, the skinny drums shall be wind resistant to the
30 extent of withstanding wind created by traffic under normal roadway conditions
31 including high speed truck traffic in close proximity to the skinny drums. Do not
32 place ballast on top of the drum. Upon impact, the main body of the drum shall
33 deform and become detached from the base allowing vehicles to easily pass over the
34 remaining base.

35 (5) Material Certification

36 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
37 skinny drums and a Type 7 material certification for all used skinny drums before
38 use.

39 (6) Approval

40 All materials are subject to the approval of the Engineer.

41 1089-6 FLASHING ARROW BOARDS

42 (A) General

43 Provide a trailer mounted arrow board that meets or exceeds the physical and operational
44 requirements of the MUTCD and which has been evaluated by NTPEP. The following
45 specifications supplement those basic requirements. Provide a totally mobile complete
46 unit capable of being located as traffic conditions demand.

1 The display housing shall meet the minimum size requirements of a Type C panel with
2 a 15 or 25 lamp configuration.

3 The display housing shall have a hand-crank mechanism to allow raising and lowering
4 the display with a locking device to ensure the display housing will remain secured in
5 either position

6 The display housing will have a minimum height of 7 ft from the bottom of the sign to
7 the ground when raised in the upright position.

8 The display housing assembly shall be of weather resistant construction.

9 The lamps shall be controlled to provide the following modes as a minimum: Flashing
10 Right or Left Arrow, Flashing Double Arrow and Caution Mode (4 outermost corner
11 lamps).

12 **(B) Power System**

13 Provide a unit that is solar powered and supplemented with a battery backup system that
14 includes a 110/120 VAC powered on-board charging system.

15 The unit shall also be capable of being powered by standard 110/120 VAC power source.

16 The batteries, when fully charged, shall be capable of powering the display for
17 20 continuous days with no solar power.

18 Store the battery bank and charging system in a lockable, weather and vandal resistant
19 box.

20 **(C) Controller**

21 Provide an automatic brightness/dimming of the display and a manual override dimming
22 switch.

23 The controller shall provide a battery-charge status indicator.

24 Mobile radio or any other radio transmissions shall not affect the controller.

25 Store the controller in a lockable, weather and vandal resistant box.

26 **(D) Trailer**

27 Finish all exterior metal surfaces with Federal orange enamel per Federal Standard 595a,
28 color chip ID# 13538 or 12473 respectively. The trailer shall be able to support
29 a 100 mph wind load with the display fully extended.

30 The trailer shall be equipped with leveling jacks capable of stabilizing the unit in
31 a horizontal position when located on slopes 6:1 or flatter.

32 The trailer shall be properly equipped in compliance with North Carolina Law governing
33 motor vehicles.

34 Provide a minimum 4" wide strip of fluorescent orange retroreflective sheeting to the
35 frame of the trailer. Apply the sheeting to all sides of the trailer. The sheeting shall meet
36 the requirements of Section 1088-1. Drums may be supplemented around the unit in
37 place of the sheeting.

38 **(E) Reliability**

39 Provide a sign unit that all components are rated to operate at temperatures ranging from
40 -30°F to 165°F.

41 The sign manufacturer shall notify the Work Zone Traffic Control Unit whenever
42 modifications are made to a prequalified sign on the NCDOT Approved Products List.

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1 The Work Zone Traffic Control Unit will review changes and per its discretion either
2 make no change to the sign's status or remove it from the list until the sign can be
3 reevaluated.

4 (F) Material Certification

5 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
6 flashing arrow boards, a Type 7 material certification for all used flashing arrow boards,
7 and wind load certifications required in Subarticle 1089-6(D) for all new and used
8 flashing arrow boards before use.

9 (G) Approval

10 The sign shall be on the NCDOT Approved Products List before use on construction
11 projects in North Carolina. A sign may be removed from the NCDOT Approved
12 Products List due to unsatisfactory field performance and shall not return to the list until
13 the manufacturer identifies the reason for the failure and the problem has been corrected
14 to the satisfaction of the Department.

15 The sign manufacturer shall notify the Department whenever modifications are made to
16 their sign that was prequalified on the NCDOT Approved Products List. The Department
17 will review changes and per its discretion, either make no change to the sign's status on
18 the NCDOT Approved Products List or remove the sign from the list until the sign can be
19 reevaluated.

20 1089-7 PORTABLE CHANGEABLE MESSAGE SIGNS

21 (A) General

22 Provide trailer mounted portable changeable message signs that meet MUTCD and have
23 been evaluated by NTPEP.

24 Provide a totally mobile complete sign unit capable of being located as traffic conditions
25 demand.

26 (B) Display Panel

27 Provide 3 lines of a programmable message with at least 8 characters per line and
28 a character height of at least 18".

29 The display characters will be composed of LED elements. The display panel may be of
30 the following types- Full Matrix, Continuous Line Matrix, and Character Matrix.

31 Messages are to be automatically centered and proportionally spaced on each line of
32 a Full Matrix and Continuous Line Matrix displays. Character Matrix displays shall
33 display odd number character messages one character left of the centerline.

34 The display characters shall be protected with a polycarbonate lens that shall not decrease
35 the daytime visibility of the sign.

36 The display panel shall have an electro-hydraulic system to allow raising and lowering
37 the display with 360° rotation capability. A locking device(s) shall be provided to ensure
38 the display will remain secure in the raised, lowered and rotated positions. The sign shall
39 have the capability to be raised and rotated to its operating position by one person.

40 A manual backup mechanism for the raising and lowering the display panel shall be
41 provided in the event the electro-hydraulic system fails.

42 The display panel assembly shall be of weather resistant construction

43 (C) Power System

44 The unit shall be Solar powered and supplemented with a battery backup system which
45 includes a 110/120 VAC powered on-board charging system.

1 The batteries, when fully charged, shall be capable of powering the display for
 2 20 continuous days with no solar power. The unit shall be capable of being powered by
 3 standard 110/120 VAC power source.

4 Store the battery bank and charging system in a lockable, weather and vandal resistant
 5 box.

6 **(D) Controller**

7 The controller shall provide at a minimum; a keyboard, a display for message review and
 8 editing, a light source for nighttime operations, an event time clock and all other required
 9 controls for the operation of the display. Access to controller operations shall have the
 10 capability to be password protected.

11 The controller shall include the following capabilities; manually dimming the display,
 12 storing at least 99 user generated messages, adjusting the flash rate of display and display
 13 phasing and monitoring battery-charge status.

14 Mobile radio or any other radio transmissions shall not affect the controller.

15 The controller shall be stored in a lockable, weather and vandal resistant box.

16 The controller shall be pre-programmed with messages shown below and stored in
 17 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

18 **A.** Test Pattern A is 1/2 of the LEDs/flip-discs/or combination on at a time.

19 **B.** Test Pattern B is for the remaining 1/2 of the LEDs/flip-discs/or combination on at
 20 a time.

Section 1089

1 (E) Trailer

2 Finish all exterior metal surfaces with Federal orange enamel per Federal Standard 595a;
3 color chip ID# 13538 or 12473 respectively except for the sign face assembly that shall
4 be flat black.

5 Provide a minimum 4" wide strip of fluorescent orange retroreflective sheeting to the
6 frame of the trailer. Apply the sheeting to all sides of the trailer. The sheeting shall meet
7 Article 1088-1. Drums may be supplemented around the unit in place of the sheeting.

8 The trailer shall be able to support a 100 mph wind load with the display fully extended.

9 The trailer shall be equipped with leveling jacks capable of stabilizing the unit in
10 a horizontal position when located on slopes 6:1 or flatter.

11 The trailer shall be properly equipped in compliance with North Carolina Law governing
12 motor vehicles.

13 (F) Reliability

14 Provide a sign unit that all components are rated to operate at temperatures ranging from
15 -30°F to 165°F.

16 (G) Material Certification

17 Furnish a Type 3 material certification in accordance with Article 106-3 for all new
18 changeable message signs, a Type 7 material certification for all used changeable
19 message signs and wind load certifications required in Subarticle 1089-7(E) for all new
20 and used changeable message signs before use.

21 (H) Approval

22 The sign shall be on the NCDOT Approved Products List before use on construction
23 projects in North Carolina. A sign may be removed from the NCDOT Approved
24 Products List due to unsatisfactory field performance and shall not return to the list until
25 the manufacturer identifies the reason for the failure and the problem has been corrected
26 to the satisfaction of the NCDOT.

27 The sign manufacturer shall notify NCDOT whenever modifications are made to their
28 sign that was prequalified on the NCDOT Approved Products List. The Department will
29 review changes and per its discretion either make no change to the sign's status on the
30 NCDOT Approved Products List or removed the sign from the list until the sign can be
31 reevaluated.

32 1089-8 TEMPORARY CRASH CUSHIONS

33 (A) General

34 Provide temporary crash cushions that meet NCHRP 350 for Work Zone Test Level 2 for
35 work zones that have a posted speed limit of 45 mph or less. Provide temporary crash
36 cushions that meet NCHRP 350 for Work Zone Test Level 3 devices for work zones that
37 have a posted speed limit of 50 mph or greater. Provide temporary crash cushions that
38 shall remain intact after a side impact, and without maintenance, be capable of sustaining
39 additional side or head-on impacts.

40 Contain the temporary crash cushion debris resulting from impact within the structure of
41 the temporary crash cushion.

42 Include in the temporary crash cushion package any required rear transition panels to
43 connect the back of the temporary crash cushion to rigid or flexible barrier systems as
44 well as any required portable base as recommended by the manufacturer of the temporary
45 crash cushion, to connect the bottom of the temporary crash cushion to a paved surface.
46 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 Federal Standard No. 595a for Yellow (Color No. 13538) for all temporary crash cushions.

The reflective end treatment shall meet the requirement for reflectivity 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 that are on the NCDOT Approved Products List.

1089-9 TRUCK MOUNTED ATTENUATORS**(A) General**

Provide truck mounted attenuators that meet NCHRP 350 Test Level II for work zones that have a posted speed limit of 45 mph or less. Provide truck mounted attenuators that meet NCHRP 350 Test Level III for work zones that have a posted speed limit of 50 mph or greater.

Use trucks with gross vehicle tare weight as described in the NCHRP 350 crash test for the impact attenuator provided. Provide 2 axle flat bed type trucks with minimum gross vehicle tare weight of 5,000 lb that may be ballasted with sections of portable concrete barrier attached to the bed of the truck with bolts or straps, or concrete poured into the bed of the truck and attached to the truck with bolts, or a continuous layer of asphalt placed in the bed of the truck and attached to the truck with bolts.

Mount the attenuator on a truck chassis to provide a uniform clearance, as required by the truck mounted attenuator's manufacturer, between the bottom of the shell and the roadway. Use a steel backup support assembly of sufficient size and strength to permit mounting on the chassis by brackets, as required by truck mounted attenuator's manufacturer.

Provide truck mounted attenuators equipped with cartridges that have a standard trailer lighting system, including brake lights, tail lights and turn signals.

(B) Retroreflective End Treatment

The reflective 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 only truck mounted attenuators that are on the NCDOT Approved Products List.

Section 1090

1 1089-10 FLAGGER

2 (A) Stop and Slow Paddle

3 (1) Reflective Sheeting

4 Use reflective sheeting with a smooth, sealed outer surface that will display the same
5 color both day and night. Cover the entire sign face with Grade B reflective
6 sheeting. Reflective sheeting shall meet Article 1092-2. The distance from the
7 bottom of the sign to the ground shall be at least 7 ft.

8 (2) Material Certification

9 Furnish a Type 3 material certification in accordance with Sections 106-3 for all new
10 reflective sheeting used on flagger paddles and a Type 7 material certification for all
11 used sheeting before use.

12 (3) Approval

13 All materials are subject to the approval of the Engineer.

14 (B) Vest

15 (1) Reflective Sheeting

16 Use reflective sheeting with sealed outer surface that will display the same color both
17 day and night. Design the reflective sheeting similar to Department chevron vests.
18 Reflective sheeting shall meet Article 1092-2.

19 (2) Material Certification

20 Furnish a Type 3 material certification in accordance with Sections 106-3 for all new
21 reflective sheeting and a Type 7 material certification for all used sheeting on flagger
22 vests before use.

23 (3) Approval

24 All materials are subject to the approval of the Engineer.

25 SECTION 1090

26 PORTABLE CONCRETE BARRIER

27 1090-1 PORTABLE CONCRETE BARRIER

28 (A) General

29 Use portable concrete barrier that meets Section 854, Section 1077 and the plans. The
30 requirement for approved galvanized connectors will be waived if the barrier remains the
31 property of the Contractor.

32 (B) Used Portable Concrete Barrier

33 Used barrier will be acceptable provided the following conditions have been met:

34 (1) The Contractor has furnished a Type 7 material certification in accordance with
35 Article 106-3.

36 (2) The strength of the concrete in each barrier unit is at least 4,500 psi as evidenced by
37 nondestructive tests made in place by a rebound hammer in accordance with
38 ASTM C805.

39 (C) Anchor Bolts

40 Use anchor bolts that meet ASTM A325.

41 (D) Approval

42 All materials are subject to the approval of the Engineer.

Section 1091

1 (F) Solid Wall HDPE Conduit

2 Use HDPE conduit that conforms to UL Standard 651B. Provide conduit meeting
 3 Table 1091-1 with minimum wall thickness ratios corresponding to
 4 EPEC-40 (Schedule 40), EPEC-80 (Schedule 80) or EPEC-B (SDR 13.5) as listed in
 5 UL Standard 651B, Table 5.1, 5.2 and 5.3.

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

6 Ensure the PE resin compounds used in manufacturing the conduit meet or exceed the
 7 cell classification PE 334420C (black with 2% minimum carbon black) or
 8 PE 334420E (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 F50>24 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

9 Furnish conduits in the colors for the applications shown in Table 1091-3. For conduits
 10 manufactured with stripes, ensure the stripes are uniformly located around the conduit
 11 with 120 degrees of separation. Do not use "Solid Yellow" or "Black with Yellow
 12 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

1 Ensure the HDPE conduit is resistant to benzene, calcium chloride, ethyl alcohol, fuel oil,
2 gasoline, lubricating oil, potassium chloride, sodium chloride, sodium nitrate and
3 transformer oil and is protected against degradation due to oxidation and general
4 corrosion.

5 Furnish factory lubricated, low friction, conduit with a coefficient of friction of 0.10 or
6 less in accordance with Telcordia GR-356.

7 Ensure the supplied conduit is identified and certified as meeting, UL Standard 651B.
8 Ensure the conduit is marked at least with the following information on 10 ft or less
9 intervals:

10 (1) Material: HDPE

11 (2) Trade Size: i.e., 2"

12 (3) Conduit Type: SDR 13.5 or EPEC-B

13 (4) Manufacturer's name or trademark

14 (5) Manufacturer's identity code to identify manufacturing date, facility, etc.

15 (6) UL symbol or UL listing number

16 Furnish coilable conduit that is supplied on reels in continuous lengths for transportation
17 and storage outside. Ensure that the process of installing the coilable conduit on the reel
18 does not alter the properties or performance of the conduit for its intended purpose.

19 **(G) Conduit Plugs, Pull Line and Tracer Wire**

20 Furnish conduit plugs that provide a watertight barrier when installed in conduit. Furnish
21 conduit plugs sized in accordance with conduit. Ensure conduit plug provides a means to
22 secure a pull line to the end of the plug. Provide removable and re-usable conduit plugs.
23 Conduit plugs are not required to be listed electrical devices.

24 For all spare conduits, furnish 3/4", pre-lubricated, woven polyester tape, pull line with
25 minimum rated tensile strength of 2,500 lb. Pull lines are not required to be listed
26 electrical devices.

27 Provide green insulated number 14 AWG, THWN, stranded copper wire to serve as
28 tracer wire.

29 **1091-4 DUCT AND CONDUIT SEALER**

30 Use duct and conduit sealer or mastic which is a putty-like compound and:

31 **(A)** Is permanently non-hardening, non-oxidizing, and non-corrosive to metals, rubber,
32 plastic, lacquer and paints;

33 **(B)** Is readily workable for thumbing into openings and forming into seals around wires
34 inside conduits and openings around conduits;

35 **(C)** Has a service temperature range of minus 30°F to 200°F;

36 **(D)** Is clean, non-poisonous and non-injurious to human skin;

Section 1091

1 (E) Seals against water, dust and air and shall adhere to wood, glass, plastics, metal, rubber
2 and painted surfaces; and

3 (F) Is non-conductive.

4 **1091-5 ELECTRICAL JUNCTION BOXES**

5 **(A) General**

6 Provide electrical junction boxes with covers of the type and size indicated by the
7 contract or plans for the termination of conduits.

8 **(B) Polymer Concrete (PC) Junction Boxes**

9 Provide polymer concrete (PC) boxes which are stackable, have bolted covers and have
10 open bottoms. Ensure vertical extensions of 6" to 12" are available from the junction box
11 manufacturer.

12 Use polymer concrete material made of an aggregate consisting of sand and gravel bound
13 together with a polymer and reinforced with glass strands to fabricate box and cover
14 components which are exposed to sunlight. Other thermosetting glass-reinforced
15 materials may be used for components which are not normally exposed to sunlight.

16 Provide certification that the polymer concrete boxes and covers meet
17 Tier 15 requirements of ANSI/SCTE 77. Provide certification that testing methods are
18 compliant with ANSI/SCTE 77.

19 Provide the required logo on the cover. Provide at least 2 size 3/8" diameter hex head
20 stainless steel cover bolts to match inserts in the box. Provide pull slot(s) with stainless
21 steel pin(s). Polymer concrete junction boxes are not required to be listed electrical
22 devices.

23 **(C) Cast Metal (BR) Junction Boxes**

24 Provide cast-metal (BR) box, replaceable frame and cover that are hot dipped galvanized
25 with factory or field drilled conduit entrances. Provide a cover with checkered imprint,
26 pry bar slots, and reinforcing ribs for heavy loading, neoprene gasket, and brass or
27 stainless steel bolts. Provide a blind tapped (1/4" NC thread minimum) boss on interior
28 of box for grounding.

29 **1091-6 GROUNDING ELECTRODES**

30 Provide grounding electrodes of the following types as indicated in the specifications and
31 plans.

32 **(A) Ground Rods**

33 Provide 5/8" diameter, 10 ft long, copper-clad steel ground rods with 10 mil thick copper
34 cladding.

35 **(B) Sectional Ground Rods**

36 Provide sectional ground rods comprised of 5/8" diameter, 10 ft long, steel ground rods
37 with 10 mil thick copper cladding, welded together in a butt configuration with
38 an exothermic weld. As an alternative, provide UL listed bronze couplers designed to
39 connect 5/8" diameter copper-clad steel rods. Do not use threaded ground rods or
40 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 Section 10(3) of the *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

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 10% of the studs tested on any one sign 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.

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" 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

Section 1092

1 1092-2 RETROREFLECTIVE SHEETING

2 Reflectorize all signs. Use colors and sheeting grades of the sign backgrounds and messages
 3 as shown in the contract. After preparation of the sign panels, in accordance with
 4 Subarticle 901-3(D), apply retroreflective sheeting as required herein. The retroreflective
 5 sheeting shall consist of white or colored sheeting having a smooth outer surface and the
 6 property of a retroreflector over its entire surface.

7 Retroreflective sheeting shall meet ASTM D4956 and are listed on the NCDOT Approved
 8 Products List.

9 The reflective material specified herein is intended for use on surfaces of various traffic
 10 control devices, including drums, barricades, traffic cones and highway signs, to assure their
 11 adequate visibility at all times upon exposure to a light source when totally dry or wet.
 12 Provide reflectorization that produces a wide-angle retroreflectivity, enhancing nighttime
 13 visibility. This retroreflective sheeting shall consist of encapsulated, enclosed lens or
 14 prismatic with a transparent plastic having a smooth, flat outer surface. Provide material that
 15 is flexible, of good appearance, free from ragged edges, cracks and extraneous materials, and
 16 exhibits good quality workmanship.

17 (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

1 For areas printed with transparent colors, the coefficient of retroreflection shall not
2 be less than 70% of the values for the corresponding color.

3 (1) Adhesive

4 Meet ASTM D4956.

5 (2) Field Performance

6 The fabricating agency will date all signs (month, year) at the completion of
7 fabrication. That date constitutes the start of the field performance obligation period.

8 **(B) Manufacturer's Warranty and Obligations**

9 (1) Warranty

10 The sheeting manufacturer warrants to the Department that all materials furnished
11 under this Specification will be new, of good components and workmanship and
12 agrees to the following conditions.

13 Retroreflective sheeting processed and applied to sign blank materials in accordance
14 with the manufacturer's manuals shall be warranted by the manufacturer to perform
15 effectively as stated in this section. The manufacturer's manuals shall contain
16 a complete descriptive explanation of all the requirements necessary of the sign
17 fabricator.

18 (2) Obligation Grades A, B and C

19 (a) Years 1 through 7 (Years 1 Through 2 for Fluorescent Orange)

20 Cover the cost of restoring the sign face in its field location to its original
21 effectiveness at no cost to the Department for materials, labor and equipment.
22 In addition to the reflective requirements for Grade B fluorescent orange, the
23 sheeting shall at least maintain a total Luminance Factor (Y) of 25
24 (ASTM D4956) and a Fluorescence Luminance Factor (YF) of 13%
25 (ASTM E2301) for 3 years. Maintain at least 80% of fluorescent orange
26 sheeting reflectivity for years 1 and 2.

27 (b) Years 8 through 10 (Year 3 for Fluorescent Orange)

28 Replace the sheeting required to restore the sign face to its original
29 effectiveness. Maintain 50% of fluorescent orange sheeting reflectivity for
30 year 3.

31 (c) Years 11 through 12

32 Replace 50% of the sheeting required to restore the sign face to its original
33 effectiveness.

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1 1092-3 CERTIFICATION

2 Provide a Type 6 material certification in accordance with Article 106-3 for all retroreflective
3 sheeting used in the manufacture of signs certifying that the sheeting meets Section 1092.

4 SECTION 1094 5 GROUND MOUNTED SIGNS

6 1094-1 GROUND-MOUNTED SIGN SUPPORTS

7 (A) Breakaway or Simple Steel Beam Sign Supports

8 Fabricators of breakaway or simple steel beam sign supports shall be AISC Category I
9 certified.

10 Steel supports for Type A and B ground mounted signs shall be galvanized rolled steel
11 sections, either breakaway or simple design, as required by the contract. Fabricate
12 supports from plates, W shapes, and S shapes, as required by the contract, and they shall
13 conform to ASTM A36. Splices in the supports will not be permitted. Perform
14 galvanizing before assembly that conforms to ASTM A123. Cutting steel supports to
15 length after they have been galvanized will not be permitted in new construction. The
16 support(s) shall be uniformly straight to within 1/8" tolerance for pieces less than 20 ft in
17 length, and 1/4" tolerance for pieces over 20 ft in length.

18 Fabricate high strength bolts, nuts and washers required for breakaway supports from
19 steel in accordance with ASTM A325 and galvanize in accordance with ASTM B695,
20 Class 55.

21 (B) Three Pound Steel U-Channel Posts

22 Make 3-lb steel U-channel posts out of rerolled rail steel or new billet steel, conforming
23 to the mechanical requirements of ASTM A499, Grade 60, and the chemical
24 requirements of ASTM A1, for rails having nominal weights of 91 lb/yd or greater.
25 Proportion the cross section so a moment of 1,450 ft-lb, applied to the cross section
26 normal to the flanges, will produce an extreme fiber stress no greater than 39,500 psi.
27 Use posts that weight 3 lb/lf. Punch or drill all posts with 3/8" diameter holes on the
28 centerline, spaced 1" on centers, starting 1" from the top and extending to the bottom of
29 the posts. Galvanize these posts after fabrication for the full length and total area in
30 accordance with ASTM A123. The zinc coating inside of the 3/8" diameter holes shall
31 not exceed Specification requirements enough to prevent a 5/16" diameter bolt from
32 freely passing through.

33 Use U-channel post sections of the same general configuration as that shown in the
34 contract, however minor variations may be considered acceptable by the Engineer
35 provided all other requirements are met.

36 (C) Two Pound Steel U-Channel Posts

37 Use 2-lb steel U-channel posts that are variable length galvanized steel, U-shaped
38 channel posts.

39 Fabricate the U-channel posts from steel meeting ASTM A1008 or ASTM A499, or
40 an approved alternate. The posts shall weigh 2 lb/lf, and be of the length necessary to
41 meet the erection requirements of the contract. Before galvanizing, punch or drill
42 3/8" diameter holes on 1" centers, beginning 1" from the top of the post, for a minimum
43 distance equal to the vertical dimension of the respective sign or mile marker. Galvanize
44 these posts after fabrication in accordance with ASTM A123. The zinc coating inside of
45 the 3/8" diameter holes shall not exceed Specification requirements enough to prevent
46 a 5/16" diameter bolt from freely passing through.

1 U-channel post sections shall be of the same general configuration as that shown in the
 2 contract, however, minor variations may be considered acceptable by the Engineer,
 3 provided all other requirements are met.

4 **(D) Steel Square Tube Posts**

5 Use steel square tube posts of variable length galvanized steel. The post shall be
 6 a minimum 14 gauge steel square tube. Before galvanizing punch or drill all posts with
 7 3/8" diameter holes on the centerline, spaced 1" on centers, starting 1" from the top and
 8 extending to the bottom of the posts.

9 Galvanize these posts after fabrication for the full length and total area in accordance
 10 with ASTM A123. G90 zinc coating shall not be accepted. The zinc coating inside of
 11 the 3/8" diameter holes shall not exceed Specification requirements enough to prevent
 12 a 5/16" diameter bolt from freely passing through.

13 Steel square tube sections shall be of the same general configuration as that shown in the
 14 contract, however, minor variations may be considered acceptable by the Engineer,
 15 provided all other requirements are met.

16 **(E) Wood Supports**

17 Wood supports shall conform to Articles 1082-2 and 1082-3.

18 **1094-2 RIVETS FOR SIGN OVERLAYS**

19 Rivets for sign overlays shall be 1/8" diameter aluminum rivets of the pull through type, and
 20 be approved by the Engineer. Submit for approval several samples of rivets, along with
 21 adequate descriptive catalog literature.

22 **SECTION 1096**
 23 **OVERHEAD SIGN STRUCTURES**

24 **1096-1 ALUMINUM OVERHEAD SIGN STRUCTURES**

25 Materials for aluminum overhead sign structures shall conform to Article 1092-1 and
 26 *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and*
 27 *Traffic Signals*. Where the Contractor proposes to use materials that are not covered by these
 28 references, such use will be contingent on the Engineer's approval of these materials.

29 **1096-2 STEEL OVERHEAD SIGN STRUCTURES**

30 Use Category I certified by the American Institute of Steel Construction Fabricators for steel
 31 overhead sign structures as required by Subarticle 1072-1(A). Use either structural carbon
 32 steel or structural low-alloy steel for steel overhead sign structures meeting *AASHTO LRFD*
 33 *Bridge Design Specifications*. Other steel may be used, subject to the approval of the
 34 Engineer. Structural steel that has been cold-rolled to increase the yield strength will be
 35 permitted. Mechanically galvanize all fasteners. Hot-dip galvanize all other components of
 36 the structural assembly after fabrication has been completed. The galvanizing shall meet
 37 ASTM B695, Class 55, for fasteners and ASTM A123 for other structural steel.

38 **1096-3 WELDING**

39 Perform all welding in the fabrication of the supports by AWS certified welders. Furnish
 40 a copy of the AWS certification for each welder used for fabrication. All welds shall be free
 41 of cracks, blow holes, slag, and other irregularities, and be wire brushed, sandblasted or
 42 otherwise cleaned.

43 Aluminum welding processes and procedures, shielding gases, preparation, weld quality,
 44 inspection and correction of welds, and the qualification of welding procedures, welders and
 45 welding operators will be governed by the AWS Structural Welding Code, D1.2.

Section 1098

1 The welding of steel components, including structural details, filler metal, workmanship and
2 technique, qualification and inspection will be based on the applicable requirements of the
3 AWS Structural Welding Code, D1.1.

4 **SECTION 1098** 5 **SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEM** 6 **MATERIALS**

7 **1098-1 GENERAL REQUIREMENTS**

8 **(A) Qualified Products**

9 Furnish new equipment, materials, and hardware unless otherwise required. Inscribe
10 manufacturer's name, model number, serial number and any additional information
11 needed for proper identification on each piece of equipment housed in a case or housing.

12 ITS and Signals Qualified Products List (QPL) is available on the Department's website.

13 Certain signal and communications equipment, material and hardware shall be
14 pre-approved on the QPL by the date of installation. Equipment, material and hardware
15 not pre-approved when required will not be allowed for use on the project. Consult the
16 QPL web site to obtain pre-approval procedures.

17 **(B) Submittal Requirements**

18 Furnish a Type 3 material certification in accordance with Article 106-3. When
19 requested by the Department, provide additional certifications from independent testing
20 laboratories and sufficient data to verify item meets applicable Specifications. Ensure
21 additional certification states the testing laboratory is independent of the material
22 manufacturer and neither the laboratory nor the manufacturer has a vested interest in the
23 other.

24 Identify all proprietary parts in Contractor-furnished material. The Department reserves
25 the right to reject material that uses proprietary components not commercially available
26 through electronic supply houses.

27 For Contractor-furnished material listed on the QPL, furnish submittals in the format
28 defined by the QPL.

29 For Contractor-furnished material not on the QPL, furnish 3 copies of the equipment list
30 including 3 copies of catalog cuts. Identify proposed material on catalog cuts by
31 a reproducible means (highlighter pen does not transfer to copies). Ensure material lists
32 contain material description, brand name, manufacturer's address and telephone number,
33 stock number, size, identifying trademark or symbol and other appropriate ratings.

34 Do not fabricate or order material until receipt of the Engineer's approval.

35 **(C) Observation Period**

36 Warrant workmanship and Contractor-furnished equipment for a 30-day observation
37 period under the payment and performance bond from date of acceptance.

38 If workmanship or equipment fails during the 30-day observation period, repair or
39 replace with new equipment and begin a new 30-day observation period.

40 The observation period for this work is not part of the work to be completed by the
41 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 compact discs or other 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" x 11" documentation, including 11" x 17" drawings folded to 8 1/2" x 11", 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" x 34".

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 2 copies of system connection diagrams showing system interconnection cables and associated terminations.

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1 (G) Wire and Cable

2 Furnish wire and cable on reels. When requested by the Department, furnish samples of
3 wire and cable to the Department at no additional cost.

4 (H) Electrical Service

5 Furnish external electrical service disconnects with single pole 50 A inverse time circuit
6 breaker with at least 10,000 RMS symmetrical amperes short circuit current rating in
7 a lockable NEMA 3R enclosure. Ensure service disconnects are listed as meeting
8 UL Standard UL-489 and marked as being suitable for use as service equipment.
9 Fabricate enclosure from galvanized steel and electrostatically apply dry powder paint
10 finish, light gray in color, to yield a minimum thickness of 2.4 mils. Provide ground bus
11 and neutral bus with at least 4 terminals with minimum wire capacity range of number 14
12 through number 4.

13 Furnish NEMA Type 3R meter base rated 100 A minimum that meets the requirements of
14 the local utility. Provide meter base with ampere rating of meter sockets based on
15 sockets being wired with insulated wire rated at least 167°F.

16 Furnish 4 terminal, 600 volt, single phase, 3 wire meter base with the following:

- 17 (1) Line, Load and Neutral Terminals accept #8 to 2/0 AWG Copper/Aluminum wire,
- 18 (2) Ringed or Ringless Type, with or without bypass,
- 19 (3) Made of galvanized steel,
- 20 (4) Listed as meeting UL Standard UL-414, and
- 21 (5) Overhead or underground service entrance as specified.

22 Ensure meter bases have electrostatically applied dry powder paint finish, light gray in
23 color, with minimum thickness of 2.4 mils.

24 Furnish 1" watertight hub for threaded rigid conduit with meter base.

25 If meter base and electrical service disconnect are supplied in the same enclosure, ensure
26 assembly is marked as being suitable for use as service equipment. Ensure combination
27 meter and disconnect mounted in a pedestal for underground service is listed as meeting
28 UL Standard 231. Otherwise, ensure combination meter and disconnect is listed as
29 meeting UL Standard 67.

30 (I) Painting

31 Where painting of signal equipment cabinets, signal heads, signal poles, and pedestals is
32 required, apply paint at the factory. No field painting will be allowed except when paint
33 has been scratched or marred. In such cases, apply 2 field coats of the same color and
34 grade enamel as the original paint to the scratched or marred portions.

35 (J) Performance of Warranty Repair and Maintenance

36 Provide authorization to the Traffic Electronics Center of the North Carolina Department
37 of Transportation (NCDOT) to perform all warranty repairs after project acceptance. The
38 decision to perform warranty work at the Traffic Electronics Center by NCDOT
39 electronics technicians or to have warranty work performed by the vendor shall be at the
40 discretion of the State. Provide any training required by the manufacturer to authorize
41 the Traffic Electronics Center to perform warranty work and ensure manufacturer will
42 furnish parts to the Traffic Electronics Center for all warranty repairs at no cost to the
43 State. In addition, ensure the manufacturer agrees to provide prompt technical support to
44 the NCDOT electronics technicians for a period of one year after the end of the warranty
45 period at no cost to the State. Defective parts replaced under warranty by the Traffic
46 Electronics Center will be returned to the vendor at the vendor's request.
47 Provide schematics, part lists, and other documentation to perform bench repair to the

1 Traffic Electronics Center within 2 weeks upon request. The Department agrees not to
2 divulge any proprietary information in the schematics, part lists and other documentation
3 upon request from the vendor. After project acceptance and at the request of the State,
4 manufacturer shall perform warranty repairs to equipment which fails during the
5 warranty period at no cost to the State including freight costs to ship repaired equipment
6 back to the Traffic Electronics Center. Ensure all equipment is repaired and returned to
7 the Traffic Electronics Center within 21 calendar days of receipt by the manufacturer.

8 **1098-2 BACKPLATES**

9 Comply with ITE standard *Vehicle Traffic Control Signal Heads*. Provide backplates specific
10 to the manufacturer of the vehicle signal heads. Provide stainless steel fasteners and hardware
11 for attachment to signal head. Provide backplates that extend at least 5" from the vehicle
12 signal head outline. Ensure the backplate fills in the gaps between cluster-mounted vehicle
13 signal sections (5-section vehicle signal heads). A 1/4" maximum gap between vehicle signal
14 head and backplate, as viewed from the front, will be allowed.

15 Fabricate metallic backplates for vehicle signal heads from sheet aluminum at least
16 0.05" thick. Provide backplates painted an alkyd urea black synthetic baking enamel with
17 minimum gloss reflectance that meets Federal Specification MIL-E-10169, Instrument Black.

18 Provide polycarbonate or vacuum formed ABS plastic backplates that are black on both the
19 front and back sides with a consistent color throughout the entire piece for each backplate.
20 Provide backplates that contain UV inhibitors and stabilizers for protection against
21 UV degradation. Provide backplates that have a minimum tensile stress at yield of 5,300 psi
22 at 73°F and meet UL Standard 94. Ensure polycarbonate backplates have a minimum
23 thickness of .100" with one side dull black and the other side semi-gloss black. Ensure
24 vacuum formed ABS plastic backplates have a minimum thickness of 0.125" with a hair cell
25 finish on the front side and a smooth finish on the back side.

26 **1098-3 MESSENGER CABLE**

27 Comply with ASTM A475 for extra high strength grade wire strand, Class A zinc coating.
28 Fabricate messenger cable from seven steel wires twisted into a single concentric strand.

29 **1098-4 RISER SEALING DEVICES**

30 Furnish appropriately sized clamp-on aluminum weatherheads for electrical control and
31 power cables.

32 Furnish heat shrink tubing for the installation of fiber-optic or coaxial cable in a new riser.
33 Ensure the heat shrink tubing is made of modified polyolefin and includes a hot-melt
34 adhesive. Provide tubing that has a length of at least 5" before heating. Ensure the heat
35 shrink tubing will provide a watertight fit around individual cables and outer wall of the riser
36 after heat is applied in accordance with the manufacturer's instructions.

37 Furnish heat shrink tubing retrofit kits for the installation of fiber optic cable or coaxial cables
38 to an existing riser with existing cables. Ensure the heat shrink material is made of modified
39 polyolefin and is supplied in a flat sheet design. Ensure the kit contains an apparatus to
40 secure both ends of the flat sheet together to form a tube shaped cylinder. Ensure the securing
41 apparatus is flexible to the point that it will allow the heat shrink material to conform to the
42 shape and dimensions of the riser and cables once heat is applied and will not separate during
43 the heating process. Provide heat shrink tubing retrofit kits with a hot-melt adhesive. Provide
44 the flat sheet heat shrink material that has a minimum length of 5" prior to heating. Ensure
45 the heat shrink tubing retrofit kit provides a watertight fit around individual cables and outer
46 wall of the riser after heat is applied in accordance with the manufacturer's instructions.

47 **1098-5 JUNCTION BOXES**

48 **(A) General**

49 Comply with Article 1091-5.

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1 (B) Standard Size Junction Boxes

2 Provide standard size junction boxes and covers with minimum inside dimensions of
3 16"(l) x 10"(w) x 10"(d).

4 (C) Oversized Junction Boxes

5 Provide oversized junction boxes and covers with minimum inside dimensions
6 of 30"(l) x 15"(w) x 24"(d).

7 1098-6 POLE LINE HARDWARE

8 Provide universal grade strandvises used for extra high strength steel messenger cable.

9 Provide other pole line hardware constructed of hot-dipped galvanized steel conforming to
10 ASTM A153.

11 Provide machine bolts, eyebolts and thimble eye bolts with minimum tensile strength of
12 12,400 lb. Provide hot-dipped galvanized nuts, 3" x 3" curved square washers and
13 thimbleyelets.

14 Provide suspension clamp fabricated from hot-dipped galvanized steel with minimum length
15 of 5 3/4". Ensure clamp has a groove rated for the messenger cable size it is intended to
16 secure. Provide J-hook fabricated from 3/8" thick hot-dipped galvanized steel flat or oval
17 stock with sufficient hook radius to cradle 11/16" diameter cable. Provide two 1/2" diameter
18 hot-dipped galvanized bolts and nuts to tighten the clamp around the messenger cable.
19 Provide one 5/8" diameter hot-dipped galvanized bolt of sufficient length to attach J-hook and
20 clamp to the wood pole with a 3" x 3" curved square washer and double nuts.

21 Provide 3-bolt clamp fabricated from hot-dipped galvanized steel with minimum length
22 of 5 3/4". Ensure clamp has 2 parallel grooves rated for the messenger cable size it is
23 intended to secure. Provide three 5/8" diameter hot-dipped galvanized bolts and nuts to
24 tighten the clamp around the messenger cable.

25 Provide parallel groove clamp consisting of high strength, high conductivity non-copper
26 bearing aluminum alloy clamp halves with interlocking fingers to prevent mismatch. Ensure
27 clamp halves have molded grooves to secure #8-1/0 AWG stranded copper wires. Provide
28 clamps with grooves prefilled with antioxidant joint compound. Provide 3/8" hex head,
29 square shank, galvanized steel bolt with galvanized steel lock washer and nut.

30 Provide 1/2" and 3/4" wide, .030" thick Type 316 stainless steel straps with Type 316 stainless
31 steel buckles.

32 Provide either 0.05" x 0.30" aluminum wrapping tape or 0.06" diameter Type 316 stainless
33 steel lashing wire for lashing cables to messenger cable. Ensure aluminum wrapping tape is
34 1350 alloy, O-temper, with 12,800 psi tensile strength. Use 0.045" diameter Type 316
35 stainless steel lashing wire to lash fiber-optic communications cable to messenger cable.

36 Provide hot-dipped galvanized steel clamp with groove sized for 1/4" to 3/8" messenger cable
37 for securing lashing wire(s) to messenger cables at ends of each spiraled run. Ensure clamp
38 hardware is hot-dipped galvanized steel.

39 1098-7 GUY ASSEMBLIES

40 Furnish guy assemblies with anchor assemblies, guy cable and guy cable guard.

1 Provide anchor assemblies with all miscellaneous hardware consisting of either expanding
 2 anchor with rod and triple-eye attachment, screw anchor with extension rod and triple-eye
 3 attachment, or expanding rock anchor with triple-eye attachment. Ensure anchor assembly
 4 size is adequate for site conditions. Provide rods constructed of hot-dipped galvanized steel
 5 sized according to the soil bearing conditions in the area. Provide triple-eye guy attachments
 6 constructed of hot-dipped galvanized steel. Anchor assemblies with double-strand eyes may
 7 be used instead of those with the triple-eye feature when only one guy cable is to be attached.
 8 Ensure anchor assemblies are 7 ft minimum in length.

9 For type of anchor assembly furnished, ensure the following:

10 **(A) Expanding Anchor**

11 Provide steel construction with protective paint or heat shrink of 6 mil plastic to protect
 12 metal during shipping and storage.

13 **(B) Screw Anchor**

14 Provide hot-dipped galvanized steel construction.

15 **(C) Expanding Rock Anchors**

16 Provide malleable iron and rust-resisting paint construction.

17 Provide 3-bolt clamp to match messenger cable size.

18 Provide full round guy cable guards that are 8 ft in length and constructed of UV stabilized,
 19 high impact, bright yellow HDPE.

20 Provide guy cables consisting of messenger cable of the same size as the largest sized
 21 messenger cable to be guyed. Comply with Article 1098-3.

22 **1098-8 INDUCTIVE DETECTION LOOPS**

23 **(A) Loop Sealant**

24 Provide loop slot sealant that completely encapsulates loop wire when installed according
 25 to manufacturer's instructions. Provide loop sealant that does not generate temperatures
 26 greater than 220°F. Ensure sealant bonds with asphalt and concrete pavement saw slots
 27 so sealant and encapsulated loop wire do not come out of slot. Ensure sealant is self-
 28 leveling, but with sufficient viscosity to prevent exit from saw slot when installed along
 29 a 10% grade.

30 Provide sealant that protects loop wire by preventing the entrance of dirt, water, rocks,
 31 sticks, and other debris into saw slot, and is resistant to traffic, water, gasoline, chemical
 32 and chemical fumes, mild alkalis, oils and mild acids. Ensure sealant will not be affected
 33 by water and sealant does not chemically interact with pavement and loop wire
 34 insulation.

35 Ensure loop sealant has sufficient flexibility to permit expected pavement expansion and
 36 contraction due to weather and to permit pavement movement due to traffic without
 37 cracking for a temperature range of -40 to 160°F.

38 Provide sealant with a usable life of at least ten minutes once mixed, when the ambient
 39 temperature is 75°F. Ensure sealant dries to tack free state in less than 2 hours, and does
 40 not flow within or out of saw slot after exposed surface has become tack free. Tack free
 41 time will be determined by testing with a cotton ball until no sealant adheres to cotton
 42 ball and no cotton adheres to sealant.

43 Ensure 2 part sealant cures within 48 hours to attain 95% of published properties for the
 44 cured material.

45 Ensure one part sealant cures within 30 days to attain 95% of published properties for the
 46 cured material.

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1 (B) Loop Wire

2 Provide loop wire composed of 19-strand conductor insulated by a cross-linked
3 polyethylene compound. Ensure insulated conductors are completely encased in tubes of
4 low density polyethylene compound. Print manufacturer's name, manufacture year and
5 any applicable part number on encasing tube at intervals of 2 ft or less.

6 Provide number 14 AWG copper conductors fabricated from 19 strands that comply with
7 ASTM B3 before insulating. Ensure stranded conductors use either concentric or bunch
8 stranding and comply with circular mil area and physical requirements of ASTM B8 or
9 ASTM B174 for bunch stranding.

10 Provide insulating compound that is cross-linked thermosetting black polyethylene in
11 accordance with ASTM D2655. Ensure insulation is applied concentrically about
12 conductor. Provide insulation thickness not less than 0.026" at any point and minimum
13 average thickness of 0.030" as measured by UL Standard 62.

14 Ensure insulation of finished conductor will withstand application of a 60 Hertz or
15 3,000 Hertz, 7,500 volt (RMS) essentially sinusoidal spark test potential as specified in
16 UL Standard 83.

17 Provide insulated conductors that are factory-installed in a protective encasing tube that
18 complies with the following:

19 Encasing tube fabricated of polyethylene compound conforming to ASTM D1248 for
20 Type I, Class C, Grade E5. Provide a minimum inside diameter of 0.150". Provide
21 a wall thickness of 0.040" \pm 0.010". Provide an outside diameter of 0.240" \pm 0.010".

22 (C) Conduit

23 Comply with Subarticle 1091-3(C) for PVC conduit.

24 1098-9 LEAD-IN CABLE

25 Furnish lead-in cable with 2 conductors of number 14 AWG fabricated from stranded tinned
26 copper that complies with IMSA Specification 50-2 except as follows:

27 (A) Ensure conductor is twisted with a maximum lay of 2.0" resulting in at least 6 turns per
28 foot.

29 (B) Provide a ripcord to allow cable jacket to be opened without using a cutter.

30 Provide length markings in a contrasting color showing sequential feet and within 1% of
31 actual cable length. Ensure character height of the markings is approximately 0.10".

32 1098-10 FIBER-OPTIC CABLE

33 (A) SMFO Communications Cable

34 Furnish single mode fiber-optic cable manufactured into a loose buffer tube design,
35 installed around a central strength member where the cable complies with
36 RUS CFR 1755.900 and ICEA 640 requirements. Ensure the Manufacture is ISO 9001
37 and TL9000 registered and that the manufacturer's cable is RUS listed. The operating
38 temperature range of the cable shall be -40°F to +158°F.

39 Furnish individual fibers manufactured from silica and dopant materials with each fiber
40 having a color coated finish that is compatible with local injection detection (LID)
41 devices. Distinguish each fiber from others by color coding that meets EIA/TIA-598.
42 Furnish single mode fiber that does not exceed attenuation ratings of 0.25 dB/km at
43 1550 nm and 0.35 dB/km at 1310 nm and complies with ITU G.652D and
44 IEC 60793-2-50 Type B.1.3 industry standards for low water peak, single mode fiber.
45 Provide fibers that are useable and with a surface, sufficiently free of imperfections and
46 inclusions to meet optical, mechanical and environmental requirements.

1 Ensure the core central strength member is a dielectric glass reinforced rod and that the
 2 completed cable assembly has a maximum pulling rating of 600 lbf during installation
 3 (short term) and 180 lbf long term installed.

4 Construct buffer tubes (nominal size of 2.5 mm) manufactured from a polypropylene
 5 copolymer material to provide good kink resistance and allows the buffer tube to
 6 maintain flexibility in cold temperature over the expected lifetime of the cable. Ensure
 7 that buffers tubes contain no more than 12 fibers per buffer tube unless specified
 8 otherwise, and that all buffer tubes are filled with a water blocking gel or water swellable
 9 material. Construct the cable such that the buffer tubes are stranded around the central
 10 strength member in a reverse oscillating arrangement to allow for mid-span entry.
 11 Distinguish each buffer tube from others by color coding that meets EIA/TIA-598. Use
 12 filler tubes to maintain a circular cross-section of the cable. Ensure the filler tubes are the
 13 same nominal size as the buffer tubes of 2.5 mm. Apply binders (water swellable yarn,
 14 kevlar, etc.) with sufficient tension to secure buffer tubes and filler tubes to the central
 15 member without crushing the buffer tubes. Ensure that binding material is
 16 non-hygroscopic, non-wicking and dielectric with low shrinkage. Ensure the binders are
 17 of a high tensile strength that is helically stranded evenly around cable core.

18 Ensure the cable core is protected from the ingress of moisture by a water swellable
 19 material or that is filled with a water blocking compound that is non-conductive. Ensure
 20 the water swellable material (when activated) or the water blocking compound is free
 21 from dirt and foreign matter and is removable with conventional nontoxic solvents.
 22 Furnish at least one ripcord to aid in the process of removing the outer jacket. Furnish
 23 the outer jacket constructed of a medium-density polyethylene material to provide
 24 reduced friction and enhanced durability. Ensure the polyethylene material contains
 25 carbon black to provide UV protection and does not promote the growth of fungus.
 26 Ensure the cable jacket is free of slits, holes or blisters and the nominal outer jacket
 27 thickness is ≥ 0.050 ".

28 Ensure the completed cable assembly contains identification markings printed along the
 29 outside cover of the jacket every 2 ft. Ensure the character height of the markings is
 30 approximately 0.10". Provide length markings in sequential feet and within 1% of actual
 31 cable length.

32 Mark each cable with the following:

- 33 (1) Sequential length marks in feet as specified
- 34 (2) The name of the manufacturer
- 35 (3) "OPTICAL CABLE"
- 36 (4) Month/year of manufacture
- 37 (5) Number(s) of and type(s) of fibers
- 38 (6) Cable ID Number for product traceability

39 **(B) Drop Cable**

40 Furnish drop cable meeting the material requirements listed in Subarticle 1098-10(A)
 41 with the exceptions herein to provide communications links between splice enclosures
 42 and through interconnect centers. Furnish drop cable containing at least 6 individual
 43 fibers.

44 Furnish drop cable that complies with RUS-CFR 1755.900 and is RUS listed. Ensure
 45 each drop cables has the same operating characteristics as the SMFO cable it is to be
 46 coupled with.

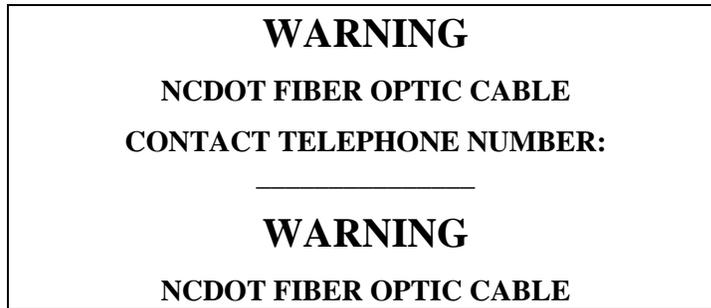
47 On one end of cable furnish six ST-PC connectors for termination on connector panel in
 48 equipment cabinet. Provide either factory assembled drop cables with ST-PC connectors
 49 or field installed connectors. No connectors are required for drop cables running from
 50 one splice enclosure directly to another splice enclosure.

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1 Ensure attenuation of drop cable at 1310 nm does not exceed 0.4 dB/km and the
2 attenuation at 1550 nm does not exceed 0.3 dB/km. Ensure attenuation loss for complete
3 drop cable assembly does not exceed a mean value of 1.5 dB.

4 (C) Communications Cable Identification Markers

5 Furnish yellow communications cable identification markers that are resistant to fading
6 when exposed to UV sources and changes in weather. Use markers designed to coil
7 around fiber-optic cable that do not slide or move along the surface of the cable once
8 installed. Ensure exposure to UV light and weather does not affect the markers natural
9 coiling effect or deteriorate performance. Provide communications cable wraps that
10 permit writing with an indelible marking pen and contain the following text in black:



17 **Figure 1098-1. Communication Cable Identification Marker.**

18 Overall Marker Dimensions: 7"(l) x 4"(w)

19 Lettering Height: 3/8"for WARNING, 1/4" for all other lettering

20 Submit a sample of proposed communications cable identification markers to the
21 Engineer for approval before installation.

22 (D) Fiber-Optic Cable Storage Guides

23 Furnish fiber-optic storage guides (snowshoes) that are non-conductive and resistant to
24 fading when exposed to UV sources and changes in weather. Ensure snowshoes have
25 a captive design such that fiber-optic cable will be supported when installed in the rack
26 and the minimum bending radius will not be violated. Provide stainless steel attachment
27 hardware for securing snowshoes to messenger cable and black UV resistant tie-wraps for
28 securing fiber-optic cable to snowshoe. Ensure snowshoes are stackable so multiple
29 cable configurations are possible.

30 1098-11 FIBER-OPTIC SPLICE CENTERS

31 (A) Interconnect Center

32 Furnish compact, modular interconnect centers designed to mount inside equipment
33 cabinets. Design and size interconnect centers to accommodate all fibers entering
34 cabinets.

35 Provide splice trays that hold, protect, and organize optical fibers, and secure fibers inside
36 splice tray. Design and size splice trays to be dielectric, to accommodate all fibers
37 entering splice tray, and to provide sufficient space to prevent microbending of optical
38 fibers. Provide connector panels with ST-type connectors.

39 Furnish SMFO pigtailed with each interconnect center. Provide pigtailed containing
40 connector panels that are no more than 6 ft in length with a factory assembled PC-ST
41 connector on one end. Ensure SMFO pigtailed meet the operating characteristics of the
42 SMFO cable with which it is to be coupled.

43 Furnish SMFO jumpers that are at least 3 ft in length with factory assembled PC-ST
44 connectors on each end. Ensure SMFO jumpers meet the operating characteristics of the
45 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 2 cables and with at least 4 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.

1098-12 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 2 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:

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.

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1 **1098-13 DELINEATOR MARKERS**

2 Furnish tubular delineator markers, approximately 6 ft long, and constructed of
3 Type III HDPE material. Provide delineator assemblies that are ultraviolet stabilized to help
4 prevent components from color fading, warping, absorbing water, and deterioration with
5 prolonged exposure to the elements. Provide delineators designed to self-erect after being
6 knocked down or pushed over. Provide orange delineator posts.

7 Provide text, including division contact number, hot stamped in black on a yellow reflective
8 background material that will not fade or deteriorate over time. Provide delineator markers
9 with nominal message height of 15" that contain the text in Figure 1098-2 visible from all
10 directions approaching the assembly.

W A R N I N G	F I B E R	O P T I C	C A B L E S
BEFORE EXCAVATING OR IN AN EMERGENCY CALL (____) ____-____			
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION			

11 **Figure 1098-2. Delineator Marker.**

12 **1098-14 PEDESTALS**

13 Furnish pedestal assemblies with foundations that conform to the latest edition of the
14 *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and*
15 *Traffic Signals* in effect on the date of project advertisement. Refer to *Roadway Standard*
16 *Drawings* No. 1743 for structural design specifications for each type of pedestal.

17 **(A) Pedestal Shaft**

18 Furnish one piece pedestal shafts fabricated from either aluminum or galvanized steel
19 pipe with a uniform pipe outer diameter of 4.5" and of the lengths specified for the type
20 of pedestal shown on *Roadway Standard Drawing No. 1743*. Refer to Article 1743-2 for
21 pedestal type descriptions.

22 For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals), furnish
23 shafts constructed from schedule 40 extruded aluminum pipe that conforms to Aluminum
24 Association Alloy 6063-T6 with a tensile strength of 30 KSI and a minimum wall
25 thickness of 0.237". Aluminum conduit will not develop the necessary strength required
26 and is not allowed. Thread and deburr in accordance with American National Standard
27 Pipe Threads, NPT (ANSI B2.1). Finish the exterior with a rough surface texture
28 consisting of a uniform grain pattern that is perpendicular to the axis of the pipe along the
29 full pipe length. Unless otherwise specified, do not use galvanized steel pipe for Type I
30 and Type II pedestal shafts.

1 For Type III (heavy-duty pedestals), furnish schedule 120 galvanized steel pipe that
 2 conforms to ASTM A53. Provide an 11" square by 1" thick steel base plate with
 3 minimum yield strength of 36 ksi that conforms to ASTM A36. Fabricate the base plate
 4 with four equally spaced bolt holes on an 11" bolt circle. Orient the bolt holes in the
 5 corners of the plate. Size the holes to accommodate 1" diameter machine bolts. Weld the
 6 pedestal shaft to the center of the base plate using a socket connection. Provide
 7 circumferential fillet welds at the top and bottom of the base plate. Perform all welding
 8 in accordance with the latest AWS Code. Hot-dip galvanize the pedestal shaft and base
 9 plate assembly after fabrication in accordance with ASTM A123. Unless otherwise
 10 specified, do not use aluminum pipe for Type III pedestal shafts.

11 **(B) Transformer Bases**

12 Furnish transformer bases for each type of pedestal shown on *Roadway Standard*
 13 *Drawings* No. 1743 fabricated from aluminum that meets Aluminum Association
 14 Alloy 356 or equivalent, and that are designed to break upon impact in accordance with
 15 AASHTO requirements. Submit FHWA certification for each type of transformer base
 16 that reflects compliance with NCHRP 350. For use in grounding and bonding, provide
 17 a 0.5" minimum diameter, coarse thread hole cast into transformer base located inside
 18 base and oriented for easy access.

19 Provide a minimum access opening for all transformer bases of 8" x 8" with an access
 20 door that is attached with stainless steel hinges on one side of the transformer base.
 21 Provide a 1/4" x 3/4" long stainless steel vandal proof screw to secure access door.

22 For Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals),
 23 provide overall base dimensions of 15" (l) x 13 3/4" (w) x 13 3/4" (d) for square bases
 24 and 14" (l) x 16 1/2" (w) x 16 1/2" (d) for octagonal bases. Provide a threaded opening at
 25 the top of the base to receive a 4" NPT pipe shaft. Fabricate the bottom of the
 26 transformer base with 4 equally spaced holes or slots for a 12" bolt circle to secure the
 27 entire assembly to the concrete foundation.

28 For Type III (heavy-duty pedestals), provide square bases with overall dimensions of
 29 17" (l) x 13" (w) x 13" (d). Fabricate the top of the transformer base with 4 equally
 30 spaced holes or slots for an 11" bolt circle to attach the pedestal shaft. Size the holes or
 31 slots to accommodate 1" diameter machine bolts. Fabricate the bottom of the transformer
 32 base with 4 equally spaced holes or slots for a 12" bolt circle to secure the entire
 33 assembly to the concrete foundation. Size the holes or slots to accommodate 1" diameter
 34 anchor bolts. Provide the following mounting hardware for heavy-duty pedestals:

35 (1) Four 1" diameter by 3 1/2" long machine bolts (ASTM F593), with heavy hex nuts
 36 (ASTM A563 Grade DH, or A 194 Grade 2H), and thick flat washers, and lock
 37 washers (ASTM F436) per pedestal assembly. Galvanize in accordance with
 38 ASTM A153.

39 (2) Three heavy hex nuts (ASTM A563 Grade DH, or A194 Grade 2H), 2 thick flat
 40 washers, and one lock washer (ASTM F436) for each anchor bolt. Galvanize in
 41 accordance with ASTM A153.

42 (3) Six minimum slotted stainless steel shims of necessary thickness for leveling per
 43 pedestal assembly.

44 **(C) Anchor Bolts**

45 For each pedestal, provide 4 anchor bolts in accordance with ASTM F1554, Grade 55, of
 46 the size and length specified in *Roadway Standard Drawings* No. 1743 each having one
 47 heavy hex nut with 2 washers at the top and 2 heavy hex nuts with one washer at the
 48 bottom. Provide anchor bolts with coarse threads at 10 threads per inch for a minimum
 49 length of 4" from each end of the bolt. All thread anchor rods may be used.

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1 Ensure anchor bolts are hot-dipped galvanized in accordance with ASTM A153 with
2 completely galvanized nuts and washers. Provide hex nuts with coarse threads. Ensure
3 hex nuts are in accordance with ASTM A563 Grade DH, ASTM A194, Grade 2H or
4 equivalent. Ensure washers are in accordance with ASTM F436 or equivalent. As a
5 minimum, provide standard size washers.

6 (D) Pedestal Cap

7 Furnish a 4 1/2" outside diameter slip fit domed pedestal top cap for each pedestal
8 assembly designed to fit over the outside of the pedestal shaft. Fabricate the cap from
9 aluminum that meets Aluminum Association Alloy 356. Ensure the cap provides
10 3 equally spaced stainless steel set screw fasteners to secure the cap to the pedestal shaft.

11 (E) Pole Flange Base for 4 1/2" Pipe

12 Furnish a flange base with cover for use with Type I (pedestrian pushbutton pedestals)
13 and Type II (normal-duty pedestals) only. Flange bases are non breakaway supports that
14 are to be used with a breakaway bolt system for AASHTO compliance for breakaway
15 structures. Provide aluminum or steel flange bases with a minimum 7.5" diameter bolt
16 circle. Ensure bases are either continuously welded to shafts or threaded to receive
17 shafts. Each base should be designed to accommodate either three or four 1/2" bolts
18 equally spaced on the bolt circle to receive breakaway anchors. Provide NPT threads on
19 the internal opening of the flange base through the full length of the flange base with
20 locking set screws at the top of the base to receive a 4" NPT pipe shaft.

21 Fabricate aluminum flange bases that meet Aluminum Association Alloy 356
22 requirements for architectural bases. Fabricate steel flange bases that meet ASTM A36.

23 Do not use flange bases for Type III pedestals.

24 (F) Breakaway Anchors

25 Furnish single or double neck omni-directional breakaway anchor bolt coupling systems
26 for use with Type I (pedestrian pushbutton pedestals) and Type II (normal-duty pedestals)
27 only. Use breakaway anchors that are FHWA certified to be compliant with NCHRP
28 Report 350 as an alternative to transformer bases. Use with non breakaway pole flange
29 bases. Use 1/2" diameter bolts for pushbutton posts and 3/4" bolts for normal-duty
30 pedestals. Fabricate from steel with a minimum yield strength of 55 KSI. Galvanize in
31 accordance with ASTM A153. Do not use breakaway anchors with Type III pedestals, or
32 in conjunction with breakaway transformer bases.

33 (G) Foundation

34 Install pedestal foundations of the type and size shown on *Roadway Standard Drawings*
35 No. 1743.04 Furnish Class A minimum concrete that conforms to Article 1000-4.

36 Provide reinforcing steel that conforms to the applicable parts of Section 1070.

37 1098-15 SIGNAL CABINET FOUNDATIONS

38 Provide foundations with a minimum pad area that extends 24" from front and back of cabinet
39 and 3" from sides of cabinet.

40 Furnish cabinet foundations with chamfered top edges. Provide minimum Class B concrete.

41 Provide preformed cabinet pad foundations with 7"(l) x 18"(w) minimum opening for the
42 entrance of conduits. For precast signal cabinet foundations, include steel reinforcement to
43 ensure structural integrity during shipment and placing of item. Include four 3/4" coil thread
44 inserts for lifting. Comply with Article 1077-16.

1098-16 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 6.7 of CALTRANS TEES. Provide base adapters and extenders a height of at least 12".

1098-17 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" drop per 2 ft. 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 varistors (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 under side 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 2 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.

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1 Connect each conductor, including unused conductors, within or entering cabinet to
2 a terminal using crimped spade lugs. Place no more than 2 conductors on any single
3 terminal screw. Terminations to back panel may be soldered. Do not use quick
4 connectors or barrel connectors. Make all connections at terminals. Do not make in-line
5 splices.

6 Ensure outgoing circuits have same polarity as line side of power supply. Ensure
7 common return has same polarity as grounded conductor (neutral) of power supply.

8 Neatly package all wiring. Dress harnesses by lacing, braiding, or tying with nylon tie
9 wraps at closely spaced intervals. Attach wires, cables, or harnesses to cabinet walls for
10 support or to prevent undue wear or flexing. Use nylon tie straps or metal clamps with
11 rubber or neoprene insulators. Screw these attachment devices to cabinet. Do not use
12 stick-on clamps or straps.

13 Tag AC+, AC-, chassis ground, and flasher circuit conductors with non-fading,
14 permanent sleeve labels at conductor ends at terminals or use color-coded wire. Ensure
15 sleeve labels tightly grip conductors. Alternatively, use hot stamped labels on internal
16 conductor insulation at intervals of no greater than 4". Ensure label legends are
17 permanent.

18 Ensure all jumpers are wire conductors or metal plates. Do not use printed circuit back
19 panels or back panels using wire tracks as jumpers.

20 Lay out all equipment and components for ease of use and servicing. Ensure equipment
21 controls can be viewed and operated without moving or removing any equipment.
22 Ensure there is access to equipment or components for servicing without removing any
23 other equipment or components. Removal of equipment is acceptable to access fan or
24 thermostat. Ensure equipment can be removed using only simple hand tools. Ensure
25 layout of equipment and terminals within the various cabinets furnished is identical from
26 cabinet to cabinet, unless otherwise approved.

27 Mount equipment using harnesses with suitable multipin (or similar) connectors. Design
28 or key all equipment to make it physically impossible to connect unit to wrong connector.
29 Ensure that functionally equivalent equipment is electrically and mechanically
30 interchangeable.

31 Equip vents with standard-size, replaceable filters or, if located where they can easily be
32 cleaned, permanent filters.

33 **(B) Type F1 Cabinet**

34 Provide dual-circuit flasher and 20-amp inverse time circuit breaker with at least
35 10,000 RMS symmetrical amperes short circuit current rating. Install one insect-resistant
36 vent on bottom and one on top on opposite wall to facilitate airflow.

37 **(C) Type F2 Cabinet**

38 Provide 20" high x 16" wide x 12" deep cabinet, dual-circuit flasher, 20-amp inverse time
39 circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating,
40 and solid state time switch. Provide filtered power to time switch. Install one insect-
41 resistant vent on each side of cabinet at the bottom to facilitate airflow.

42 **(D) Type F2 and F3 Cabinet – Surge Protection and Documentation**

43 Furnish and install a power line surge protector in the service power. Provide a 2-stage
44 power line surge protector that allows connection of the radio frequency interference
45 filter between stages of the device. Ensure device has a maximum continuous current
46 rating of at least 10 A at 120 V. Ensure device can withstand at least 20 peak surge
47 current occurrences at 20,000 A for an 8x20 microsecond waveform. Provide maximum
48 clamp voltage of 395 V at 20,000 A with a nominal series inductance of 200 µh. Ensure
49 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

1 Install surge protector in circuit breaker enclosure in a manner that will permit easy
2 servicing. Ground and electrically bond surge protector to cabinet within 2" of surge
3 protector.

4 Furnish and install a suitably sized plastic envelope or container in cabinet for holding
5 cabinet wiring diagrams and equipment manuals. Locate envelope or container so it is
6 convenient for service personnel. Furnish 2 sets of non-fading cabinet wiring diagrams in
7 a paper envelope or container and place them in the plastic envelope or container.

8 **(E) Type F3 Cabinet**

9 Provide 25" high x 22" wide x 15" deep cabinet, dual-circuit flasher, fan, thermostat and
10 switch-controlled cabinet light (15 watt minimum, incandescent).

11 Install a vent or vents at or near the cabinet bottom to permit the intake of air sized for the
12 rated flow of air from the fan, but no smaller than 20 sq. in. Install fan with a minimum
13 100 CFM rating.

14 Equip cabinet with 2 inverse time circuit breakers (20A & 15A) with at least 10,000 RMS
15 symmetrical amperes short circuit current rating installed to ensure personnel servicing
16 the cabinet, including rear of back panel, cannot inadvertently be exposed to a hazard.
17 Install a terminal block that will accommodate service wire as large as number 4 AWG,
18 and connect it to the circuit breaker. Install circuit breakers in addition to any fuses that
19 are a part of the individual control equipment components. Wire switch-controlled
20 cabinet light and thermostatically-controlled fan to the 15A circuit breaker. Provide
21 thermostat with a minimum range of 90° F to 130° F and with a rating sufficient for fan
22 load.

23 Equip cabinet with a duplex receptacle that is connected to the AC out and neutral out
24 terminals of the surge protector.

25 **1098-18 SPREAD SPECTRUM WIRELESS RADIO**

26 **(A) General**

27 Furnish a spread spectrum wireless radio system with all necessary hardware and signage
28 in accordance with the plans and specifications to provide a data link between field
29 devices (i.e. Traffic Signal Controllers, Dynamic Message Signs, etc.). Provide a radio
30 system with a bi-directional, full duplex communications channel between 2 "line-of-
31 sight" antennas using license free, spread spectrum technology operating in the
32 902 - 928 MHz frequency band.

33 Furnish material conforming to the National Electrical Code (NEC), the National
34 Electrical Safety Code (NESC), Underwriter's Laboratories (UL) or a third-party listing
35 agency accredited by the North Carolina Department of Insurance, and all local safety
36 codes in effect on the date of advertisement. Comply with all regulations and codes
37 imposed by the owner of affected utility poles.

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1 (B) 900 MHz Wireless Radio

2 Furnish license free 902 - 928 MHz radio modem with antennas, coaxial cable and
3 mounting hardware, and configuration software. Design radio modem to work in “point-
4 to-point”, “point-to-multipoint”, “multipoint-to-point” and “multipoint-to-multipoint”
5 configurations. Ensure the spread spectrum wireless radio meets the following minimum
6 requirements:

- 7 (1) License free (ISM) Spread Spectrum radio band (902 - 928 MHz)
- 8 (2) Frequency Hopping Technology (Direct Sequence Spread Spectrum Technology is
9 not acceptable)
- 10 (3) Bi-Directional, Full Duplex
- 11 (4) Provide at least 3 Programmable Radio Frequency (RF) output levels ranging from
12 1mW up to 1 Watt.
- 13 (5) Provide user-selectable radio frequency channels (Min. 50) and hopping patterns
14 (Min. 50) that will allow the user to adjust operating characteristics to avoid
15 interference within the intended 902 - 928 MHz frequency range.
- 16 (6) RS-232 interface capable of operating from 1200 bps to 115.2 Kbps, with 8 or 9 bit
- 17 (7) DB9-F connector for RS-232 port
- 18 (8) Maximum of 8 mSec. end-to-end latency
- 19 (9) 16 bit Cyclic Redundancy Check (CRC) error checking with auto re-transmit
- 20 (10) Built-in store-and-forward (single radio repeater, back-to-back radio set-ups are not
21 allowed to accomplish this function)
- 22 (11) 32 Bit encryption
- 23 (12) Receiver Sensitivity of -108dBm @ 10^{-6} BER
- 24 (13) Antenna port: Threaded Connector (Nickel and/or Silver Plated Brass)
- 25 (14) Front panel LED indicators (at a minimum):
 - 26 (a) Power
 - 27 (b) Transmit Data
 - 28 (c) Receive Data
 - 29 (d) Data Port Indicators consisting of at least 3 LED's grouped together
30 representing a Low, Medium or High Signal Strength with regards to the
31 communications link with another targeted radio. Software running on a laptop
32 is not acceptable in meeting this requirement for front panel LED Data Port
33 Indicators.
- 34 (15) Operating temperature of -40 to +165°F at 0 to 95% Humidity
- 35 (16) Power supply requirements:
 - 36 (a) Wall Adapter:
 - 37 (i) Input Voltage (120 VAC UL/CSA) wall cube plug-in module
 - 38 (ii) Output Voltage (6VDC to 24VDC)
 - 39 (b) Typical current draw of no greater than 400 mA when powered with 12 VDC
40 input and transmitting one watt of RF output power
 - 41 (c) Radio Sleep mode with a maximum current draw of $<1\mu\text{A}$
- 42 (17) Shelf mounted design

1 Furnish a Radio Frequency Signal Jumper constructed of an RG-58 Coaxial Cable. On
2 one end of the cable supply a RF Threaded Connector that is compatible with the radio
3 supplied and on the other end supply a Standard N-Type Male Connector to mate with
4 the lightning arrestor. Provide the jumper in 6 ft lengths. Ensure that the cable is
5 assembled by a manufacturing facility. Contractor and/or Vendor assembled cables are
6 not acceptable.

7 Furnish an RS-232 data interface cable to be installed between the radio modem and the
8 field device's RS-232 interface. Ensure the cable is compatible with CALTRANS TEES
9 and 2070L compliant controllers. Ensure cable is at least 6 ft long. Ensure that the cable
10 is assembled by a manufacturing facility. Contractor and/or Vendor assembled cables are
11 not acceptable.

12 Ensure that installing the wireless radio system with a fully functional field device
13 (i.e. controller) does not require any field device modifications with regards to hardware
14 or software.

15 **(C) Software**

16 Furnish units with a Windows-based software program that uses a GUI (Graphical User
17 Interface) to provide "remote programming, radio configuration, remote maintenance,
18 diagnostics and spectrum analyzer" features. Ensure the software will operate on all past
19 and current Microsoft® Windows operating platforms: Windows 98®, Windows 2000®,
20 Windows NT®, Windows XP®, Windows Vista® or Windows® 7. Provide
21 configuration software that can be upgraded in the future at no additional charge.

22 Ensure the radio modem is configurable from a single location (i.e. master radio location)
23 via supplied software (no extra cost). Furnish software supplied with drivers to allow
24 easy set-up with all industry standard traffic signal controllers, including 2070 controllers
25 containing custom software written specifically for the North Carolina Department of
26 Transportation. Ensure the supplied software contains pre-written drivers for industry
27 standard radar packages and Dynamic Message Sign controllers.

28 **(D) Directional Antenna (Yagi)**

29 Furnish a directional antenna of welded construction that allows for vertical and
30 horizontal polarization. Furnish an 8.5 dBd Gain or 13 dBd Gain antenna that comply
31 with Table 1098-4.

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TABLE 1098-4 PROPERTIES OF 8.5 dBd GAIN ANTENNA	
Property	Requirement
Frequency Range	896 - 940 MHz
Nominal Gain	8.5 dBd
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 ohms
Length	24"
Rated Wind Velocity	125 mph
Rated Wind Velocity (with 0.5" radial ice)	100 mph
Projected Wind Surface Area (flat plane equivalent)	0.26 sf
Number of Elements	6

TABLE 1098-5 PROPERTIES OF 13 dBd GAIN ANTENNA	
Property	Requirement
Frequency Range	902 - 928 MHz
Nominal Gain	13 dBd
Front to Back Ratio	20 dB
Horizontal Beamwidth (at half power points)	40 degree
Vertical Beamwidth (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 ohms
Length	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 sf
Number of Elements	13

- 1 Furnish mounting hardware with the antenna that will secure the antenna to a mounting
- 2 pipe that has a 1.1/2" Nominal Pipe Size (approximately 2" OD pipe diameter), as
- 3 recommended by the manufacturer of the antenna and as approved by the Engineer.

(E) Omnidirectional Antenna

Furnish an omnidirectional antenna of a solid, single piece construction in accordance with Table 1098-6.

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

Furnish mounting hardware with the antenna that will secure the antenna to a mounting pipe that has a 1.5" Nominal Pipe Size (approximately 2" OD pipe diameter), as recommended by the manufacturer of the antenna and as approved by the Engineer.

(F) 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" 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" NPT aluminum pipe, and provides a surface that is at least 6 3/4" long x 4 1/4" to provide contact with the pole. Ensure the pole base plate is designed to allow both ends of the 96" 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" NPT aluminum pipes. Provide a 1 1/2" x 18" long aluminum pipe threaded on both ends and a 1 1/2" x 24" aluminum pipe threaded on one end with an end cap.

(G) Coaxial Cable

Furnish 400 Series coaxial cable to provide a link between the antenna and the lightning arrester that meets the following minimum specifications:

Property	Requirement
Attenuation (dB/100 ft) @ 900 MHz	3.9 dB
Power Rating @ 900 Mhz	0.58 kW
Center Conductor	0.108" diameter Copper Clad Aluminum
Dielectric: Cellular PE	0.285" diameter
Shield	Aluminum Tape - 0.291" diameter Tinned Copper Braid - 0.320" diameter
Jacket	Black UV protected polyethylene
Bend Radius	1" with less than 1 ohm impedance change at bend
Impedance	50 ohms
Capacitance	23.9 pF/ft

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1 (H) Standard N-Type Male Connector

2 Furnish Standard N-Type Male Connector(s) of proper sizing to mate with the 400 series
3 coaxial cable and use a crimping method to secure the connector to the coaxial cable.
4 Furnish a connector that meets the following minimum specifications:

- 5 (1) Center Contact: Gold Plated Beryllium Copper (spring loaded, non-solder)
- 6 (2) Outer Contact: Silver Plated Brass
- 7 (3) Body: Silver Plated Brass
- 8 (4) Crimp Sleeve: Silver Plated Copper
- 9 (5) Dielectric: Teflon PTFE
- 10 (6) Water Proofing Sleeve: Adhesive Lined Polyolefin – Heat Shrink
- 11 (7) Attachment Size: Crimp Size 0.429" (minimum) hex
- 12 (8) Electrical Properties:
 - 13 (a) Impedance: 50 ohms
 - 14 (b) Working Voltage: 1000 Vrms (max)
 - 15 (c) Insertion loss: $0.1 \times \sqrt{F_{GHz}}$
 - 16 (d) VSWR: 1.25:1 (max) up to 3GHz

17 (I) Coaxial Cable Shield Grounding and Weatherproofing Kits

18 (1) Furnish a Coaxial Cable Shield Grounding Kit containing components that will
19 adequately bond and ground the cable shield to the pole ground. Ensure the
20 grounding kit complies with MIL-STD-188-124A for coaxial cable and protects the
21 cable from lightning currents of at least 200kA. Ensure each kit is supplied, as
22 a minimum, with the following:

- 23 (a) Preformed Strap: 24 Gauge copper strap that is at least 1 5/8" long and is sized
24 to mate with the 400 series coaxial cable
- 25 (b) Tensioning Hardware: Copper nuts and lock washers
- 26 (c) Grounding Lead Cable: #6 AWG, stranded, insulated copper wire

27 (2) Furnish a Weatherproofing Kit containing components that will protect the coaxial
28 cable shield grounding system against the ingress of moisture and prevent vibrations
29 from loosening the connections. Ensure the weatherproofing kit is supplied, as
30 a minimum, with the following:

- 31 (a) Butyl Mastic Tape: 3 3/4" wide by 24" long (approximately)
- 32 (b) Electrical Tape: 2" wide by 20" long (approximately)

33 (J) Lightning Arrestor

34 Furnish a lightning arrestor installed in line between each antenna and its designated
35 radio modem inside the equipment cabinet in accordance with Table 1098-8. Furnish
36 lightning arrestor with multistrike capability, low strike throughput energy, flange mount
37 and bulkhead mount options and a standard N-Type female connector on both the
38 surge-side and protected-side connectors.

**TABLE 1098-8
PROPERTIES OF LIGHTNING ARRESTOR**

Property	Requirement
Filter Type	DC Block (non gas tube design)
Surge	20kA, 800MHz to 2.0GHz \leq 1.1 : 1 VSWR 18kA, 800MHz to 2.3GHz \leq 1.1 : 1 VSWR 18 kA, 700MHz to 2.7GHz \leq 1.2 : 1 VSWR
Insertion Loss	\leq 0.1 dB over frequency range
Max Power	500 W @ 920MHz (750 W at 122° F)
RF Power	300 Watts
Let Through Voltage	\leq ± 3 Volts for 3kA @ 8/20 μ s Waveform
Throughput Energy	\leq 0.5 μ J for 3kA @ 8/20 μ s Waveform
Temperature	-40 to 185° F Storage/Operating
Vibration	1G at 5 Hz up to 100Hz
Unit Impedance	50 Ohm
VSWR	1.1:1
Frequency Range	800 MHz to 2200 MHz

1 **(K) Coaxial cable – Power Divider (Splitter)**

- 2 Furnish a coaxial cable power divider for repeater radio sites in accordance with
3 Table 1098-9. Ensure the power divider accommodates a single primary input RF source
4 and divides/splits the signal (power) equally between 2 output ports.

**TABLE 1098-9
PROPERTIES OF COAXIAL CABLE - POWER DIVIDER**

Property	Requirement
Power Division	2 - Way
Frequency	900 - 1100 MHz
Insertion Loss	0.22 dB
Impedance	50 Ohm
VSWR ref. to 50 Ohm (max)	1.3:1
Max. Input Power	500 Watts
Connectors	Standard N-Type Female
Dimension	2.5"W x 5"L
Weight	1.5 lb (approximately)

5 **(L) Disconnect Switch**

- 6 Furnish a double pole, single throw snap switch in a weatherproof outlet box with cover,
7 suitable for use in wet locations. Ensure outlet box and cover supports a lockout tag
8 device. Ensure outlet box includes one 1/2" diameter hole in back of box. Furnish
9 mounting hardware, sealing gaskets and lockout tag.

10 **(M) Warning Signs and Decal**

- 11 Furnish "RF Warning Sign" and "Decal" at locations called for in the plans. Furnish
12 mounting hardware to secure the sign to either metal or wood poles.