FIELD SAMPLING AND TESTING MANUAL

SECTION 800

MATERIALS

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TABLE OF CONTENTS - 800

Section 800 MATERIALS
800.01 DESCRIPTION.
Section 801 GENERAL STATEMENT
801.01 ACCEPTANCE.
801.02 REQUIREMENTS.
Section 802 PORTLAND CEMENT CONCRETE
802.01 GENERAL.
802.02 METHODS OF SAMPLING FRESH CONCRETE.
A. General.
B. Sampling from Revolving Drum Truck Mixers or Agitators.
C. Sampling from Open-Top Truck Mixers, Agitators, Non-Agitating Equipment, or Other Types of Open-Top Containers.
D. Main line Paving.
E. Numbering and Identifying Samples.
802.03 TESTS ON CONCRETE.
A. Concrete Slump Test
1. Scope.
2. Apparatus.
3. Procedure.
B. Air Content of Freshly Mixed Concrete.
1. Scope.
2. Apparatus.
3. Determination of Air in the Aggregate (Correction Factor).
4. Calibration of the "Acme" Air Meter.
5. Determination of Air Content in Concrete ("Acme" Air Meter).
6. Calibration of the "Forney" Air Meter.
7. Determination of Air Content in Concrete ("Forney" Air Meter).
C. Determining Weight per Cubic Foot, Yield, and Cement Content of Concrete.
1. Scope.
2. Apparatus.
3. Procedure.
4. Calculations.
D. Determination of Water Content of Plastic Concrete Using a Microwave Oven.
1. Scope.
2. Apparatus.
3. Procedure.
E. Making and Curing Concrete Compression and Flexural Test Specimens in the Field.
1. Scope.

2. Sampling Concrete.
3. Casting Procedure.
4. Curing Procedure.

F. Flexural Strength of Concrete Using Simple Beam with Third-Point Loading.
1. Scope.
2. Apparatus.
3. Procedures.
4. Measurement of Specimens After Test.
5. Determine and Enter Modulus of Rupture.

Section 804 CEMENT AND LIME

804.01 REQUIREMENTS.
804.02 SAMPLING CEMENT.

Section 816 AGGREGATES

816.01 SAMPLING.
A. Required Aggregate Sample Size.
B. Sampling In-Place Roadway Material.
C. Sampling from a Windrow.
D. Sampling from a Conveyor Belt.
E. Sampling from a Truck.
F. Sampling from a Stockpile.

816.02 SAMPLE REDUCING.
A. Quartering a Sample.
B. Splitting a Sample.

816.03 SAMPLE NUMBERING.
816.04 AGGREGATE TESTING.
A. Total Moisture Content By Drying To Constant Weight.
1. Scope.
2. Apparatus.
3. Procedure.
4. Calculations.

B. Determining Surface Moisture in Aggregates.
1. Scope.
2. Apparatus.
3. Procedure.
4. Calculations.

C. Sieve Analysis of Aggregates.
1. Scope.
2. Apparatus.
3. Procedure.
4. Precautions.

D. Fine Aggregate for Concrete.
   1. Gradation.
   2. Lightweight Pieces of Aggregate.
   3. Specific Gravity and Absorption.
E. Coarse Aggregate for Concrete.
   1. Gradation.
   2. Material Passing No. 200 Sieve.
      a. Apparatus.
      b. Procedure.
   3. Shale, Hard Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces.
   4. Specific Gravity and Absorption.
F. Aggregates for Surfacing, Base, Asphalt Mixes, Blotter, and Seal Coats.
   1. Lightweight Pieces of Aggregate.
      a. Scope.
      b. Apparatus.
      c. Procedure.
      d. Sample Calculations.
   2. Determining the Percentage of Fractured Particles in Coarse Aggregate.
      a. Scope.
      b. Apparatus.
      c. Procedure
      d. Calculations.
   3. Determination of the Liquid Limit.
      a. Scope.
      b. Apparatus.
      c. Sample Preparation.
      d. Adjustment of Liquid Limit Device.
      e. Procedure.
      f. Calculations.
   4. Determination of the Plastic Limit and Plasticity Index.
      a. Scope.
      b. Apparatus.
      c. Sample.
      d. Procedure.
      e. Calculation.
   5. Specific Gravity and Absorption of Coarse Aggregate
      a. Scope.
      b. Apparatus.
      c. Procedure.
      d. Calculations.

6. Specific Gravity and Absorption of Fine Aggregate
   a. Scope.
   b. Apparatus.
   c. Pycnometer Calibration.
   d. Procedure.
   e. Calculations.

Section 818 BITUMINOUS MATERIALS

818.01 SAMPLING BITUMINOUS MATERIALS.
   A. Sampling Bitumen.
   B. Containers.
   C. Protection and Preservation of Samples.
   D. Numbering Samples.
   E. Acceptance.

818.02 TESTING.
   A. Sieve Test of Asphalt Emulsions.
      1. Scope.
      2. Apparatus.
      3. Test Conditions.
      4. Procedure.
   B. Saybolt Viscosity of Emulsions Using a Saybolt Furol Viscometer.
      1. Apparatus.
      2. Preparation of Apparatus.
      3. Calibration and Standardization.
      4. Procedure.

Section 820 FLYASH.

820.01 GENERAL.

Section 826 JOINT MATERIALS

826.01 GENERAL.

826.02 SAMPLING.

Section 834 STRUCTUAL STEEL AND RELATED MATERIALS

834.01 BOLTS, NUTS, AND WASHERS.

Section 836 REINFORCING STEEL

836.01 GENERAL.
   A. Bars.
   B. Wires.
   C. Post-Tensioning Steel.

Section 800

MATERIALS

800.01 DESCRIPTION.

Entries in the 800 series are, in some cases, a review of what can be found in other sections of this Manual, or, sampling and/or testing requirements that do not fit into any other sections of this Manual.

Section 801

GENERAL STATEMENT

801.01 ACCEPTANCE.

Acceptance of all material shall be as specified in Section 106 of the NDDOT Standard Specifications.

801.02 REQUIREMENTS.

When the Department's Specifications or Special Provisions require that materials meet AASHTO, ASTM, AWPA, or other Specifications, the latest Specifications together with all interim Specifications which have been printed and distributed before the date of the invitation for bids shall apply.

When material is accepted by certification the Certificate of Compliance shall be submitted to the project engineer/manager and shall provide the following information:

1. Project number to which the material is consigned.
2. Name of the Contractor to which the material is supplied.
3. Kind of Material supplied.
4. Quantity of material represented by the certificate.
5. Satisfactory means of identifying the consignment.
6. Statement that the material meets the pertinent specifications required by the Contract.
7. Signature of a person having legal authority to bind the supplier.

Section 802

PORTLAND CEMENT CONCRETE

802.01 GENERAL.

There are a number of situations where small amounts of concrete are required and there is no particular requirement covering the sampling and testing in these situations. Therefore, when small amounts of concrete are required for a specified item; for example, the apron of a pipe, all that will be required will be that the engineer/manager notify the District Laboratory that the materials used were approved materials that had been tested in other phases of the work. In this way, there will be no need to sample and test the material that goes into the small items of work.

The Materials and Research Division will perform all tests to determine if the quality of air-entraining admixtures, chemical admixtures, and curing materials meet the specification requirements. Any chemical admixtures should be examined in the field and if it has become caked or sticky in shipment or storage, it shall be rejected.

The concrete curing materials may be cotton or burlap cloth, geotextile fabric, or liquid membrane-forming compounds. All sheets or mats should be inspected and those having cuts, tears, or other defects such as weak, broken, or missing yarn should be rejected or repaired to the engineer's/manager's satisfaction. When liquid membrane-forming compounds are used on a project, samples may be required for testing. No samples, however, need be taken unless specifically required by Materials and Research. The compound to be sampled must be thoroughly shaken or stirred before the sample is taken. One sample shall be taken at random, representing each lot, batch, or other unit of production in a shipment.

802.02 METHODS OF SAMPLING FRESH CONCRETE.

Conduct sampling according to AASHTO T 141. The summary and exceptions follow:

A. General. When obtaining the composite sample do not exceed 15 minutes elapsed time between the first and final portion. Start tests for slump or air content or both within five minutes after sampling. Completed these tests as quickly as possible. Mold specimens for strength tests within 15 minutes of sampling. Keep elapsed time, between obtaining and using a sample, as short as possible. Protect samples from sources of rapid evaporation (i.e., sun and/or wind), or any other contaminating elements.

B. **Sampling from Revolving Drum Truck Mixers or Agitators.** Sample the concrete at two or more regularly spaced intervals during discharge of the middle portion of the batch. Do not sample until after all of the water has been added to the mixer or from the very first or last portion of the batch discharge. Sample by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of batch discharge by the rate of drum revolutions and not by the gate opening size .

C. **Sampling from Open-Top Truck Mixers, Agitators, Non-Agitating Equipment, or Other Types of Open-Top Containers.** Obtain a composite sample of the concrete after discharge. Avoid contamination with subgrade material or prolonged contact with an absorptive subgrade.

D. **Main line Paving.** Take samples from the batch immediately after being deposited on the subgrade. Take at least five samples from different portions of the pile. Thoroughly mix these samples to form the test specimen.

E. **Numbering and Identifying Samples.** A sample is a representation of the in place concrete. Note the in-place location of the concrete for future reference.

Using a permanent marker, mark all cylinders and beams with a numeric/alpha identification. All cylinders cast from the same concrete sample are called a set. Assign a numeric designation to each set followed by a letter designation that changes with each cylinder or beam within the set(example: a set of two 7-day and two 28-day cylinders from the same concrete sample could be numbered 1-A, 1-B, 1-C, and 1-D. The next set would be 2-A, 2-B, etc.).

802.03 TESTS ON CONCRETE.

A. **Concrete Slump Test.** Conduct this procedure according to AASHTO T 119. The summary and exceptions follow:

1. **Scope.** Sample concrete according to the applicable instruction in Section 802.02 of this manual. Concrete that has been used for one test may not be used to perform another test. This test is not considered applicable to non-cohesive(slumps >9 inches) and non-plastic(slumps < ½ inch) concrete or concrete batched with coarse aggregate over 1 1/2 inches in size.

2. **Apparatus.**

    1. Slump cone.
    2. Tamping rod (5/8 in. diameter, 24 in. long, hemispherical tip).
    3. Pails.
    4. Shovel.

3. **Procedure.**

    1. To limit segregation, mix the concrete with a shovel until uniform in appearance.

    2. Dampen and place the cone on a flat, moist, nonabsorbent, rigid surface. Immediately fill the cone in three layers from the sample. Make each layer approximately 1/3 the volume of the cone. To insure symmetrical distribution of the concrete within the cone, move each full scoop around the top edge of the cone as the concrete slides from it. Compact each layer of concrete with 25 strokes of the tamping rod. Distribute the strikes in uniform manner over the cross section of the cone. Tamp the bottom layer through its full depth. Tamp the other two layers so that the rod just penetrates the layer below. After compacting the top layer, strike-off the surface of the concrete with a trowel so that the cone is filled to the top.

    3. Raise the mold a distance of 12 inches in 5 ± 2 seconds by a steady upward lift with no lateral or torsional motion. Complete the entire test from the start of the filling through removal of the mold without interruption and complete it within an elapsed time of 2½ minutes.

    4. Immediately measure the slump by determining the vertical difference between the top of the mold and the displaced original center of the top surface of the specimen. To do this, turn the mold up side down and lay the tamping rod across its base extending over the slumped specimen. If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. Record the slump to the nearest ¼ inch of subsidence of the specimen during the test.

B. **Air Content of Freshly Mixed Concrete.** Conduct this procedure according to AASHTO T 152. The summary and exceptions follow:

    1. **Scope.** Sample concrete according to the applicable instruction in Section 802.02 of this manual. Concrete that has been used for one test may not be used to perform another test.

    This section presents test methods for determining the air content of freshly mixed concrete, "Acme" air meter and the "Forney" air meter methods. Both meters are used by the Department.

    2. **Apparatus.**

        1. Air meter ("Acme" or "Forney").

2. Pails.
3. Shovel.
4. Small scoop.
5. Steel tamping rod, 24 in. x 5/8 in. with rounded tip.
6. Rubber mallet weighing approximately 1 1/4 lbs.
7. A measure for water.
8. A rubber bulb syringe.
9. **Rubber mallet.**

3. **Determination of Air in the Aggregate (Correction Factor).** Determine the correction for air held within the particles of the aggregate at the beginning of the job. Although sufficiently accurate for the duration of work, "Check Determinations" from time to time are desirable. Determine the aggregate correction factor of the combined fine and coarse aggregate in approximately the same moisture condition, amount, and proportions occurring in the concrete. Prepare a sufficient amount of aggregate to fill the container and proceed as follows:

   1. Fill the container about 1/3 full of water. Pour the aggregate slowly into the container and stir vigorously by hand, so that the aggregate is completely inundated with no air entrapped around or between the particles. If air is entrapped between the particles, this test will show erroneous results.

   2. Fill the container with water. Wipe the contact surfaces clean and clamp the top section of the apparatus firmly to the container.

   3. Proceed as specified in the section entitled "**Determination of Air Content in Concrete**" for the type of air meter you are using.

   4. Read and record the subsidence of the water level. The subsidence of the water level is due to the air within the aggregate particles, and is the correction factor to be applied in determining the air content of the concrete.

4. **Calibration of the "Acme" Air Meter.** The "Acme" air meter is designed to read in percentage of air entrained when the pressure gauge reads 15 psi. In cases where the pressure gauge is in error, however, determine a new pressure other than 15 psi to get the correct air content of the concrete.

   To check if the pressure gauge is correct, first note the number and percentage value stamped on the calibration cylinder. Each air meter is furnished with a companion check cylinder. Both the cylinder and air meter have the same number and to assure correct calibration the cylinder from one air meter may not be used with any other air meter. Place the cylinder

in the air meter pot with the open end down. Fill the container with water, clamp on the top of the air meter, and fill with water to the arrow mark.

Apply 15 psi pressure. The balance reading on the water glass should be within ±0.1% of that stamped on the calibration cylinder. If it is not, the pressure must be adjusted until the cylinder value is obtained. This pressure is noted and is used for all following air content determinations.

5. **Determination of Air Content in Concrete ("Acme" Air Meter).**

   1. Fill the container with concrete in three equal lifts, rodding each lift 25 times with the tamping rod. Rod the bottom layer through its full depth. Rod the other two layers so that the rod just penetrates the layer below. Follow the rodding of each layer by tapping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer. Strike off the surface. Small variations in the strike off will have little effect on the results.

   2. Wipe the contact surface clean and clamp the top section of the apparatus firmly to the container.

   3. Close the petcock at the bottom of the water glass and open the petcock and the funnel valve at the top. Fill the apparatus with water to a level slightly above the arrow mark on the graduated balance. Close the funnel valve and adjust the water level to the arrow mark on the graduated scale by means of the lower petcock.

   4. Close the top petcock and apply pressure with the pump until the gauge reads exactly the desired value as determined in the previous calibration section.

   5. Read the subsidence of the water level and subtract the correction for air held within the pours of the aggregate particles (determined earlier.) The resulting value is the percentage of air in the concrete.

   6. Release the pressure by opening the top petcock. Release the water by opening the "C" clamps. Remove the top and clean the apparatus at once and permit it to dry. It may be necessary to clean the water glass occasionally which, after removing the valve from the funnel valve assembly, may be done with a strip of cloth and one of the wire guards of the water glass. Oil the threads on the thumb screws and on the funnel valve occasionally.

6. **Calibration of the "Forney" Air Meter.** Supplied with each "Forney" air meter is a short piece of threaded straight tubing, a threaded curved tube, and a metal calibration vessel.

   1. Fill the container full of water.

   2. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover. Clamp the cover on the base with the tube extending down into the water.

   3. With both petcocks open, add water with the syringe through the petcock having the pipe extending below, until all air is forced out the opposite petcock. Leave both petcocks open.

   4. Pump up the air pressure to a little beyond the predetermined initial pressure line on the gauge. Wait a few seconds for the compressed air to cool to normal temperature and then stabilize the gauge hand at the proper initial pressure line by pumping or bleeding off air as needed.

   5. Close both petcocks and immediately press down on the thumb lever exhausting air into the base. Wait a few seconds until the gauge is stabilized. If all the air was eliminated and the initial pressure line was correctly selected, the gauge should read 0%. If two or more tests show a consistent variation from 0% in the result, then change the initial pressure line to compensate for the variation. Use the newly established initial pressure line for subsequent tests.

   6. Screw the curved tube into the outer end of the petcock and by pressing on the thumb lever and controlling the flow with the petcock lever, fill the 5% calibrating vessel (345 ml) level full with water from the base.

   7. Release the air at the free petcock. Open the other petcock and let the water in the curved pipe run back into the base. There is now 5% air in the base.

   8. With the petcocks open, pump the air pressure in the exact manner as outlined in paragraph 4. Close the petcocks and immediately press the thumb lever. Wait a few seconds for the needle to stabilize. The dial should now read 5%.

   9. If two or more readings show that the gauge reads incorrectly at 5% air in excess of 0.2%, then remove the gauge glass and readjust the

gauge to 5% by turning the re-calibrating screw located just below the center of the dial.

10. When the gauge reads correctly at 5%, additional water may be withdrawn in the same manner to check results at 10%, 15%, 20%, etc.

7. Determination of Air Content in Concrete ("Forney" Air Meter).

1. Fill the container with concrete in three equal lifts, rodding each lift 25 times with the tamping rod. Rod the bottom layer through its full depth. Rod the other two layers so that the rod just penetrates the layer below. Follow the rodding of each layer by tapping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer. Strike off the surface. Small variations in the strike off will have little effect on the results.

2. Wipe the contact surface clean and clamp the top section of the apparatus firmly to the container. Open both petcocks.

3. Using the syringe, inject water through one petcock until all air is displaced. Air bubbles will appear at the other petcock. Continue until all bubbles disappear. Close the air bleeder valve.

4. With the built-in pump, pump the air slightly above the initial pressure line, calibrated for the air meter being used.

5. Wait a few seconds and adjust the needle on the gauge to the initial pressure line by pumping up or bleeding off with the air release valve as needed.

6. Close both petcocks, then press down on the needle valve lever to release the air into the base. Hold the needle valve lever down a few seconds, lightly tapping the gauge with a finger to stabilize the gauge needle. **Tap the sides of the measuring bowl smartly with the mallet.**

7. Read the percent of air into the concrete on the gauge, subtract the correction for air, and record for the report.

8. Release the pressure, then empty, and thoroughly clean the bowl, cover, and petcock openings.

C. Determining Weight per Cubic Foot, Yield, and Cement Content of Concrete. Conduct this procedure according to AASHTO T 121. The summary and exceptions follow:

1. **Scope.** Sample concrete according to the applicable instruction in Section 802.02 of this manual. Concrete that has been used for one test may not be used to perform another test.

   This test method determines the weight per cubic foot of freshly mixed concrete and gives formulas for calculating the yield and cement content.

2. **Apparatus.**

   1. Volume measure bucket
      When Size 3, 4, or 5 aggregate is used in the mix, either a 1/2-cu ft bucket or the bottom bowl of the air meter shall be used.
   2. Tamping rod.
   3. Platform balance, 200 lb capacity.
   4. Rubber mallet.

3. **Procedure.** Fill the container with concrete in three equal lifts, rodding each lift 25 times with the tamping rod. Follow the rodding of each layer by tapping the sides of the bowl 10 to 15 times with the mallet until the cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer. After consolidation of the concrete, the top surface shall be struck off and finished smoothly using great care to leave the bucket level full. Clean all excess concrete from the exterior of the filled bucket and weigh to the nearest 0.1 lb.

4. **Calculations.**

   Unit Weight: Calculate the net weight of the concrete by subtracting the weight of the bucket from the gross weight. Calculate the unit weight of concrete in pounds per cubic foot by multiplying the net weight by the multiplication factor for the bucket used. The 1/2 cu ft buckets are calibrated and the multiplication factor for each measure is printed on the outside. The volume of the bucket instead of the multiplication factor may be printed on some buckets. In this case, divide the printed volume into one to get the multiplication factor to use.

   Calibration of Bowl from the Air Meter: To calibrate, determine the weight of water at 16.7°C (62°F) required to fill the bowl. Use a glass cover plate to accurately fill the bowl. Obtain the multiplication factor for any bowl by dividing the unit weight of water at 16.7°C (62°F), namely 62.4 lbs per

cu ft, by the weight, in pounds, of water at 16.7°C (62°F) required to fill the bowl.

Yield: Calculate the yield in terms of cu ft per batch as follows:

Yield = Total Weight of Batch* ÷ Measured Unit Weight

*Obtain the total weight of batch from the mix design form (SFN 9311)

Cement Content: Calculate the cement content, in sacks per cu yd of concrete as follows:

Cement Content = 27 x Sacks per Batch ÷ Yield

D. **Determination of Water Content of Plastic Concrete Using a Microwave Oven.** Conduct this procedure according to NDDOT method. The method follows:

1. **Scope.** This method covers a procedure for determining the moisture of plastic concrete in gallons per sack of cement.

2. **Apparatus.**

    1. Microwave oven with defrost cycle.
    2. Ceramic, 12-in. diameter pie plates.
    3. Plastic containers with tight fitting lids.
    4. Balance.

3. **Procedure.** Use a sample size of approximately 1500 g. Weigh and place the sample in a plastic container with a tight fitting lid until ready for testing. Test as soon as possible after sampling and do not exceed one hour. Transfer the sample to a ceramic pie plate. Dry the sample in a microwave oven set on the defrost cycle. Dry the sample to a constant weight. This will take approximately one hour. Record all weights on the "Water Content Determination Worksheet for Plastic Concrete" (SFN 18456). After all the information is recorded on the worksheet, follow the formulas and calculate the gallons per sack of cement.

E. **Making and Curing Concrete Compression and Flexural Test Specimens in the Field.** Conduct this procedure according to AASHTO T 23. The summary and exceptions follow:

1. **Scope.** This method covers procedures for making and curing specimens of concrete.

2. **Sampling Concrete.** Sample concrete according to the applicable instructions in Section 802.02 of this manual. Use at least one cubic foot of concrete. Concrete that has been used for one test may not be used to perform another test.

3. **Casting Procedure.** Transport the sample to the test specimens molding site and remix with a shovel to assure maximum uniformity. Protect the sample from moisture loss from the time the sample is taken to the time it is molded. Do not exceed 15 minutes.

   Oil metal molds lightly with a mineral oil before using. Plastic molds are waxed and do not require oiling. Mold specimens as near as practicable to the place where they are to be stored during the first 24 hours. If it is not practicable to mold the specimens where they will be stored, move them to a place of storage immediately after being struck off. Avoid jarring, striking, tilting or scarring the surface of the specimen when moving the specimen to a safe place.

   Compression Test Cylinders: Mold the test specimen by placing the concrete in the mold in three layers of approximately equal volume. In order to insure a symmetrical distribution of the concrete within the mold, place each scoop of concrete carefully by moving the scoop around the top edge of the mold as the concrete slides from it. Further distribute the concrete by using a circular motion of the tamping rod. Rod each layer with 25 strokes of the tamping rod. Evenly distribute the strokes over the cross section of the mold. Penetrate the underlying layer by about 1 in. with each stroke. Rod the bottom layer throughout its depth. When voids are left by the tamping rod, tap the sides of the mold sufficiently to close the voids. After rodding the top layer, strike off the surface of the concrete with a trowel to a level surface even with the top of the mold. Cover the mold with a plastic bag drawn down snugly and fastened with a rubber band or string.

   Flexural Test Beams: Form the test specimen with its long axis horizontal. Place the concrete in two layers, approximately 3 inches in depth. Rod each layer once for every 2 square inches of area. Fill the top layer by slightly overfilling the mold. After completing the rodding, strike off the top with a straightedge and finished with a wood float. Make the test specimen promptly and without interruption.

4. **Curing Procedure.** During the first 24 hours keep test specimens moist and at a temperature between 60° and 80°F. If the weather is hot, cover with wet burlap or wet sand. Check the temperature several times. In cold weather some means of heating may be required. Protect test specimens from damage at all times.

Compression Test Cylinders: Remove test specimens, made to check the accuracy of the mix design for strength of concrete or as a basis of acceptance, from the molds at the end of 24 hours and submerge in water saturated with lime at a temperature of 60°to 80°F until time of testing.

Temperatures in the required range are easy to maintain at certain times of the year. Take extra care during the heat of summer or the cold of fall and winter, to conform to the requirements. Deliver specimens to the testing laboratory in time for them to be capped and stored under laboratory conditions for at least 24 hours.

Remove test specimens for determining when a structure may be put into service from the molds at the end of 24 hours and stored as near to the point of sampling as possible so that they receive the same protection from the elements as the portions of the structure which they represent.

Flexural Test Beams: Cure test specimens under the conditions specified in the previous section of this manual. At the end of the 24-hour period, remove the specimens from the molds and store in a moist condition as specified for compressive test cylinders.

Cure test specimens for determining when a structure may be put into service in the same manner as the concrete in the structure. At the end of the 24-hour period, take the specimens, still in the molds, to a location near the field laboratory. Remove the test specimens from the molds and store by placing them on the ground with there top surface up. Bank the sides and ends with earth or sand and keep damp, leaving the top surface exposed to the specified curing treatment. Test the specimens immediately after removal from the curing bed.

F. Flexural Strength of Concrete Using Simple Beam with Third-Point Loading. Conduct this procedure according to AASHTO T 97. The summary and exceptions follow:

1. **Scope.** This test method determines the flexural strength of concrete by the use of a simple beam with third-point loading.

2. **Apparatus.** Beam Testing Machine.

3. **Procedures.** Before the first test of the day, wind the chart drive. If needed, add one drop of recorder ink to the pen. Close the control valve. Pump the head up about 1/2". Install the chart. Check the accuracy of the pen arm radius, the pen zeroing, and the chart drive speed (see below). Whenever any recorder adjustments are made (for example, flexing the pen

arm to vary the point pressure), other than the chart drive speed, check the accuracy of the pen arm radius and the pen zeroing.

1. **Adjusting the Pen Arm Radius.** Unclamp the chart and rotate it until the pen lines up with the inner end of the "arc for checking pen radius" line. While holding the chart firmly against the back-up plate, grasp the pen arm near the pivot above the flexible portion of the arm and swing the pen outward to the border line. Adjust as necessary by loosening the pen arm screw; move the arm and re-tighten the screw.

2. **Adjusting the Pen Zeroing:** With the control valve closed and the loading head pumped up about 1/2", rotate the chart concentric with the hub so that the pen traces through the cluster of dots between -2 psi and +2 psi. Adjust the micrometer screw (built into the pen arm) as necessary, using a small screwdriver.

3. **Adjusting the Chart Drive Speed:** Clamp the chart to the hub. The chart must move a one minute division (near hub) for every 59 to 61 seconds. Adjust the drive regulator (glass covered on most recorders) as necessary. The chart must make a complete revolution in 15 minutes (±15 seconds).

4. **Procedure for Testing Specimens:** Turn the test specimen on its side with respect to its molded position. Center the test specimen on the bearing blocks. Center the loading system in relation to the applied force. Bring the load applying blocks into contact with the surface of the specimen at the one third points between the supports. At no load, check for full contact between the specimen, the load applying blocks and supports. If full contact is not obtained between the specimen and the supports and the gap is in excess of 0.004" (0.1 mm) for a length of one inch or more, grind or cap the contact surfaces of the specimen or shim with leather strips. Minimize grinding lateral surfaces of the specimens because it may change the physical characteristics of the specimens and affect the test results.

   Use leather shims when the specimen surfaces in contact with the blocks or supports depart from a plane by not more than 0.015" (0.38 mm). Leather shims shall be of a uniform 1/4" (6.4 mm) thickness.

   The load may be applied rapidly, up to approximately 50% of the breaking load. Thereafter, apply the load continuously at a rate which constantly increased the extreme fiber stress between 125 and 175 psi until rupture occurs.

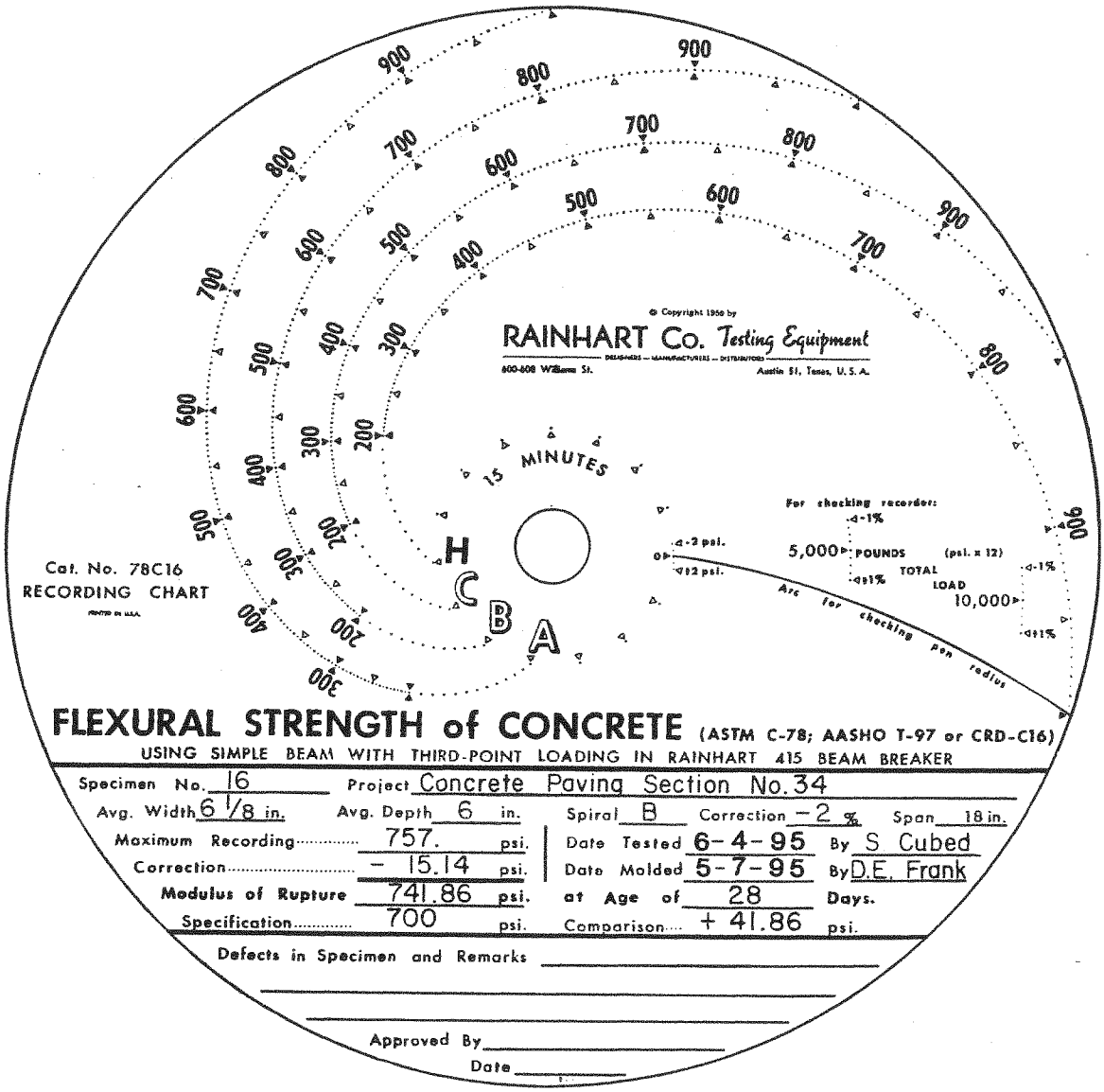
4. **Measurement of Specimens After Test.** Take three measurements across each dimension (one at each edge and at the center) to the nearest 0.05" (1.3 mm) to determine the average width, average depth, and the line of fracture location of the specimen at the section of failure.

5. **Determine and Enter Modulus of Rupture.** Enter "Maximum Recording _____ psi" on the recording chart (see example chart). Measure to the nearest 0.1" (or 1/16") at section of failure and enter the "Avg. Width ____ in." and "Avg. Depth _____ in." as tested.

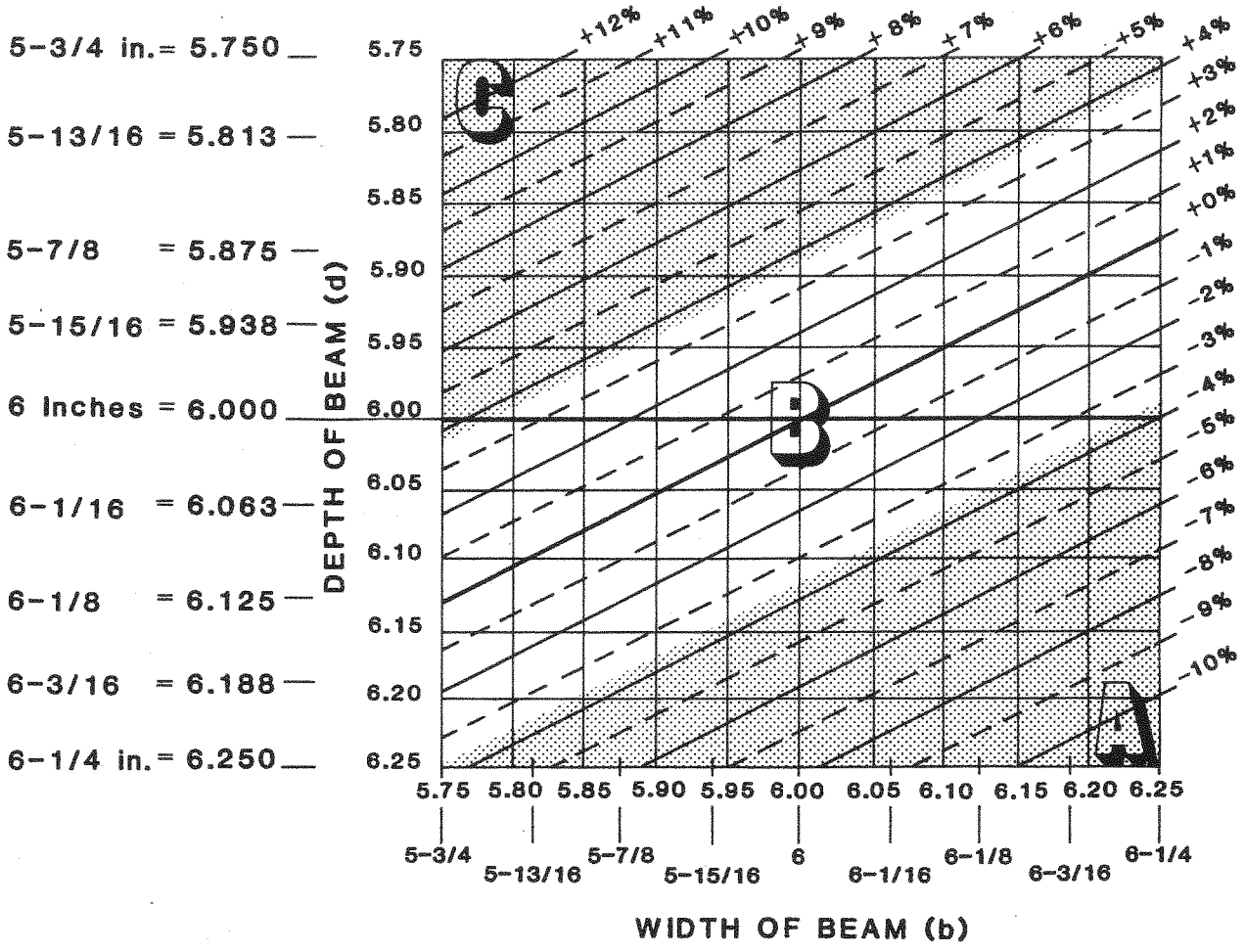
    1. If fracture occurs within the middle 6" of the 18" span tested, locate the point on the graph (example following) corresponding with these measurements; observe which diagonal line is nearest to such point and the percent factor on that line; enter this factor as "Correction _____%", on the back of the chart multiply the "Maximum Recording _____ psi" by this factor; enter the results as "Correction _____ psi" and make the indicated addition or subtraction entering the result as "Modulus of Rupture _____psi."

    2. If the fracture occurred outside of the middle 6" of the 18" span tested by not more than 0.9", compute the modulus of rupture on the chart back, using the specification formula (Note 1) and 12 times the "Maximum Recording _____ psi" (12 x psi) as the maximum applied load in pounds; enter this result on the chart face as "Modulus of Rupture _____ psi" and write "See chart back" in the space above it.

    3. If the fracture occurred outside the middle 6" of the 18" span tested by more than 0.9", discard the test results.



Sample of chart used in determining the Flexural Strength of Concrete.



Graph for Correcting Beam Dimensions

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Section 804

CEMENT AND LIME

804.01 REQUIREMENTS.

All cement is accepted for use on the project when the project engineer/manager receives a satisfactory certification from the cement mill. This will generally be mailed to the contractor who will relay it to the project engineer/manager, who shall submit it to the Materials and Research Division. One random sample of cement will be submitted to the Materials and Research Division per source per project.

Lime is accepted by certification.

804.02 SAMPLING CEMENT.

Obtain one random sample per cement source per project from the silo, truck, or hopper. A minimum sample size of 15-pounds is required. Place samples directly in moisture-proof air-tight containers to avoid moisture absorption and aeration of the sample.

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Section 816

AGGREGATES

816.01 SAMPLING.

The Contractor obtains all aggregate samples except verification samples. It is desirable to sample any material as near as possible to, if not at, the final in-place position. Hierarchy of preferred sampling locations are; in-place, windrow, conveyor belt, and truck box or stockpile. Conduct sampling according to ASTM D 75. The summary and exceptions follow:

A. Required Aggregate Sample Size. The sample size is based on the type and number of tests to be performed. Obtain test samples from larger samples. Use a sample splitter or a quartering method to reduce large samples. Table A gives the approximate sample size required for different maximum aggregate sizes.

TABLE A

SIZE OF SAMPLE TO BE OBTAINED[C]

Nominal Size of Aggregate[A]		Approximate Minimum Mass of Field Samples kg (lb)[B]	
Fine Aggregate			
2.36 mm	(No. 8)	10	(25)
4.75 mm	(No. 4)	10	(25)
Coarse Aggregate			
9.5 mm	(⅜ in)	4	(8)
12.5 mm	(½ in)	8	(16)
16.0 mm	(⅝ in)	15	(30)
19.0 mm	(¾ in)	20	(44)
25.0 mm	(1 in)	40	(88)
37.5 mm	(1½ in)	60	(132)

[A] For processed aggregate, the nominal size of particles is the largest sieve size listed in the applicable specification upon which any material is permitted to be retained.

[B] For combined coarse and fine aggregates, for example, base or subbase, the minimum weight shall be the coarse aggregate minimums plus 10 kg (25 lb).

[C] Interpolate sizes inbetween those listed.

B. **Sampling In-Place Roadway Material.** When taking samples from roadway material in place, take samples at several places across the roadway for the full depth of the course. Exercise care to avoid the inclusion of material from the underlying subgrade or base course. Reduce the sample to the required size by quartering or splitting as described in Section 816.02 of this manual.

C. **Sampling from a Windrow.** Combine three samples from each sublot to form a composite sample and quarter or split to the desired size as described in Section 816.02 of this manual. This will yield a total of three samples from each lot. Sample the windrow by removing the top 1 ft of material and obtain part of the sample from each side. Avoid the segregated coarser material at the bottom of the side slope. Sample windrows after equalization.

D. **Sampling from a Conveyor Belt.** When sampling from a conveyor, stop the conveyor belt and clean off a section of material from the belt. To obtain the sample from the stopped conveyor belt, insert two templates, conforming to the shape of the belt, and space them apart so that the material contained between them will yield a sample of the required weight. Carefully remove all the material between the templates. Make sure to take all of the fine material.

   Repeat this procedure three or four times and combine the separate samples to form a composite sample. Reduce the sample to the required size by quartering or splitting as described in Section 816.02 of this manual.

E. **Sampling from a Truck.** For coarse aggregate samples from trucks, take samples from trenches. Use a minimum of three trenches (the total number of trenches depends on the size of the truck and the tonnage). Dig trenches across the truck box at points on the surface that appear to be representative of the material. Make the trench bottom approximately level, at least 1-ft wide and 1 ft below the surface of the aggregate. Take equal portions of material by pushing the shovel downward into the material in the bottom of the trench at three equally spaced points. Do not scrap the material horizontally. For sampling fine aggregate in truck boxes, insert a sampling tube approximately 1 1/4 in (minimum) in diameter by 6 ft (minimum) in length into the material at the required number of locations. Combined all samples to form a composite sample. Reduce the sample to the required size by quartering or splitting as described in Section 816.02 of this manual.

F. **Sampling from a Stockpile.** Segregation often occurs when materials are stockpiled. Thus, it is difficult to ensure unbiased samples from stockpiles. For coarse or mixed coarse and fine aggregate, make every effort to enlist the services of power equipment to develop a separate, small sampling pile composed of material from various levels and locations in the main pile. Combine several increments to compose the field sample.

Where power equipment is not available, combine material from at least three increments; the top third, middle third, and bottom third of the pile. Shove a board vertically into the pile just above the sampling point to aid in preventing further segregation. In sampling stockpiles of fine aggregate, remove the outer layer, which may be segregated, and sample the material beneath. Alternative Sampling Method: Insert a sampling tube into the pile at a minimum of five random locations to extract material to form a sample. Sampling tubes are approximately 1 1/4 in (minimum) diameter by 6 ft (minimum) in length.

816.02 SAMPLE REDUCING.

Two methods for reducing a sample are presented in this section. Use either method. (A sample splitter is faster and more convenient.) Do not attempt to obtain a predetermined weight of sample. Divide and redivide a large sample until the size of sample is within a desired range.

A. Quartering a Sample. Conduct this procedure according to AASHTO T 248. The summary and exceptions follow:

Place the large sample on a firm, fairly smooth surface, such as a piece of linoleum, a floor, boards, or a piece of oil cloth or canvas. For a very dry sample, uniformly dampen the material to prevent segregation. Mix the material thoroughly. Using a shovel, flatten the material into a circular layer of uniform thickness. (If a piece of oil cloth or canvas is used, alternately lift the corners and pull over the sample as if preparing to fold the canvas diagonally.) Divide the sample into approximately four equal parts by striking two perpendicular lines through the center of the sample. Separate the four parts completely. Using a brush, make sure that you included all the fines in each part. (If a canvas is used, the separation may be accomplished by passing a broom handle underneath the canvas and lifting slightly. This must be done twice to form the two perpendicular lines of separation.)

Next discard the two diagonally opposite quarters. Be careful to discard all the remaining fines from the discarded sections. Remix the remaining quarters and repeat this process until you obtain the desired sample size from the diagonally opposite quarters. At the end of each cycle, the discarded portion and remixed portions are considered similar.

B. Splitting a Sample. Conduct this procedure according to AASHTO T 248. The summary and exceptions follow:

Sample Splitters: Use a sample splitter with an even number of equal width chutes, but not less than a total of 8 for coarse aggregate, or 12 for fine aggregate. The chutes must discharge alternately to each side of the splitter. For coarse aggregate and mixed aggregate, we require the minimum chute

width to be approximately 50% larger than the largest particle in the sample. For dry fine aggregate with 100% passing the 3/8-in sieve, use a splitter having chutes 1/2 in to 3/4 in wide. Use a splitter with two receptacles and a hopper or straight-edged pan having a width equal to or slightly less than the overall width of the assembly of chutes. The receptacles hold the two sample halves following splitting The hopper or straight-edged pan allows sample feeding at a controlled rate into the chutes.

Mix the sample thoroughly. Place the receptacles under the splitting chutes. Close the chute shut off valve. Pour the sample into the chute hopper and distribute the sample evenly over the full length and width of the hopper. Trip the shut off lever rapidly. To obtain the desired sample size, repeat the process using the material in only one of the receptacles.

After reducing the sample to the appropriate size shown in Table B, conduct the sieve analysis outlined in Section 816.04 C. of this manual. Split or quarter the material passing the No. 4 sieve to obtain a ≈500 g sample. Use a small splitting device (if available) to split fine material passing the No. 4 sieve. When performing a sieve analysis of sand in which at least 95% of the original sample passes the No. 4 sieve, reduce the sample to approximately 500 g.

TABLE B

SIZE OF SAMPLE NEEDED FOR SIEVE ANALYSIS

Maximum Size* Square Openings	Minimum Weight of Test Sample
9.5 mm (⅜ in)	1 kg (2 lb)
12.5 mm (½ in)	2 kg (4 lb)
16.0 mm (⅝ in)	4 kg (8 lb)
19.0 mm (¾ in)	5 kg (11 lb)
25.0 mm (1 in)	10 kg (22 lb)
37.5 mm (1½ in)	15 kg (33 lb)
50 mm (2 in)	20 kg (44 lb)
63 mm (2½ in)	35 kg (77 lb)
75 mm (3 in)	60 kg (130 lb)
90 mm (3½ in)	100 kg (220 lb)
100 mm (4 in)	150 kg (330 lb)
112 mm (4½ in)	200 kg (440 lb)
125 mm (5 in)	300 kg (660 lb)
150 mm (6 in)	500 kg (1100 lb)

* Maximum size (of aggregate) in specifications for, or description of aggregate, the smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

816.03 SAMPLE NUMBERING.

Use a separate number series for each different material class, size, and use. For example; number preliminary pit samples "Prel-1," "Prel-2," etc., and number informational samples different from samples used in the acceptance process.

Begin sample numbering with Sample 1 and continue in an unbroken sequence. Label check samples with the same number used on the original sample followed by an alpha designation (example: Sample 7A would indicate a check on Sample 7).

When submitting a portion of a field sample to the district laboratory, label the sample with the original field sample number followed by a separate number indicating it's order in the samples already submitted to the district laboratory. As an example; sample 25-5 indicates that the sample is a portion of field sample 25 and the fifth sample submitted to the district laboratory. The district laboratory uses a separate numbering system which includes the field numbering system for test result correlation.

816.04 AGGREGATE TESTING.

Retest any aggregates in which segregation, degradation, or contamination is suspected or evident through mishandling or improper storage. Concrete aggregates are particularly susceptible to this.

A. **Total Moisture Content By Drying To Constant Weight.** Conduct this procedure according to AASHTO T 255. The summary and exceptions follow:

1. **Scope.** Use this procedure when the total moisture content of an aggregate, soil, or asphaltic cement concrete mix is desired to be known or for the purpose of determining the sufficiency of aggregate dryness for sieve analysis. Materials dried as described are considered to have been dried to a constant weight. They are completely dry and all internal moisture has been removed. The percentage of moisture obtained is based on the dry weight of the material. This method is not applicable for emulsion or cutback asphalt mixtures.

2. **Apparatus.**

    1. Sample container
    2. Balance
    3. Hot plate, field stove, oven, or microwave

3. **Procedure.** Use a sample size of at least 500 grams for fine aggregate and asphalt mixes and 2500 grams for coarse aggregate. Check the

recommended sample size for the nominal size of aggregates in Table C. If a sample size is needed for a nominal aggregate size that is not given in the table, determine the size by interpolation. After obtaining a representative sample by the standard size reduction procedure, place the sample in a container with a known tare weight and obtain the weight of the wet sample and container. Record this weight as wet weight.

TABLE C

SAMPLE SIZE FOR NOMINAL WEIGHT AGGREGATE

Nominal Size of Aggregate	Mass of Sample (min.)
4.75 mm (No.4)	0.5 kg (1 lb)
9.5 mm (⅜ in)	1.5 kg (3 lb)
2.5 mm (½ in)	2 kg (4 lb)
19.0 mm (¾ in)	3 kg (7 lb)
25.0 mm (1 in)	4 kg (9 lb)
37.5 mm (1½ in)	6 kg (13 lb)
50 mm (2 in)	8 kg (18 lb)
63 mm (2½ in)	10 kg (22 lb)
75 mm (3 in)	13 kg (29 lb)
90 mm (3½ in)	16 kg (35 lb)
100 mm (4 in)	25 kg (55 lb)
150 mm (6 in)	50 kg (110 lb)

Dry the material by heating at a moderate temperature of 110°C or less (230°F) until it has given up all its free and absorbed moisture. At no time should the sample exceed this temperature. Watch the sample close. If free water begins to boil, you are close to the maximum allowable temperature. If drying the material in a microwave oven use the defrost setting. It should be noted that whenever drying a sample on a hot plate or stove top, great care must be taken to keep from burning the sample or losing material when the sample is stirred.

Remove the container from the heat source and weigh carefully. Record this weight, tentatively, as dry weight of the dry material plus container.

Return the container to the heat source and heat for a short period of time. Reweigh and if there is a loss of weight from the previous weighing, subject the material to further drying until two successive weighings are identical within the accuracy of the weighing device. Replace the tentative weight with this final weight.

4. **Calculations.** Calculate the percent moisture as follows:

$$\% \textit{ Moisture} = \frac{W_w - D_w}{D_w - T} \times 100$$

Where T = Tare Weight of Container.
W_w = Wet Weight and Container.
D_w = Dry Weight, Sample, and Container.

B. Determining Surface Moisture in Aggregates. Conduct this procedure according to NDDOT Method. A summary follows:

1. **Scope.** Use this test method to determine the percentage of surface or free moisture in aggregates. Surface moisture is that moisture in an aggregate which is in excess of absorbed moisture. When an aggregate has just enough moisture to satisfy its absorption properties, it is said to be in a saturated surface-dry condition. In concrete work, the moisture absorbed in the aggregates is not considered capable of hydrating the cement or affecting the slump or workability. Only the surface moisture is included in determining the water in batch weights and water-cement ratios.

2. **Apparatus.**

   1. Sample container
   2. Balance
   3. Hot plate, field stove, oven, or microwave.

3. **Procedure.** Use a sample size of approximately 500 g for fine aggregate and 2500 g for coarse aggregate. After obtaining a representative sample by standard size reduction procedure, place the sample in a container with a known tare weight and obtain the weight of the wet sample and container, and record this weight as wet weight.

   Dry the material by heating at a moderate temperature of 110°C or less (230°F) until it appears to have given up all free and absorbed moisture.

Remove the container from the stove or hot plate and weigh carefully. Record this weight tentatively as dry weight of dry material plus container.

Again place the container on the drying apparatus and heat for a short period of time. Reweigh and if there is a loss of weight from the previous weighing, reheat the material for further drying until two successive weighings are identical within the accuracy of the weighing device. Replace the tentative dry weight determined above with this final weight.

4. **Calculations.** Calculate the percent of surface moisture as follows:

$$\%\ \textit{Surface Moisture} = \frac{W_w - D_w}{D_w - T} \times 100 - A$$

Where: W_w = Wet Weight and Container
D_w = Dry Weight and Container
T = Tare Weight of Container
A* = Percent Absorption of Aggregate

* As determined by aggregate specific gravity test results provided by the District Materials Coordinator.

C. **Sieve Analysis of Aggregates.** Conduct this procedure according to AASHTO T 27. The summary and exceptions follow:

1. **Scope.** This test method determines the particle size distribution (sieve analysis) of fine and coarse aggregates.

2. **Apparatus.**

1. Set of sieves
   a. Round sieves, 8- and 12-in diameter, with mechanical shaker.
   b. Square sieves, 16 in, with sieve rocker or mechanical rocker.
2. Balance
3. Three large pans required for drying and handling sample.
4. Stove.
5. Bronze brush.
6. Paint brush, approximately 1-in wide.
7. One large and one small sample splitter.
8. Mixing bowl, approximately 8- to 10-in diameter.
9. Spoons.
10. Additional No. 200 and No. 10, or No. 16, sieves for wash method.
11. Mortar and rubber tipped pestle.

3. **Procedure.** The following procedure pertains to a sample which is a mixture of fine and coarse aggregate. If a sample contains only coarse aggregate (the No. 4 sieve is designated as the division between fine and coarse), only Steps 1 through 5 below apply. If a sample contains only fine aggregate, only Steps 6 through 12 below apply.

   Perform a washed analysis, using only the Minus No. 4 fraction, on all samples (exceptions are aggregate Classes 42, 43, 44, and 45).

   For aggregate Classes 42, 43, 44, and 45, wash the total sample and omit Steps 3 through 7. The size of the sample may require hand sieving over some of the coarser sieves in place of the mechanical sieving procedure as outlined in Steps 9 and 10. Omit Step 12 and calculate percentages retained on the basis of the weight of the original sample as determined in Step 3.

   1. Select sieves suitable to furnish the information required by the specifications covering the material to be tested. Use of additional sieves may be desirable to prevent the required sieves from becoming over-loaded.

   2. Dry the sample thoroughly.

   3. Weigh the dried sample to the nearest 1.0 g. Use SFN 9987 or SFN 2455, as required, to record all data.

   4. Shake the material by hand through the coarsest selected sieve, taking care not to lose any material. Place the material retained on this sieve onto the aggregate balance and weigh to the nearest 1.0 g and record. Repeat this process using only the material passing the coarsest sieve and shake through the next finest sieve. Place the retained material on the balance, weigh and record this non-cumulative weight. Continue this process down to and including the No. 4 sieve. Use 8-in circular sieves; however, for coarse aggregate, 16-in square sieves are also available along with mechanical shakers or rockers for manual shaking. Use the 16-in sieves for coarse aggregate on concrete structural projects where frequent testing is necessary. Other than a change in sieve size, use the same procedure for coarse aggregate for concrete that is similar to that described except that the No. 8 sieve will be included after the No. 4 sieve.

   5. To record and calculate the column "cumulative weight" on SFN 9987 or SFN 2455, add the weight retained on the largest sieve to the weight retained on the next smaller sieve. Add the cumulative weight retained on the No. 4 to the weight of the Minus No. 4 material and record as the

weight check. Calculate the percent retained on each sieve by dividing each cumulative weight by the original weight and multiplying by 100. Convert each of the percent-retained-values to percent passing by subtracting the percent retained value from 100, and recorded in the space provided on the form. At this stage, the percent of the total sample which passes the No. 4 sieve is then known as the total Minus No. 4 material. Keep this on hand, ready for further analysis.

6. Reduce the total Minus No. 4 material to a size which will allow it to be placed in a set of stacked sieves and shaken with the mechanical shaker to completion in one single operation. The size of the sample must be small enough so that, at the completion of the shaking operation, not more than 200 grams will be retained on any one sieve; but large enough so that accurate and reproducible results are obtainable. Use the small sample splitter for this purpose and the final sample size should be between 300 and 700 g. Do not attempt to obtain a sample at an exact predetermined weight . Additional information on sample size is contained in Section 816.01.

7. Weigh the sample to the nearest 0.1 g and record.

8. Determine sieve analysis of Minus No. 4 material by washed analysis.

   a. After drying and weighing, place the sample in the container and add sufficient water to cover it. Agitate the sample so that a complete separation of all particles finer than the No. 200 sieve from the coarse particles occurs. Stack a No. 10 or No. 16 sieve cn top of a No. 200 sieve and decant (pour slowly without agitating the settled sediment) the water through the sieves. Discard the water containing the Minus No. 200 material, to prevent losing any of the retained material.

   b. Add more water to sample and repeat this procedure until the wash water becomes clear. Wash the material retained on the sieves back into the sample in the mixing bowl, slowly and carefully pour off the excess clean water, dry the sample to a constant weight, and record as weight after wash.

   c. Stack the required fine sieves with the coarsest at the top decreasing in size with the pan at the bottom. Use additional sieves to prevent more than 200 g being retained on any one sieve at the completion of the shaking operation.

   d. Place the sample in the stack of sieves and shake with the mechanical shaker until not more than 0.5% by weight of the total sample passes any sieve during one minute. Approximately 15 to 20 minutes is

sufficient for most material. Use manual shaking of the material on any one sieve to check on the thoroughness of sieving by any mechanical shaker.

e. Remove the top sieve, brush the retained material into a pan, weigh to the nearest 0.1 g, and record. Repeat this process with each succeeding sieve, brushing the material into individual pans, and recording the non-cumulative weights.

f. Add the non-cumulative weight retained on the largest sieve to the weight retained on the next smallest sieve and record in the cumulative column. Calculate the percent retained on each sieve by dividing each weight by the total dry weight of the Minus No. 4 sample obtained in Step 7 and multiplying by 100. Subtract each of these values from 100 to obtained the percent passing each sieve. Subtract the weight after wash from the original weight and record as wash loss. Sum the cumulative weight retained on the No. 200, the weight of the Minus No. 200 material, and the wash loss, and record as the weight check. The values obtained represent the grain size distribution of the Minus No. 4 material (a portion of the original sample). Convert these values to percentages of the total original sample, by multiplying each value by the percent passing the No. 4 sieve obtained in Step 5.

g. For both the Plus No. 4 and Minus No. 4, compare the original weight to the weight check. Subtract the smaller value from the larger value, divide the result by the original weight, and multiply by 100, to obtain the percent difference. **For acceptance purposes, the two must not differ by more than 0.3%.**

4. **Precautions.** When working with mixed materials that are coated, lumpy, or baked together, the material must be pulverized enough to separate the particles and remove the coating as much as possible. The idea is to pulverize enough to separate most of the particles, without breaking up any appreciable amount of individual material particles.

   In brushing the material out of the sieves, use the bronze brush for approximately the No. 30 sieve and coarser and the paint brush for the finer sieves. Tapping the sieves lightly with a stick of wood on the retaining ring to facilitate removal of the particles is acceptable. Do not attempt to completely remove all the particles, but examine each sieve visually before and after sieving and the amount of aggregate particles stuck in the mesh must appear to remain approximately the same for accurate results.

Examine the sieves constantly for damage which will affect the test results. A common occurrence is the separation of the mesh from the side of the sieve, especially in the finer sieves. Hold the sieves up to a light to inspect for damages.

D. Fine Aggregate for Concrete.

1. **Gradation.** See Section 816.04 C.3 for test procedure.

2. **Lightweight Pieces of Aggregate.** To determine the percentage of lightweight pieces in the aggregate passing the No. 4 sieve and retained on the No. 30 sieve, see Section 816.04 F.1. of this manual. Calculate the result based on the total sample submitted for testing and record on SFN 2455.

3. **Specific Gravity and Absorption.** See Section 816.04 F.6.

E. Coarse Aggregate for Concrete.

1. **Gradation.** See Section 816.04 C.3 for required sieves.

2. **Material Passing No. 200 Sieve.** The procedure shall be done according to AASHTO T 11. The following is a summary:

   a. **Apparatus**

      1. Balance
      2. Sieves: 3/8", No. 200, No. 16, No. 4, and one sieve pan.
      3. Five pans
      4. Sample splitter

   b. **Procedure.** When reducing a sample of concrete aggregate for sieve analysis, obtain a representative sample of approximately 2500 grams.

      Dry the sample to a constant weight and record on the back of SFN 2455 as weight of total sample and again as dry weight before washing (example of worksheet may be found in Appendix D).

      Determine the amount of material finer than the No. 200 sieve by washing, using the following procedures:

      1. Place the sample to be washed into the mixing bowl, add water, and stir until all fines are in suspension.

2. Stack a No. 16 sieve on top of a No. 200 sieve and decant (pour slowly without agitating the settled sediment) the water through the sieves. The water containing the Minus No. 200 material may be discarded, but care must be taken to prevent losing any of the retained material.

3. Add more water to the sample and repeat this procedure until the wash water becomes clear. Wash the material retained on the sieves back into the sample in the mixing bowl, slowly and carefully pour off any excess clean water. Dry sample and weigh, until constant weight is achieved. Record as dry weight after washing. Subtract dry weight after washing from dry weight before washing and divide result by dry weight before washing. Multiply this result by 100 and record as material passing No. 200 sieve percent of total sample.

3. **Shale, Hard Iron Oxide Particles, Lignite and Other Coal, Soft Particles, Thin or Elongated Pieces.** To determine the amount of deleterious substance retained on the No. 4 sieve, use the following procedure:

a. Wash and dry the sample or use the material from the previous procedure.

b. Stack the required sieves (No. 4 and 3/8") with the coarsest at the top and a pan at the bottom. The amount of material retained on a sieve may be regulated by either introduction of a sieve with larger openings immediately above the given sieve or by testing the sample in a number of increments.

c. Place the washed sample in the stack of sieves and shake with the mechanical shaker until not more than 0.5% by weight of the total sample passes any sieve during one minute. Approximately ten minutes will be sufficient for most materials.

d. Remove material retained on the 3/8" and the No. 4 sieves into a pan. Weigh to the nearest 0.1 gram and record as weight of Plus No. 4 fraction. Material passing the No. 4 sieve can be discarded.

e. Hand pick the shale, hard iron oxide particles, **lignite and other coal, and thin or elongated pieces,** and place in separate containers. Weigh each container and calculate the percentages of deleterious substances by dividing each weight by the weight of the Plus No. 4 fraction and multiplying by 100.

f. Check the remainder of the sample for soft particles. To determine if particles are soft, use a small 4 oz. ball pin hammer and a flat, **non-deflecting plate.** Take the hammer and strike each particle with a minimum amount of effort to see if it cracks on impact. **A drop of 4" to 5" is sufficient. Place cracked material in container and weigh. Determine the percentage of soft material by dividing its weight by the weight of the Plus No. 4 fraction and multiplying by 100.**

4. **Specific Gravity and Absorption.** See Section 816.04 F.5. for procedure.

F. Aggregates for Surfacing, Base, Asphalt Mixes, Blotter, and Seal Coats.

1. **Lightweight Pieces of Aggregate.** Conduct this procedure according to AASHTO T 113. The summary and exceptions follow:

a. **Scope.** This test method determines the percent of lightweight pieces in aggregate by means of sink-float separation in a heavy liquid of a specific gravity of 1.95. This test is not normally conducted in the field except in cases where the results are consistently near the specification limits.

b. **Apparatus.**

1. Balance
2. Sieves No. 4 and No. 30
3. Specific gravity hydrometer
4. Zinc chloride
5. Enamel pan, approximately 12 in. diameter by 8 in. deep, for mixing solution
6. Two enamel pans approximately 8 in. diameter by 3 in. deep
7 Fine strainer or piece of No. 30, or finer, sieve

c. **Procedure.** Determine the sieve analysis of the sample to obtain the percent retained on the No. 4 sieve, percent passing the No. 4 sieve and retained on the No. 30 sieve, and percent passing the No. 30 sieve. See sample calculations, in the next Section, lines 1, 2, and 3.

The lightweight particles separate from the aggregate by float separation using a heavy media solution of zinc chloride. To prepare a zinc chloride solution, mix zinc chloride with water at room temperature. Try proportions of about 2800 g of zinc chloride to about 1100 ml of water. During mixing, the solution heats up considerably. After cooling to room temperature, adjust the specific gravity to 1.95 ± 0.02 by adding water or zinc chloride in small quantities. Use the solution at this room

temperature. **Zinc chloride is a poison. Handle and store accordingly. Avoid zinc chloride dust or vapor from the solution by wearing a dust mask and safety goggles. The zinc chloride solution is corrosive to skin and clothing. Use rubber gloves and a rubberized apron to avoid contact with skin or clothing.**

Obtain and weigh a representative sample of dry plus No. 4 material weighing up to 2500 g. Record this weight. This fraction is to be no smaller than 1500 g, provided the sample contains this much. Pour this coarse material into the flotation basket and slowly immerse it into the heavy media solution and stir gently. Skim off floating material with a fine strainer. Wash the lightweight particles off the strainer by dipping into a pan of water. Repeat stirring and skimming several times until no further material comes to the surface of the heavy media solution. Wash the recovered material off with water and dry and weigh. Use hot water to wash off the solution (preferred). Record the weight.

Obtain a representative dry sample of the material passing the No. 4 sieve and retained on the No. 30 sieve. This sample should weigh approximately 300 to 500 g. **The material from the sieve analysis passing the No. 4 sieve is normally used for this portion of the test.** Agitate the sample by stirring for a period of 15 seconds. Allow the sample to settle for 30 seconds and decant. Perform this procedure until the specimen is free of floating pieces or a maximum of three times. After washing and drying the fine lightweight material, weigh and record.

Compute the percent lightweight particles in the total sample as shown on line 6 of the next Section. This method of calculating assumes that there are not lightweight particles in the Minus 30 fraction.

To reuse the heavy media solution, check the specific gravity and adjust each time.

d. Sample Calculations. Results from sieve analysis.

1.	Percent retained on No. 4 sieve	32.3% (.323)
2.	Percent passing No. 30, total sample	13.7% (.137)
3.	*Percent passing No. 4 - Percent passing the No. 30*	54.0% (.540)
	From Plus 4 sample:	
	A. Weight of dry Plus No. 4 material	2500.0 g
	B. Weight of Lt Wt pieces in Plus No. 4 material	192.7 g
	C. Percent Lt Wt pieces, + No. 4 material	192.7 g ÷ 2500 g x 100 = 7.7%
4.	Lt Wt pieces, +No. 4 material, % of total sample	7.7% x .323 = 2.5%
	From -No. 4 to +No 30 sample:	
	A. Weight of dry -No. 4, +No. 30 material	320.0 g
	B. Weight of Lt Wt pieces, -No. 4, +No. 30 material	35.8 g

C.	Percent Lt Wt pieces, -No. 4, +No. 30	35.8 g ÷320.0 g x 100 = 11.2%
5.	Percent Lt Wt pieces, -No. 4, +No.30, total sample	11.2% x .540 = 6.0%
6.	Percent Lt Wt pieces, total sample	2.5% + 6.0 = 8.5%

2. Determining the Percentage of Fractured Particles in Coarse Aggregate.

a. Scope. This procedure determines the percent, by weight, of particles which, by visual inspection, have the essential characteristics of crushed aggregate.

b. Apparatus.

1. Balance
2. No. 4 sieve
3. Sample splitter
4. Spatula

c. Procedure. Obtain a sample of approximately 500 grams. Wash and dry the sample to constant weight. Sieve the sample over the No. 4 sieve. Test only material larger than No. 4. This is considered the total sample.

Spread the sample on a clean flat surface large enough to permit the material to be spread thinly for careful inspection. Using the spatula or similar tool, separate the material into three separate portions:

1. Fractured particles
2. Questionable fractured particles
3. Particles with no fractured faces

The particles will have either one or two fractured faces depending on the class of aggregate being tested.

d. Calculations. Report the percentage of particles with fractured faces to the nearest 1% according to the following formula:

$$FF = (WF + WQ \div 2) \div WA \times 100$$

Where: FF = % of particles with fractured faces
WF = weight of fractured particles
WQ = weight of questionable fractured particles
WA = weight of total sample

3. **Determination of the Liquid Limit.** Conduct this procedure according to AASHTO T 89, Method B. The summary and exceptions follow:

   a. **Scope.** The liquid limit (LL) of a soil is the moisture content, expressed as a percentage of the weight of oven dried soil, at which the soil passes from a plastic to a liquid state. To determine the plasticity index (PI) it is necessary to perform the liquid limit test and the plastic limit (PL) test. The plasticity index is the difference between these two values (PI = LL - PL).

   b. **Apparatus.** The plasticity index set requires the following:

      1. One hand shovel
      2. One balance conforming to AASHTO M 231, Class C
      3. Two spatulas
      4. Two evaporating dishes
      5. One mortar and pestle
      6. Six moisture sample cans, 3 oz capacity
      7. One liquid limit device
      8. One grooving tool
      9. One gauge for the liquid limit device
      10. No. 4 sieve, pan, and cover
      11. **Oven**

   c. **Sample Preparation.** Dry the material at a temperature not exceeding 60°C (140°F). Split the material with a sample splitter to obtain a representative sample for testing. Break up the clumps of soil with a mortar and rubber covered pestle without reducing the size of the individual grains. Separate the sample by sieving through the No. 40 sieve.

   d. **Adjustment of Liquid Limit Device.** Adjust the lift height of the cup, by using the adjustment plate. The center of the point of the cup, which comes in contact with the base, must be one cm above the base. The gauge is used for this measurement. Secure the adjustment plate by tightening the screws. With the gauge in place, check the adjustment by revolving the crank rapidly several times. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustment is necessary.

   e. **Procedure.** Take a sample of approximately 50 g from the thoroughly mixed portion of the material. Place the sample in the mixing dish and thoroughly mix with 8 ml to 10 ml of distilled water by alternately and repeatedly stirring, kneading, and chopping with a spatula. Add additional

water in increments of 1 ml to 3 ml and thoroughly mix. Once testing begins, do not add additional dry soil to the moistened soil. Do not use the cup of the liquid limit device to mix the soil and water.

Note 1: The amount of time needed for a material to absorb the water will depend on the material being tested.

Note 2: Sandy or silty material may require less water than the initial amount of water, 8 ml to 10 ml, and increments of 1 ml to 3 ml.

After obtaining a uniform mass of soil and water, place a sufficient quantity of the mixture in the cup above the spot where the cup rests on the base. Squeeze and spread the mixture level with the spatula, and at the same time trim the material to a depth of 10 mm at the point of maximum thickness. Use as few strokes of the spatula as possible. Use care to prevent the entrapment of air bubbles within the mass. Divide the soil with a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean, sharp groove is formed. Six strokes from the back to front are permitted to avoid tearing the sides of the groove or slipping of the soil cake on the cup. Increase the depth of the groove with each stroke and scrape the bottom of the cup with only the last stroke.

Lift and drop the cup containing the prepared sample by turning the crank at a rate of approximately two revolutions per second for 25 blows. If the two sides of the sample come in contact at the bottom of the groove along a distance of about 1/2 in. at the end of 25 blows, stop and determine the Moisture Content of the material. This Moisture Content in percent is the liquid limit. If the two sides fail to come in contact about 1/2 in. at the end of 25 blows, return to the mixing dish and add more water as described before. If the two sides come together 1/2 in. in less than 25 blows, the soil is too wet, discard and start over with a new 50-g sample with less water.

Observe at least two groove closures before accepting one for the record. This is to ensure the accepted number of blows is truly characteristic of the soil under test.

For determining Moisture Content (LL), remove a slice of soil approximately as wide as the spatula extending from edge to edge at right angles to the groove. Include that portion of the groove in which the material flowed together. Place it in a suitable tared container and cover. Weigh the container and soil promptly and record the weight. Oven dry

the soil in the container to a constant weight at 110±5°C (250±9°F) and record this weight. Record the loss in weight due to drying as the weight of water.

f. **Calculations.** Calculate the Moisture Content of the soil as follows:

Liquid Limit = (Wt of water ÷ Wt of oven-dried soil) x 100

4. **Determination of the Plastic Limit and Plasticity Index.** Conduct this procedure according to AASHTO T 90. The summary and exceptions follow:

a. **Scope.** The plastic limit of a soil is the lowest water content at which the soil remains plastic. The plasticity index of a soil is the range, expressed in moisture content, where the material is in a plastic state. Thus, it is the numerical difference between the liquid limit and the plastic limit.

b. **Apparatus.** The plasticity index set requires the following:

1. One hand shovel
2. One balance
3. Two spatulas
4. Two evaporating dishes
5. One mortar and pestle
6. Six moisture sample cans, 3 oz. capacity
7. One liquid limit device
8. One grooving tool
9. One gauge for the liquid limit device
10. No. 4 sieve, pan, and cover.
11. Ground glass plate.
12. **Oven**

c. **Sample.** For the plasticity index, use the same screened material that was used for the liquid limit.

d. **Procedure.** If both the liquid and the plastic limits are required, take a test sample weighing about 8 grams from the thoroughly wet and mixed portion of the soil prepared for the liquid limit. Take the sample at any stage and allow to dry in air until the completion of the liquid limit test.

If only the plastic limit is required, take a quantity of soil weighing about 20 grams and mix with distilled or tap water until the mass becomes plastic enough to be easily shaped into a ball. Use a portion of this ball weighing about eight grams for the test sample.

Squeeze and form the 8-g test sample into an ellipsoidal-shaped mass. Roll this mass between the fingers and the ground glass plate or piece of paper with sufficient pressure to roll the mass into a uniform thread about 1/8 in. in diameter throughout its length. When the diameter of the thread reaches 1/8 in., break the thread into six or eight pieces and squeeze the pieces together between the thumbs and fingers of both hands into a uniform mass roughly ellipsoidal in shape and reroll. Continue this procedure until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a thread. The crumbling may occur when the thread has a diameter greater than 1/8 in. This is considered a satisfactory end point provided that the soil has been previously rolled into a thread 1/8 in. in diameter.

Do not attempt to produce failure at exactly 1/8 in. in diameter by allowing the thread to reach 1/8 in., then reducing the rate of rolling or the hand pressure, or both, and continuing the rolling without further deformation until the thread falls apart. It is permissible to reduce the total amount of deformation for feeble plastic soils by making the initial diameter of the ellipsoidal shaped mass near the required 1/8 in. final diameter.

Gather the portion of the crumbled soil together and place in a suitable tared container. Weigh the container and soil to the nearest 0.01 g and record the weight. Oven dry the soil in the container to a constant weight at 110±5°C (230±9°F) and weigh. Record this weight as the weight of water.

e. **Calculation**. Calculate the moisture content of the soil as follows:

Plastic Limit = (Wt of Water ÷ Wt of Oven-Dried Soil x 100)

The plasticity index of soil is the difference between its liquid limit and its plastic limit.

Plasticity Index = Liquid Limit - Plastic Limit

Report the plastic limit as non plastic (NP) when the plastic limit is equal to or greater than the liquid limit, or when the liquid limit or plastic limit cannot be determined.

5. **Specific Gravity and Absorption of Coarse Aggregate.** Conduct this procedure according to AASHTO T 85. The summary and exceptions follow:

a. **Scope.** Use this procedure to determine bulk specific gravity, bulk specific gravity (saturated surface dry), apparent specific gravity, and water absorption of coarse aggregates.

b. **Apparatus.**

1. Sample container - wire basket of No. 6 or finer mesh or a bucket of approximately equal width and height with a capacity of 7 liters. Construct container so as to prevent trapping air when submerged.
2. Balance equipped with apparatus for suspending sample container.
3. Water tank with overflow outlet.
4. Suspension apparatus.
5. No. 4 sieve or other sizes as needed.

c. **Procedure.** Obtain approximately 3,000 grams of coarse aggregate by dry sieving through a No. 4 sieve and wash to remove any dust. Dry to a constant weight at 110 ± 5°C (230 ± 9°F). Immerse the sample in room temperature potable water for 17 ± 1 hour.

Prepare the equipment prior to starting the test. Fill the tank with potable water so water runs out the overflow. Water temperature must be 23 ± 1.7°C (73.4 ± 3°F). Suspend the basket or bucket in the water and shake to remove entrapped air. Place the pan on top of the balance and tare. Tare the basket and pan each time to ensure accurate weights.

Remove the sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. At this point the sample is in a saturated surface dry condition. Place the sample in a tared container. Weigh the sample and record the weight as **B** on the "Worksheet for Specific Gravity of Coarse Aggregate," SFN 10081.

After weighing, place the saturated surface dry sample in the sample container, immerse in water, and determine its weight at 23 ± 1.7°C (73.4 ± 3°F). Take care to remove all entrapped air before weighing by shaking the container while immersed. Record the weight as **C** on form SFN 10081. Dry the sample to a constant weight at 110 ± 5°C (230 ± 9°F) and record as **A** on form SFN 10081.

d. **Calculations.** Substitute the results in the equations on form SFN 10081 and perform the calculations to determine bulk specific gravity (saturated surface dry), bulk specific gravity, apparent specific gravity, and absorption. Report specific gravity results to the nearest 0.001 and the absorption result to the nearest 0.1 percent.

6. **Specific Gravity and Absorption of Fine Aggregate.** Conduct this procedure according to AASHTO T 84 (NDDOT MODIFIED). The summary and exceptions follow:

   a. **Scope.** Use this procedure to determine bulk specific gravity, bulk specific gravity (saturated surface dry), apparent specific gravity, and water absorption of fine aggregate.

   b. **Apparatus.**

      1. Balance
      2. Flask & Glass Cover Plate
      3. Mold
      4. Small fan
      5. Temperature-controlled water bath
      6. No. 4 sieve

   c. **Pycnometer Calibration.** A volumetric flask of **1000 ml** capacity is generally used for this test. Calibrate the flask by determining the weight of the flask full of distilled water at 23 ± 1.7°C (73.4 ± 3 °F). Overfill the flask so the water is convexed above the brim. Very carefully slide a cover plate over the brim of the flask. The flask should be free of any air bubbles. Wipe any moisture and dust from outside of the flask and weigh the flask, water, and cover plate. Record this weight as **B** on the worksheet for Specific Gravity of Fine Aggregate, SFN 2199. Empty the flask and repeat the calibration. Repeated weighings should agree within 0.2 grams.

   d. **Procedure.** Obtain approximately 1350 grams of fine aggregate (material passing the No. 4 sieve) from the total sample. Dry the sample to a constant weight at 110 ± 5°C (230 ± 9°F). Allow the sample to cool to a comfortable handling temperature. Place the sample in a pan, cover with distilled water, and allow to soak for 17 ± 1 hour. After the soak period carefully pour off the excess water, taking care to avoid loss of any fines.Spread the entire sample on a flat, non-absorbent surface and expose it to a gently moving current of warm air produced by the fan set at a low speed. Stir the sample frequently to obtain uniform drying. The purpose of the slow, uniform drying is to bring the fines to a saturated surface dry condition. In this condition moisture fills the pores of each particle while the surface of the particle is dry. If non-uniform drying is allowed, the results may be in error because over-dried portions of the aggregate will not be saturated. Continue the process until the sample approaches a free flowing condition. It is intended the first trial of the cone test be made with some surface water in the sample.

Place the mold (large diameter down) on a smooth, level, firm, non-absorbent surface and fill with the partially dried material. Fill the cone to overflowing. Heap additional material above the top of the mold by holding the mold with cupped fingers and pouring material on top of the mold. Tamp the surface of the material in the mold 25 times with the tamper. Each drop of the tamper should start five mm (0.2") above the top of the fine aggregate. Allow the tamper to fall freely during each drop. Adjust the starting height after each drop. Distribute the drop evenly over the entire surface. After tamping is complete, remove the material spilled around the mold and slowly lift the mold vertically.

If surface moisture is still present in the sample, the fine aggregate will retain the molded shape and requires additional drying. If it slumps on the first try, the material has dried past the saturated surface dry state. It is possible to get the fine aggregate too dry on the first attempt, but the test can be saved by adding a few ml of water to the sample, mixing it, covering it, and allowing the sample to set for 30 minutes before rechecking. Only one recheck is permitted.

Test the tamped fine aggregate at frequent intervals until 25 to 75 percent of the top diameter of the cone slumps. At this point the material has reached the saturated surface dry condition. Immediately weigh out 500 grams of the saturated surface dry material for introduction into the flask. Weigh to the nearest 0.1g.

Partially fill the flask with distilled water. Immediately introduce 500 grams of the saturated surface dry material into the flask. Add distilled water to partially fill the neck of the flask. Roll and agitate the flask to eliminate the air bubbles. Periodically stop agitating and rolling the flask to allow the air bubbles to rise to the top and be eliminated. Continue the agitating, rolling, and bubble elimination procedures until all the bubbles are eliminated. It normally takes about 15 to 20 minutes to eliminate the air bubbles.

Place the flask in a water bath at 23 ± 1.7 °C (73.4 ± 3 °F) for 1 hour ± 15 minutes. To eliminate air bubbles periodically remove the flask from the bath, gently agitate it, and place it back in the bath. After the flask has been in the bath for the specified time and the sample has reached the desired temperature, remove the flask from the bath. All the air bubbles must be removed. Exercise care. This requires good technique and judgement. If the air bubbles are not completely removed, the results will be erratic.

After removal of the flask from the water bath, add distilled water to bring the level to the top of the flask. Overfill the flask so that the water is convexed over the brim and slide the glass cover plate along the brim. The flask should be free of any air bubbles. Wipe any moisture from the flask and weigh the flask, cover plate, sample and water. Record this weight as **C** on SFN 2199.

Carefully pour the sample and the water into a tared pan. Rinse the residue from the flask into the pan with a squeeze bottle.

Oven dry the sample to a constant weight at 110 ± 5 °C (230 ± 9 °F). Allow the sample to cool to room temperature for 1/2 to 1 hour and record the dry weight. Record this weight as **A** on SFN 2199.

e. **Calculations.** Substitute the results into the equations on form SFN 2199 and perform the calculations to determine bulk specific gravity (saturated surface dry), bulk specific gravity, apparent specific gravity, and absorption. Report specific gravity results to the nearest 0.001 and the absorption result to the nearest 0.1 percent.

Section 818

BITUMINOUS MATERIALS

818.01 SAMPLING BITUMINOUS MATERIALS.

Accept bituminous material by certification. **All bituminous material samples except verification samples, are obtained by the contractor under the observation of the engineer.** Frequently sampling procedure is questioned in disputes with suppliers. Make sure the procedure is done correctly at all times. Conduct sampling according to ASTM D 140. The summary and exceptions follow:

A. Sampling Bitumen. The following procedure applies for suppliers of asphalt binders meeting the criteria for acceptance under the **"Certification Method for Acceptance."** (The method of acceptance for asphalt binders is on file at the Materials and Research Division). Sample all asphalt cements at a minimum rate of one sample for every 250 tons for each supplier and grade of asphalt cement, or fraction thereof. Take the sample randomly within each 250 tons of material. Obtain additional samples as directed by the project engineer. A sample consists of two 1-liter samples from the designated transport. The first sample is used for testing and the second sample is a check sample. Submit both samples to the NDDOT Central Laboratory.

Each district office has a list of suppliers meeting the criteria for acceptance. Contact the Materials and Research Division for suppliers not on the Department's approved list.

For asphalt cutbacks, obtain two 1-liter samples from each railroad tank car and/or truck. Submit one sample to the District Lab or Materials and Research Division, and keep the other sample in the field lab for a check sample.

For all emulsions, take two 1-gallon samples, in wide-mouth pails from each shipment and submit both to the District Lab (see Section 420.02 A. for additional sampling requirements). Asphalt emulsions, especially the rapid setting type, start to break in a few minutes if left in containers open to the air. If sampling asphalt emulsions of any type by pail or open container, transfer to a sample container and seal tightly as soon as possible. If sampling directly into the sample container, seal the container as soon as possible.

For materials needing heating and circulation before unloading, obtain the required samples from a tap in the recirculating line. Take samples after thoroughly circulating the material.

Each delivery vehicle should have a sampling valve installed at least one foot from the shell and clearly marked "Sampling Valve." Draw at least 1 gallon of material from the valve and discard before taking the sample.

B. **Containers.** Sample asphalt cements in 1-liter metal cans equipped with tightly closing lids. Sample emulsions in tightly sealed wide-mouth plastic jars, bottles, or pails. Use only new containers. Containers should not be washed or rinsed, or wiped with an oil cloth. Do not use containers with solder flux inside them. Use absolutely clean and dry containers only.

C. **Protection and Preservation of Samples.** Use care to prevent the sample from contamination. Tightly seal the containers immediately after filling. Do not clean filled sample containers by submerging in solvents, or wiping with a solvent saturated cloth. Use a clean, dry rag to clean sample cans after filling. **Never use cleaning fluid of any type.**

D. **Numbering Samples.** Label bituminous samples numerically. Place a check mark following the number on check samples. Label each type of bituminous material (i.e., asphalt cement, emulsion, or cutback) with a different sequence.

818.02 TESTING.

A. **Sieve Test of Asphalt Emulsions.** Conduct this procedure according to ASTM D 244. The summary and exceptions follow:

1. **Scope.** This procedure is used to determine the percentage of material retained on a #20 sieve when a given amount of asphalt emulsion is poured through it.

2. **Apparatus.**

    1. A 3-inch #20 sieve.
    2. A pan for the 3-inch, #20 sieve.
    3. Sodium Oleate Solution (2 percent in distilled water).
    4. Desiccator.
    5. Balance.

3. **Test Conditions.** The test temperature is related to an emulsion's viscosity.

Test Temperature for Asphalt Emulsion Sieve Test	
Viscosity	Test Temperature
< 100 seconds	Room Temperature
> 100 seconds	122 $\pm$ 5° F
Specified at 122° F	122 $\pm$ 5° F

4. **Procedure.** If heating is necessary, vent and place the container containing the sample in an oven or water bath. Stir the sample to achieve homogeneity.

   Record the weight of the sieve and pan on SFN 5787. Wet the wire cloth with the 2 percent Sodium Oleate Solution. For cationic emulsions, use distilled water instead of the Sodium Oleate Solution.

   Weigh one kilogram of the emulsified asphalt into a suitable container and pour it through the sieve. Wash the container and the residue on the sieve with the Sodium Oleate Solution (distilled water if cationic) until the washing runs clear. Place the pan under the sieve and heat for two hours in oven at 230 $\pm$ 9°. Cool in a desiccator and weigh the sieve, pan, and residue. Calculate the percentage of the sample retained on the sieve.

B. **Saybolt Viscosity of Emulsions Using a Saybolt Furol Viscometer.** This method covers the procedures for determining the Saybolt Furol viscosity of emulsified asphalt. Conduct this procedure according to ASTM D 244 and D 88. The summary and exceptions follow:

1. **Apparatus.**

   a. Saybolt Furol viscometer and bath.
   b. Withdrawal tube or other suitable device.
   c. Thermometer support.
   d. Thermometers - ASTM 17° or 19° Fahrenheit (F) or Celsius (C).
   e. Filter funnels with number 20 (850 μ m) wire-mesh insert.
   f. Receiving flask.
   g. Timing device capable of recording to 1/10(0.1) second.

2. **Preparation of Apparatus.** Fill the viscometer bath with mineral oil to at least 1/4" (6 mm) above the overflow rim.

   Clean the viscometer thoroughly with water and then with an appropriate solvent such as technical grade trichloroethylene ($ClHC=CCL_2$,trich). Remove all solvent from the viscometer. Wash the receiving flask with water and rinse with trichloroethylene.

   Set up the viscometer and bath in an area where it will not be exposed to drafts or rapid changes in air temperature. Use of an enclosing hood reduces any chances that dust or vapors might contaminate the viscometer or sample.

   Place the receiving flask beneath the viscometer so that the graduation mark on the receiving flask is from four to five inches (100 to 130 millimeters, mm) below the bottom of the viscometer tube. Position the receiving flask so that the stream from the viscometer strikes the neck of the flask.

   Provide adequate stirring and thermal control for the bath so that the temperature of the test sample in the viscometer does not vary more than ±0.1°F (0.05°C) after reaching test temperature. Do not make viscosity measurements at temperatures below the dew point of the room's atmosphere.

3. **Calibration and Standardization.** Calibrate the Saybolt once every three years. Follow standard test procedures for determining the calibration factor. If the afflux time differs by more than two percent, find a correction factor by using the following formula.

$$F = \frac{V}{t}$$

   V = certified Saybolt viscosity of the standard
   t = measured afflux time at 100°F (37.8°C)
   F = correction factor

4. **Procedure.** Establish and control the bath temperature at the selected test temperature. Insert a cork stopper into the air chamber at the bottom of the viscometer. A small chain or cord may be attached to the cork to simplify rapid removal. Use a cork that fits tight enough to prevent the escape of air, as evidenced by the absence of oil on the cork when it is withdrawn.

If the selected test temperature is above room temperature, the test may be hastened by preheating the sample in its original plastic or glass container. This temperature is not to exceed 3.0°F (5.4°C) above the test temperature.

Stir the sample well, then strain it through the filter funnel equipped with a number 20 screen into a beaker. Put the sample from the beaker into the viscometer until the level is above the overflow rim.

Test the sample at either 77° or 122°F (25° or 50°C) depending on the grade of emulsion. Stir the sample in the viscometer with the appropriate thermometer equipped with the thermometer support. Use a circular motion at an approximate rate of 60 revolutions per minute. When the sample temperature remains constant within 0.1°F (0.05°C) of the test temperature, during one minute of continuous stirring, remove the thermometer. Immediately place the tip of the withdrawal tube in the gallery and apply suction to remove emulsified asphalt until its level is below the overflow rim. Do not touch the overflow rim with the withdrawal tube or the effective liquid head of the sample may become reduced.

Check to see that the receiving flask is properly positioned then snap the cork from the end of the viscometer, and at the same moment start the timing device. Stop the timing device at the instant the bottom of the oil meniscus reaches the graduation mark on the receiving flask. Record the time to the nearest 0.1 second. Multiply this time by the correction factor (F) for the viscometer to arrive at the sample viscosity and record on SFN 5787. Clean the equipment for the next test.

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Section 820

FLYASH

820.01 GENERAL.

Flyash is accepted by certification.

Section 826

JOINT MATERIALS

826.01 GENERAL.

Joint material, with the exception of hot applied joint sealant, is accepted by certification.

826.02 SAMPLING.

Submit one sample from each lot of hot applied joint sealant to the Materials and Research Division.

Section 834

STRUCTUAL STEEL AND RELATED MATERIALS

834.01 BOLTS, NUTS, AND WASHERS

Bolts, nuts, and washers are accepted according to Section 834.03 of the Standard Specifications. Testing of bolts, nuts, and washers is done under the shop inspection agreement administered by the Materials and Research Division.

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Section 836

REINFORCING STEEL

836.01 GENERAL.

All types of reinforcing steel are accepted on certification by the engineer/manager. Conduct visual inspection of the reinforcing steel before acceptance.

A. **Bars.** Deformed reinforcing bars are identified by a set of distinguishing marks legibly rolled into the surface of one side of the bar. The marks denote in the following order:

1. **Point of Origin.** Letter or symbol establishing the producing mill.

2. **Bar Size Number.** A number corresponding to the deformed bar size number. This number is based on eighths of an inch included in the nominal diameter of the bar.

3. **Type of Steel.** The letter "N" indicating production from new billet steel. This is not required for reinforcing wire or plain bars. Do not permit installation of reinforcing bars that have none or only a portion of these markings. Report this deficiency immediately to the project engineer/manager, who after appropriate investigation, will advise the contractor whether or not the affected bars may be installed.

   In addition to this, all reinforcing steel delivered to the project must be identified by heat numbers. These heat numbers must be stamped on weatherproof tags and the tags must be wired to the bars produced from the heat shown. Check the heat numbers shown on the tags with those shown on the certification. Do not install bars having a heat number not covered by a certification. A satisfactory certification must be supplied.

   The inspector should record in a field book the heat numbers shown on the metal tags together with the number of the bars, size, length, and whether straight, bent, or hooked. Record, in the same field book, corresponding information from the certification. Start this record keeping as soon as the certifications are received and the reinforcing bars are delivered to the project site.

   On occasion, the question arises as to whether or not reinforcing bars are usable because of their rusted condition. It has been found that a thin adherent film of rust or mill scale is not considered to be seriously objectionable. Remove objectionable coatings such as loose rust, loose

scale, oil, grease, dried mortar, mud, etc., by rubbing with burlap.

B. Wires. Welded steel wire fabric and welded deformed steel wire fabric must have a weatherproof tag bearing the name of the manufacturer, the specification number under which the wire fabric was produced, and the purchaser's order number attached to each bundle of flat sheets or each roll.

C. Post-Tensioning Steel. Each bundle of post-tensioning steel is to have a weatherproof tag securely fastened showing the size of the wire, appropriate AASHTO or ASTM number, heat number, and the name or mark of the manufacturer. Obtain a sample of this material for testing as instructed by the Materials and Research Engineer. High tension alloy bars must have tags attached showing applicable heat numbers.