DIVISION 10
MATERIALS

SECTION 1000
PORTLAND CEMENT CONCRETE PRODUCTION AND DELIVERY

1000-1 DESCRIPTION

This section addresses Portland cement concrete to be used for pavement, structures and precast and incidental construction. Produce Portland cement concrete composed of Portland cement, fine and coarse aggregates, 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
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

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.

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

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

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

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

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

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

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

(B) Air Entrainment

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

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

(C) Slump

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

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

(D) Set Retarding Admixture and Water Reducing Admixture

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

(E) 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.

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

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

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

Perform laboratory tests in accordance with the following test procedures:

Property	Test Method
Aggregate Gradation	AASHTO T 27
Air Content	AASHTO T 152
Slump	AASHTO T 119
Compressive Strength	AASHTO T 22 and T23

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

(B) Air Entrainment

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

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

(C) Strength of Concrete

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

When the average compressive strength of the concrete test cylinders is less than the minimum strength specified in Table 1000-1 and the Engineer determines if the concrete strength will be acceptable. When the Engineer determines average cylinder strength is below the specification, the in-place concrete will be tested. Based on these test results, the concrete will either be accepted with no reduction in payment or accepted at a reduced unit price or rejected as set forth in Article 105-3.

(D) Temperature Requirements

The concrete temperature at the time of placement shall be not less than 50°F 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 Aggre-gate	Angular Aggre-gate	Rounded Aggre-gate	Angular Aggre-gate			Min.	Max.	Min.	Max.
Units	*psi*					*inch*	*inch*	*lb/cy*	*lb/cy*	*lb/cy*	*lb/cy*
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 Light-weight	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	-	-

(E) Elapsed Time for Placing Concrete

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

TABLE 1000-2
ELAPSED TIME FOR PLACING CONCRETE

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

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

(F) Use of Set Retarding Admixtures

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

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

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

(G) Use of Water Reducing Admixtures

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

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

(H) Use of Calcium Chloride

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

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

(I) Use of Fly Ash

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

maximum water-cementitious material ratio will be the same as the water-cement ratio 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

(J) Use of Ground Granulated Blast Furnace Slag

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

(K) Use of Calcium Nitrite Corrosion Inhibitor

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 that fails to contain calcium nitrite at the required concentrations as tested is subject to rejection. Use air-entraining, water-reducing and/or set-controlling admixtures compatible with calcium nitrite solutions. Strictly adhere to the manufacturer's written recommendations regarding the use of admixtures, including storage, transportation and method of mixing. If preferred, use calcium nitrite, which acts as an accelerator, in conjunction with a retarder to control the set of concrete, as per the manufacturer's recommendation. Add an approved calcium nitrite corrosion inhibitor (30% solids) to the concrete mix at the batch plant for the bridge elements identified by the plan notes. Use the inhibitor at a minimum rate of 3.0 gal/cy. Ensure that the hardened concrete contains at least 5.1 lb/cy nitrite (NO_2) when tested in accordance with Materials and Tests Method Chem. C-20.0. The preceding paragraph does not apply to concrete used in prestressed concrete members. Concrete used in prestressed concrete members shall be tested in accordance with Subarticle 1078-4(G).

1000-5 HIGH EARLY STRENGTH PORTLAND CEMENT CONCRETE

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

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

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

1000-6 FLOWABLE FILL

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

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

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

1000-7 LATEX MODIFIED CONCRETE

(A) Materials

Refer to Division 10.

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

Do not use Type III high early strength cement.

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

Use a latex modifier conforming to Table 1000-4.

TABLE 1000-4
PROPERTIES OF LATEX MODIFIER FOR CONCRETE

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

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

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

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

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

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

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

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

(B) Equipment

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

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

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

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

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

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

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

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

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

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

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

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

(C) Proportioning and Mixing of Modified Compositions

Meet the following requirements when proportioning and mixing modified materials:

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

Yield checks and other checks are permitted.

1000-8 MEASURING MATERIALS

(A) Weighing Cement

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

(B) Weighing Aggregates

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

(C) Water

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

(D) Admixture Dispensing Systems

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

(1) Manually operated, self contained; or

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

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

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

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

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

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

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

1000-9 BATCHING PLANT

(A) General

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

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

(B) Bins and Hoppers

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

(C) Scales

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

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

(D) Water Measuring Devices

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

1000-10 MIXERS AND AGITATORS

(A) General

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

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

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

(B) Mixer Capacity

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

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

(C) Agitator Capacity

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

(D) Consistency Tests

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

1000-11 MIXING AND DELIVERY

(A) General

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

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

(1) Central Mixed Concrete

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

(2) Transit Mixed Concrete

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

(3) Shrink Mixed Concrete

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

(B) Mixing Time for Central Mixed Concrete

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

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

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

TABLE 1000-6
REQUIREMENTS FOR UNIFORMITY OF CONCRETE

Property	Requirement	Test Method
Difference in Test Samples Air Content, percent by volume of concrete	1.0%	AASHTO T 152
Slump	1.0"	AASHTO T 119
Coarse aggregate content, portion by weight of each sample retained on the No. 4 sieve	6.0%	AASHTO M 157
Weight	1.0 lb	AASHTO T 121
Average Compressive Strength at 7 days, percent of average	10.0%[A]	AASHTO T 22 AASHTO T 23

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

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

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

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

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

(C) Truck Mixers and Truck Agitators

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

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

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

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

(D) Delivery

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

1000-12 VOLUMETRIC MIXED CONCRETE

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

(A) Materials

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

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

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

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

(B) Equipment

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

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

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

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

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

(C) Proportioning Devices

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

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

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

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

(D) Calibration

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

TABLE 1000-7
VOLUMETRIC MIXED CONCRETE CALIBRATION TOLERANCES

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

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

(E) Verification of Yield

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

(F) Uniformity

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

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

SECTION 1002
SHOTCRETE PRODUCTION AND DELIVERY

1002-1 DESCRIPTION

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