CURRENT DATE OF REVISION
MT 100 SECTION
CONCRETE

METHODS OF SAMPLING AND TESTING
MT 100-17
CONTRACTOR SUBMITTED CONCRETE MIX DESIGN

1 Scope

1.1 This document describes required mix design procedures for independent concrete mix designs and establishes the information required for a mix design submittal.

1.2 This procedure applies to the Montana Department of Transportation (MDT) projects requiring an approved concrete mix design. It is to be used for preparation of a mix design by the contractor for submission to MDT's Materials Bureau for final approval.

1.3 It is the responsibility of the contractor to provide mix designs meeting the required specifications of Section 551, plans, supplemental requirements, and any special provisions included in the contract. The testing of the contractor's proposed mix design must be performed by a certified laboratory or performed by a certified technician with a Professional Engineer as the signature of record. A certified laboratory is any laboratory meeting the requirements of ASTM C1077. A certified technician will have current ACI Field, Laboratory and Strength Testing certifications or corresponding current WAQTC certifications. Perform concrete mix designs in conformance with Montana, AASHTO, ACI and ASTM procedures. Mix Designs submitted by Certified Precast or Prestressed concrete plants are exempt from this subsection. A Certified plant is any concrete plant listed on the MDT's Qualified Products List (QPL).

2 Referenced Documents

ASTM

C1077 Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

MT Materials Manual

MT 601 Materials Sampling, Testing, and Acceptance Guide Index

3 Procedure

3.1 A mix design must be submitted for each class of concrete to be used on an MDT project to the Project Manager. Mix designs, including all required information, must be submitted 15 working days prior to concrete placement. Mix designs are to be submitted as either a new mix design or a mix design transfer.

3.2 *Materials:* All materials proposed are subject to approval. Refer to MT 601 for sampling and testing requirements.

3.3 *New Mix Design (Trial Batches):* When submitting a new mix design, trial batches must be performed. Batches must be based on the same materials and proportions proposed for the project. Trial batches must be completed 15 working days before concrete placement. The Materials Bureau will review all documentation and accept or reject the mix design.

Create at least one trial batch for each concrete mix design. Simulate haul time and mixing conditions to ensure proper workability at the jobsite. It is also recommended that a larger, more representative trial batch be made in the same manner as intended for project placement. For each trial batch, test in accordance with Annex A.1. All mix designs must include aggregate properties testing information for each aggregate size in accordance with Annex A.2. For alternative mix designs, per contract specifications, test in accordance with Annex A.3. Include data sheets for cementitious materials and admixtures with the design submittal. The trial batch will be subject to rejection if any test results fail to meet specified ranges and a new trial batch will be requested. For each trial batch, cast a minimum of three sets of three test cylinders in 4” x 8” molds. Test and average one set at 3 days, one set at 7 days, and one set at 28 days. If earlier strength information is needed for de-tensioning prestressed applications, post tensioning, form removal, etc., submit strength data for the anticipated work. The average of the cylinders at 28 days must meet the minimum strength requirements of the contract. When permeability testing is required, perform testing of three cylinders cast from the trial batch in accordance with either AASHTO T 277 or AASHTO T 358. Cylinders used for AASTHO T 358 testing may be subsequently used for compressive strength determination. Based on the anticipated application of the mix design, cast and test as many specimens as needed to supply sufficient information.

3.4 *Mix Design Transfer:* Concrete mix designs used on MDT projects are valid for three years, provided they are transferred within 12 months of their previous use. Any request for transfer after three years will require new trial batches and resubmittal of the mix design. The contractor may request, in writing, the transfer of a concrete mix design to another project. There will be no substitutions of any materials or changes in mix proportions under this method. The Department may deny the transfer for any reason including, but not limited to, past performance, failing materials test results, raw material property changes, etc.

4 Acceptance

4.1 *Approval:* A representative of the MDT’s Materials Bureau will verify and sign off approval of the new or transferred concrete mix design provided required information, test results, and proper forms are submitted, and all required MDT specifications are met. When a signed copy of approval is issued to the contractor, concrete placement may begin. Any time before or after approval of the design, the Material’s Bureau may request additional materials for testing. Throughout the project, MDT may request additional tests be performed by the contractor to ensure proper placement and satisfactory test results.

4.2 *Rejection:* If a mix design produces failing results, a new mix design must be submitted for approval. The Materials Bureau may reject any design on the basis of any one failing test result.

4.3 In no case will the approval of a concrete mix design relieve the contractor of producing material meeting the contract requirements. Any changes or modifications to a mix design needed in the field must be approved by the Project Manager. A halt in production may be required for additional testing. Review and approval of the concrete mix design by a representative of the MDT’s Materials Bureau does not constitute acceptance of the concrete. Acceptance of concrete will be based solely on the test results of concrete placed on the project.

ANNEX

A.1 The following tests are required for all concrete mix design submittals:
- AASHTO R 39 Making and Curing Concrete Test Specimens in the Laboratory
- AASHTO R 60 Sampling Fresh Concrete
- AASHTO T 22 Compressive Strength of Cylindrical Concrete Specimens
- AASHTO T 119 Slump of Hydraulic Cement Concrete
- AASHTO T 121 Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- AASHTO T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
- AASHTO T 347 Slump Flow of Self-Consolidating Concrete (if applicable)
- AASHTO T 345 Passing Ability of Self-Consolidating Concrete by J-Ring (if applicable)
- AASHTO T 351 Visual Stability Index of Self-Consolidating Concrete (if applicable)
- ASTM C1064 Temperature of Freshly Mixed Hydraulic Cement Concrete
- MT 101 Making and Curing Concrete Test Specimens in the Field

A.2 The following tests are required for aggregates for all concrete mix design submittals:
- AASHTO T 2 Sampling of Aggregates
- AASHTO T 11 Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
- AASHTO T 21 Organic Impurities in Fine Aggregates for Concrete
- AASHTO T 27 Sieve Analysis of Fine and Coarse Aggregates (Including Fineness Modulus)
- AASHTO T 84 Specific Gravity and Absorption of Fine Aggregate
- AASHTO T 85 Specific Gravity and Absorption of Coarse Aggregate
- AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- AASHTO T 104 Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
- AASHTO T 112 Clay Lumps and Friable Particles in Aggregate
- AASHTO T113 Lightweight Pieces In Aggregate
- MT 121 Effect Of Organic Impurities In Fine Aggregate On Strength Of Mortar

A.3 The following tests are required for alternative mix designs for specific classes of concrete:

- AASHTO T 277 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
- ASHTO T 358 Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration
- ASTM C157 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
- ASTM C512 Standard Test Method for Creep of Concrete in Compression
- ASTM C469 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
- ASTM C457 Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

METHODS OF SAMPLING AND TESTING
MT 101-15
MAKING AND CURING CONCRETE COMPRESSIVE AND FLEXURAL STRENGTH TEST SPECIMENS IN THE FIELD
(*Modified AASHTO T 23*)

MT 101 is identical to AASHTO T 23 except for the following stipulations:

1. Include the following Montana Materials Manual references.

   MT Materials Manual
   MT 609 Field Numbering Concrete Cylinders

2. Replace the 1st sentence in Section 10.1.3.1 with the following:

   Cylinders – Upon receipt in the Materials Bureau, store specimens in a moist condition with free water maintained on their surfaces at all times at a temperature of 73 ± 3ºF (23 ± 2ºC) using water storage tanks or moist rooms complying with the requirements of AASHTO M 201, except when capping with sulfur mortar compound and immediately before testing.

3. Replace Section 11.1 with the following:

   Prior to transporting, cure and protect specimens as required in Section 10. Specimens shall not be transported until at least 8 h after final set. For transporting, efforts shall be made to protect the specimens from jarring, extreme changes in temperature, freezing, and moisture loss. Before transporting specimens from the field to the laboratory for testing, place specimens in sturdy boxes surrounded by a suitable cushioning material to prevent damage from jarring. During cold weather, protect the specimens from freezing with suitable insulation material. Prevent moisture loss during transportation by wrapping the specimens in plastic or wet burlap and by surrounding them with wet sand or sawdust or using tight-fitting plastic caps for plastic molds.

METHODS OF SAMPLING AND TESTING
MT 103-07
METHOD FOR MEASURING THE THICKNESS OF IN-PLACE CONCRETE BY USE OF CONCRETE THICKNESS GAUGE
(Montana Method)

1 Scope

1.1 This method covers the procedure for measuring the thickness of concrete pavements. Thickness is determined by using a concrete thickness gauge to measure the time required for an echo to bounce off the backside of the concrete member being tested. The thickness is a product of the velocity of sound in the material and one half the transit time (round trip) through the material.

2 Referenced Documents

AASHTO
T 148 Measuring Length of Drilled Concrete Cores

MT Materials Manual
MT 606 Selecting Sampling Locations by Random Sampling Technique

3 Apparatus

3.1 *Standard Surveying Equipment* – EDM, mirrors, level, rod, etc.

3.2 *Concrete Thickness Gauge*

3.3 *Core Drill* – for obtaining cylindrical core specimens

3.4 *Measuring Tape*

4 Vertical Control

4.1 When possible, it is recommended that at least one vertical control point be established for each day's placement of concrete, using survey methods prior to placement. After the concrete has hardened sufficiently, remeasure the same control point to determine the depth of the finished concrete. Use this point as a calibration point for the concrete thickness gauge. (Pre-established reference points and grade control points may also be used to determine concrete thickness).

5 Gauge Calibration Methods

5.1 <u>Gauge Calibration</u>

Place the concrete thickness gauge on the concrete, at the pre-established vertical control point, and calibrate according to the manufacturers instructions. The gauge will now establish the velocity for the particular concrete being tested.

5.2 <u>Direct Input Method</u>

Following the manufacturer's instructions, a direct input method may be used to calibrate the concrete thickness gauge. For the purpose of this method, a core will be taken to determine the actual thickness of the placed concrete. The concrete thickness gauge will then be calibrated using the core thickness.

6 Procedure

6.1 Calibrate the gauge according to one of the procedures described above. **The gauge must be calibrated on the concrete to be tested or the correct velocity entered into the gauge.** The calibration should be done on a smooth, clean surface to obtain the best data possible. (See Note 1) This data will be used for all subsequent tests and all tests must be completed on the same day as the gauge calibration.

6.2 Randomly select test locations (see Note 1) according to MT 606 Random Sampling Technique or as directed by the Engineering Project manager.

6.3 At the test location, take four measurements by rotating the gauge around a center point, collecting readings every 90 degrees. Average the results.

Note 1 – Make certain that the test head of the concrete thickness gauge is in good contact with the concrete surface. Testing should be done on a smooth clean surface to obtain the best data possible.

7 Calculation

7.1 Record gauge readings to the hundredth of a foot or (mm) on lab form

7.2 Record the average of the four (4) readings from each test location to a hundredth of a foot or (mm).

7.3 Determine and record the concrete thickness variation by subtracting the average of the four readings from the design thickness and record to the nearest hundredth of a foot (mm).

8 Report

8.1 Project Number
Project Name
Name of Tester
Title
Address
Date Measurements made
Test Location/Station
Test results

MT 103-07BLS

Montana Department of Transportation
Materials Division

REPORT ON DEPTH OF PCCP CONCRETE

Lab No. __________ Project No. ____________________

Project Name ____________________ Gauge No. ____________________

Tested by ____________________ Title __________ District ____________________

Submitted By ____________________ Date Tested ____________________

Sta. of section ____________________ Date Placed ____________________

Sta. Cal or Tested	**Depth measurement at four points**				**Average Depth**

Remarks:

Design thickness of PCCP __________ (in / mm)

Avg. variation from design __________ (in / mm)

Distr.
1-Materials Bureau
1-Constr Bureau
1-Pavement Analysis Sec.
1-EPM
1-Dist/Area Lab

METHODS OF SAMPLING AND TESTING
MT 108-04
SAMPLING AND CERTIFICATION OF PORTLAND CEMENT

1 Scope

1.1 This method covers the requirements for sampling and certification of Portland cement.

2 General

2.1 Cement samples shall weigh a minimum of 6.8 Kg (15 pounds). Such samples shall be placed in air-tight plastic bags which shall in turn be placed in canvas bags to protect against breakage during shipment. The bin or silo number and the grind number shall be shown on the Lab. Form No. 55 to accompany the sample.

3 Procedure

3.1 A sample of cement shall be submitted to the Materials Bureau, prior to construction, for all projects which involve bridge construction or projects which involve 114.3 cubic meters (125 cubic yards) of concrete. The sample may be taken from existing stock at the ready mix plant. On many projects this will be the only sample required unless the provisions of Section 4 make additional sampling necessary.

4 Sampling Frequency

4.1 *Project Sampling*

4.1.1 *Bridge Projects*

4.1.1.1 Minimum of one sample taken prior to the start of concrete production.

4.1.1.2 One sample for each additional 458.6 cubic meters (600 cubic yards) of concrete used.

4.1.1.3 This procedure shall be used regardless of the number of structures involved in the project.

4.1.2 *Paving Projects*

4.1.2.1 One sample taken prior to the start of concrete production.

4.1.2.2 Additional samples taken for each 4572.0 cubic meters (5,000 cubic yards) of concrete produced.

4.1.3 *Cement Treated Base Projects*

4.1.3.1 One sample taken at the start of the project.

4.1.4 *Miscellaneous Projects (cattle guards, sign bases, etc.)*

4.1.4.1 One sample taken prior to the start of concrete production on jobs involving 114.3 cubic meters (125 cubic yards) of concrete or more.

4.1.4.2 Samples need not be submitted for projects involving less than 114.3 cubic meters (125 cubic yards) of concrete.

4.2 *Random Sampling*

4.2.1 Each district shall, in addition to samples taken in accordance with Section 4.1 above, submit a random sample of each brand of cement used in that district during the year. These samples may be taken at any time during the year.

5 Cement Certification

5.1 The cement plants shall furnish the Materials Bureau with certified test results for each new grind or bin of cement produced for use within the state.

5.2 Each shipment of cement from the manufacturing plant to a highway project shall be accompanied by a certificate of compliance. This certificate shall state that the cement complies with all the requirements of AASHTO M 85 or ASTM C150, low alkali cement, and shall be signed by a responsible representative of the cement plant. Two copies of this certification shall accompany the shipment, one for the consignee and one for the Engineering Project Manager.

METHODS OF SAMPLING AND TESTING
MT 109-04
METHOD OF SAMPLING WATER

1 Scope

1.1 This method covers the sampling of water for determination of its suitability for use in concrete, for determination of corrosivity, and for chemical testing for potability. It does not include sampling for biological testing.

2 Referenced Documents

MT Materials Manual
MT 601 Materials Sampling, Testing, and Acceptance Guide Index

3 Application

3.1 This method is applicable to sampling industrial and domestic water supplies from sources such as wells, rivers, streams, lakes, ponds, reservoirs, pipelines and conduits for chemical or physical tests.

4 Point of Sampling

4.1 Where the water in a stream is mixed so as to approach uniformity, a sample taken at any point in the cross section is satisfactory.

4.2 For bodies of water such as ponds or reservoirs, avoid surface and/or bottom sampling and attempt to obtain an integrated sample containing water from all points in a vertical section. Depending upon the nature of the source being sampled, it may be desirable to sample at several points and to combine the samples to obtain a representative sample of the source.

4.3 In sampling from pipelines, conduits, pump discharge, etc., make certain that all conduits have been flushed. In the case of water wells, initial pumping for well cleaning purposes shall have been completed so the sample represents the sustained output of the source.

5 Frequency of Sampling

5.1 A sample of the water proposed for use shall be submitted in accordance with the frequency specified in MT 601.

6 Volume of Sample and Type of Container

6.1 Furnish a one liter (quart) sample in a clean glass or plastic bottle or jar with a screw cap lid with liner. Fill almost to the top, but allow a small space to allow for possible expansion due to temperature change.

7 Labeling

7.1 Label with identifying source data and state the purpose for which the sample is taken.

METHODS OF SAMPLING AND TESTING
MT 110-12
METHOD OF ACCEPTANCE FOR
REINFORCED CONCRETE PIPE AND OTHER PRECAST ITEMS
(*Montana Test Method)*

1 Scope

1.1 This procedure defines inspection responsibilities and verification processes applicable to all suppliers of pre-cast concrete pipe and associated items.

2 Referenced Documents

AASHTO
M 55 Steel, Welded Wire Reinforcement, Plain, for Concrete
M 85 Portland Cement
M 170 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
M 206 Reinforced Arch Concrete Culvert, Storm Drain, and Sewer Pipe
M 207 Reinforced Elliptical Concrete Culvert, Storm Drain, and Sewer Pipe
M 259 Precast Reinforced Concrete Box Sections for Culvert, Storm Drains, and Sewers
T 24 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
T 119 Slump of Hydraulic Cement Concrete
T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
T 347 Slump Flow of Self-Consolidating Concrete

ASTM
C361 Standard Specification for Reinforced Concrete Low-Head Pressure Pipe

MT Materials Manual
MT 101 Making and Curing Compressive and Flexural Strength Test Specimens in the Field
MT 108 Sampling and Certification of Portland Cement
MT 117 Making and Curing Concrete Compressive and Flexural Strength Specimens in the Field for Self-Consolidating Concrete (SCC)
MT 118 Method of Determining Air Content of Freshly Mixed Self Consolidating Concrete by the Pressure Method

MDT Construction Bureau
Manual for Culvert and Pipe Installation and Inspection

3 Definitions

ACPA – American Concrete Pipe Association
NPCA – National Precast Concrete Association

4 Inspection Process for ACPA and NPCA Certified Plants

4.1 Each participating manufacturer must maintain sufficient procedures and documentation to assure that their products are manufactured and tested in accordance with the guidelines of ACPA and/or NPCA certification programs. An MDT Inspector will conduct a thorough inspection of each Certified Plant to verify compliance with these requirements. Plants meeting these requirements will be listed on the Qualified Products List.

4.1.1 Yearly

Inspection Checklist

- Verify ACPA and/or NPCA certification.

- Verify that certified manufacturing plants have a Quality Control Manual, applicable AASHTO, ASTM standards, organizational chart, and personnel training and qualification records.

- Verify that production and testing equipment has been properly calibrated according to the calibration requirements as stated in the Quality Control manual.

- Verify mix designs are approved.

- Verify that the manufacturers detailed design information meets MDT requirements.

- Verify that documents are maintained for all suppliers of materials for the months the plant is producing.

    - Admixture Certifications
    - Gasket and Joint Sealant Material Certifications and Test Reports
        - Verify 12" to 33" have been sampled/tested at 1/300 frequency
        - Verify 36" and larger have been sampled/tested at 1/100 frequency

- Verify that test reports are maintained per ACPA and/or NCPA testing frequencies for the following:
    - Absorption Test Results
    - Three Edge Bearing Test

- Conduct Monthly or Frequency Based Inspection outlined in Sec. 4.2

- Sample concrete cylinders and reinforcing steel for Department testing.

- Verify that any deficiencies recorded from the previous inspection have been addressed.

4.2 Monthly or Frequency Based

Approximately once a month, unless another frequency is defined, inspect the fabricating plant's certification reports, test results, and other records from the previous inspection date to present. Ensure that the plant is 'Buy America' compliant for all steel products. Witness concrete cylinder testing is being performed correctly on certified equipment and meets MDT requirements.

Inspection Checklist

- Verify that any deficiencies recorded from the previous inspection have been addressed.

- Verify the following documentation has been maintained:

    - Buy America Certification
    - Cement Mill Reports
    - Sieve Analysis of Fine and Coarse Aggregates (once every 3 months)
    - Fly Ash Certifications
    - Other Cementitious Material Certifications and Test Reports
    - Cylinder Break Strength Results and Frequencies

- Verify fabricated cages and reinforcement conforms to MDT specifications.

- Verify a dimensional test report on one pipe size to ensure that they match the dimensions shown on the detailed drawings or AASHTO Standard Specifications.

- Observe or perform the following concrete tests:
    - Slump
    - Air Content
    - Temperature of the mix
    - Making of cylinders
    - Cylinder compression testing
    - Slump Flow (when applicable)
    - J Ring (when applicable)
    - Three Edge Bearing Test including Destructive Testing outlined in Section 4.3 (once every 3 months)

4.3 Observe destructive testing in the form of crushing precast pipe and other precast items in conjunction with the three edge bearing tests. Inspector will randomly select precast pipe sample to be tested. Verify the size, amount, and origin of the reinforcing steel. Coring and random inspections will be performed on Concrete Box culverts and miscellaneous precast items such as cutoff walls, cattle guard bases, FETS, and sound walls as directed by MDT.

5 Inspection Process for Non-Certified Plants

5.1 Inspect non-certified plants to confirm the products meet MDT specifications. Sample components i.e. concrete, reinforcing steel and other items. Check fabrication drawings and inspect the final product for quality. The plant's quality control program must be sufficient that MDT can confirm quality of materials and processes used. MDT level of inspection will vary according to Department needs.

- Verify personnel training and qualification records.

- Verify production and testing equipment has been properly calibrated.

- Verify mix designs are approved.

- Verify that the manufacturers detailed design information meets MDT requirements.

- Verify fabricated cages and reinforcement conforms to MDT specifications.

- Verify a dimensional test report on product to ensure that they match the dimensions shown on the detailed drawings or AASHTO Standard Specifications.

- Verify rate and frequency of testing is adequate and Quality Control records are maintained.

- Verify the following documentation has been maintained and required samples have been acquired:

    - Buy America Certifications and reinforcing steel samples
    - Cement Mill Reports
    - Aggregate samples for Sieve Analysis of Fine and Coarse Aggregates
    - Fly Ash Certifications
    - Other Cementitious Material Certifications and Test Reports
    - Cylinder Break Strength Results and Frequencies
    - Admixture Certifications
    - Gasket and Joint Sealant Material Certifications and Test Reports

- Observe or perform the following concrete tests:

    - Slump
    - Air Content
    - Temperature of the mix
    - Making of cylinders
    - Cylinder compression testing
    - Slump Flow (when applicable)
    - J Ring (when applicable)
    - Concrete Absorption
    - Three Edge Bearing Test or verification of test results

- Verify concrete cylinders are made and tested periodically to represent the concrete placed in all items.
- Concrete items other than concrete pipe will be entered on Form 19A. These items, together with pipe too large to test, are represented by cylinder tests as outlined above.

6 Mark of Inspection

6.1 Products manufactured at a certified plant will not carry the mark of inspection. Non-certified manufacturers of concrete pipe and other concrete items must notify MDT when producing products for a project so that inspection arrangements can be made. All concrete products produced by a non-certified plant must carry a mark of inspection. (see Figure 1). This will be stamped on each section of product, by the inspector, where it will be clearly visible. The circle M indicates the product was inspected. Final acceptance will be made in the field.

6.2 If a product is to be rejected in the field, place an X next to the product identification stamp. This mark indicates that the product is rejected for all MDT projects. If the product requires repairs, but is not necessarily rejected; mark areas requiring repair to clearly designate and track what needs correction prior to acceptance.

Figure 1
CIRCLE M STAMP

METHODS OF SAMPLING AND TESTING
MT 111-12
SAMPLING, INSPECTION AND REPORTING
ON PRESTRESSED STRUCTURAL MEMBERS

1 Scope

1.1 This method is written to the individuals completing inspection and establishes a uniform procedure for the sampling, inspecting, and reporting of pre-stressed structural members.

1.2 Inspection Process Overview

1.2.1 Provide data to the field as it becomes available. Send original test results and reports to MDT Helena Materials Lab (to be placed in the job file), keep one copy in the Inspectors personal file, and send one copy to the Project Manager for the project file.

1.2.2 Send an inspection report with each beam to the project. Provide copies to the EPM, District Materials Lab, the Construction Bureau, and the Materials Bureau. This report must state that all of the materials used in the completed beams have been sampled, tested, and documented within reports that are in the possession of the Plant Inspector. Identify the beams by number and place in the report file as an indication that the beams are complete and acceptable subject to final field inspection.

1.2.3 The following links provide access to the Department's most current forms to be used during Prestress Inspection:

Strand Tensioning & Cylinder Breaks
Form 45 – Rebar or Strand Sample
Form 48 – Shipping & Final Approval
Form 48A – Final Plant Inspection
Ready Mix Pour Record
Fabrication Inspection Report
Miscellaneous Inspection Report

2 Referenced Documents

AASHTO Methods
T 24 Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
T 119 Slump of Hydraulic Cement Concrete
T 152 Air Content of Freshly Mixed Concrete by the Pressure Method
T 347 Slump Flow of Self-Consolidating Concrete

MT Materials Manual
MT 101 Making and Curing Compressive and Flexural Strength Test Specimens
MT 108 Sampling and Certification of Portland Cement
MT 117 Making and Curing Concrete Compressive and Flexural Strength Specimens in the Field for Self Consolidating Concrete (SCC)
MT 118 Method of Determining Air Content of Freshly Mixed Self Consolidating Concrete by the Pressure Method
MT 201 Sampling Roadway Materials

3 Materials

3.1 Materials used in the manufacture of pre-stressed beams are covered individually to avoid any misunderstanding on the part of the Plant Inspectors.

3.2 Sample and test aggregates will be sampled and tested quarterly in accordance with MT 201. If new sources or deviations in material properties are apparent, resample aggregates as necessary for quality assurance.

3.3 Cementitious materials and admixtures are listed on the Department's Qualified Products. Verify that the mix design has been approved by the Helena Materials Bureau and appropriate material types and quantities are used.

3.4 Wire strand is tested in the Materials Bureau. Submit samples with a Form 45, a copy of the mill test results of the load elongation curve, and associated documentation to meet Buy America requirements. The pre-stress plant is responsible for notifying the Plant Inspector when shipments of strand are received at the pre-stress plant. Sample strand by obtaining two 5 foot (1.5 m) long sections from a reel in the shipment. Submit these samples together with reel numbers, heat numbers, and all available information such as size, strength, etc., to the Materials Bureau for testing. Strand or any other item or ingredient used in the manufacture of a structural member prior to test results being received by the Plant Inspector are at the plant's risk. Reject members constructed with strand that does not meet Department requirements.

3.5 Sample reinforcing steel as each new shipment arrives at the plant. The pre-stress plant is responsible for notifying the Plant Inspector when shipments of rebar are received at the pre-stress plant. Submit two 3 foot (1.0 m) long samples of each bar size to the Materials Bureau with a Form 45 and associated documentation required to meet Buy America requirements. Verify that all of the pertinent information is shown on the accompanying reports.

3.6 Witness the casting of cylinders representing release breaks by the pre-stress plant personnel. Witness or cast the cylinders for acceptance of twenty-eight day strength testing in accordance with MT 101. Ensure that a set of at least 3 cylinders are fabricated for each pour in addition to release cylinders of a sufficient number to perform the required tests prior to release of the strand per Specification Subsection 553.03.11 Transfer of Pre-stress (minimum of 3 cylinders).

4 Plant Inspection and Acceptance

4.1 Review all documentation to verify conformity with contract requirements. For typical documentation requirements, see Specification Subsections 553.02 and 553.03.

4.2 Verify that the bed layout measurements have been checked by plant personnel and are in agreement with the approved shop drawings.

4.3 Verify strand patterns are in agreement with the approved shop drawings prior to tensioning. Check strands for strength and elongation (temperature correction) as provided on the approved shop drawings. Document and notify pre-stress plant personnel of any materials used in the beam that have not been sampled and tested in accordance with Section 3.1.3.

4.4 Verify that the rebar cage layout has been checked by pre-stress plant personnel and is in accordance with contract requirements. Document and notify pre-stress plant personnel of any materials used in beam that have not been sampled and tested in accordance with Section 3.1.4.

4.5 Verify that a final pre-pour inspection occurs prior to forms being set. Obtain a copy of the plant's pre-pour inspection form which must include details on the placement of inserts, bulkheads, bearing plate locations, and all other applicable details.

4.6 Visually check forms for proper placement. Verify that remaining steel and lift hooks have been included in accordance with approved shop drawings prior to concrete placement.

4.7 Witness concrete tests and cylinder breaks to verify requirements of Section 3.1.5 and Specification Sections 553.03.10 and 553.03.11 are met. After forms are removed, visually inspect before allowing the strand release (cutting of strands). If repairs are necessary, do not allow strand release until repairs are completed and are cured for a minimum of 24 hours.

4.7.1 Record pour placement times and field verification information using the "Ready Mix Pour Record" when pre-stress items are constructed using ready mix concrete.

4.8 Perform Final Inspection to ensure the finished member meets plan dimensions. Document the Final Inspection on Form 48-A.

4.8.1 Mark each pre-stress member that conforms to specification requirements in all respects with a Circle M stamp (see Fig.1) before shipment from the plant. This identifying mark indicates that fabrication procedures, quality of materials and workmanship are satisfactory and the member is complete at the plant.

4.8.2 If deficiencies are identified, notify the Physical Testing Engineer, Bridge Bureau and Project Manager of the concerns and determine the corrective actions that are required. Do not mark these members with a Circle M stamp unless corrective actions have been completed and no additional concerns exist. Absence of a Circle M stamp indicates that the member is not complete or deficiencies have been observed by the Plant Inspector and additional corrective actions may be required. Note any deficiencies on the Pre-stress Beam - Final Plant Inspection Check List (Form 48-A). Noted deficiencies not corrected before shipment will be transmitted to the field with the Pre-stressed Beam Report Lab Form 48.

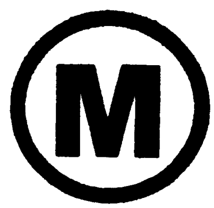


Figure 1
CIRCLE M STAMP

5 Field Inspection and Acceptance

5.1 When the product arrives at the job site, inspect members for shipping and handling damage or other defects. Notify the Project Manager of any damage or defects observed in the field.

5.2 Final acceptance of the member is made in the field in accordance with the contract. Ensure any deficiencies identified on the Pre-stressed Beam Report (Form 48) are addressed before final acceptance. Project Manager may reject any product that does not serve the necessary function or fails to meet contract requirements.

METHODS OF SAMPLING AND TESTING
MT 114-10
METHOD OF SAMPLING FOR CHLORIDE CONTENT OF BRIDGE DECK CONCRETE

1 Scope

1.1 This is a method of sampling bridge deck concrete for chloride content.

1.2 See MDT Safety Policies and Procedures Manual.

2 Apparatus

2.1 *Coring Machine*

2.2 *Pachometer* - A pachometer is available upon request from the Materials Bureau

2.3 *Gas powered (110-115 Volt A.C.) Generator* with transport cart for operating drill

2.4 *Rotary Impact Drill* of heavy duty construction

2.5 *Bit* - 3/4 inch (19mm) diameter carbide steel bit

2.6 *Vacuum cleaner*

2.7 *Pliable sampling spoon* - Copper or flexible spoon 3 inches (7.5mm) in length and less than 3/4 inch (19mm) in width

2.8 *Plastic bottles* - Approximately 2 inches (50mm) tall and 1 inch diameter with sealable caps

2.9 *Ruler* with 0.10" increments and millimeters

2.10 *Paper labels*

2.11 *Fast Setting Grout* - "Set 45", "Rockite" or other fast setting grout

2.11 *Personal Protective Equipment* - Plastic goggles, hearing protection, gloves

2.12 *Plastic bottle* containing one of the following: distilled water, deionized water, ethanol (denatured) or methanol (technical grade)

3 Sampling

3.1 Chloride samples shall be taken before coring and in an area as close as possible and with the same types of distress (i.e. delaminations or cracking) as that intended for coring.

3.2 When coring or sampling for chlorides extreme caution will be required due to traffic hazards and use of power equipment. For standard safety practices refer to the MDT Safety Policies and Procedures Manual.

4 Procedure

4.1 The Bridge Plans are used to find approximate rebar location, cover over rebar, and thickness of concrete.

4.2 The pachometer is used to locate top layer of reinforcing steel and its depth.

4.3 Drill a hole 1/4 inch (6mm) deep and discard this portion of the sample by using the Vacuum cleaner. (See Note 1)

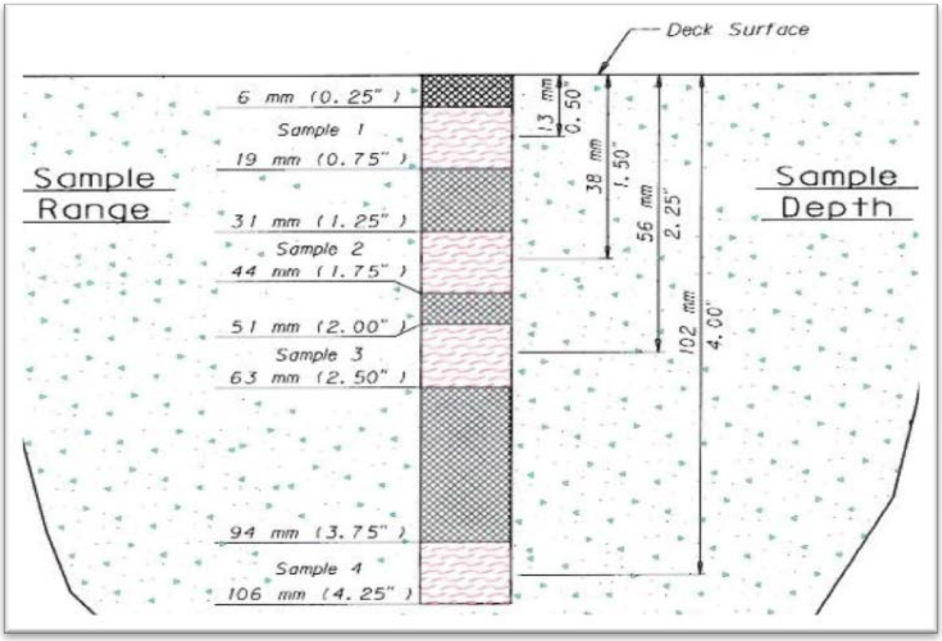
4.4 Drill the hole to a depth corresponding to the top of the rebar (see Note 1 and 2) and use copper or plastic spoon to collect minimum 10 g sample in plastic bottle labeled "A".

4.5 Clean the hole out with the Vacuum cleaner.

4.6 Drill hole to a depth of one inch below the top layer of reinforcing steel. Secure minimum 10 g sample of pulverized concrete with copper or plastic spoon and place into plastic bottle labeled as "B". (See Note 1 and 2)

4.7 Clean holes and fill with high strength epoxy grout patching compound such as "Set 45" or "Rockite".

Note 1 - The sketch as shown below defines the drilling depth for sampling:



Cross Section Through Slab

Note 2 - During sample collection and pulverizing, personnel shall use caution to prevent contact of the sample with hands or other sources of body perspiration or contamination. Further, all sampling tools (drill bits, spoons, bottles, sieves, etc.) shall be washed with alcohol or distilled water and shall be dry prior to use on each separate sample. Alcohol is normally preferred for washing because of the rapid drying which naturally occurs.

5 Labeling

5.1 The following data will be written on each label and attached to each sample bottle:

- Project number and termini
- E.B. or W.B. lane
- Position in lane measured from curb
- Depth range of sample measured from top of deck and labeled as "A" or "B"; (See Note 1)
- Depth of reinforcing steel
- Core number cross reference
- Brief description of condition of area (i.e., delaminations, cracks).

6 Submittal

6.1 Cores with chloride samples will be submitted to the Materials Bureau.

METHODS OF SAMPLING AND TESTING
MT 117-17
MAKING AND CURING CONCRETE COMPRESSIVE AND FLEXURAL STRENGTH TEST SPECIMENS IN THE FIELD FOR SELF-CONSOLIDATING CONCRETE (SCC)
(*Modified AASHTO T23*)

MT 117 is identical to AASHTO T 23 except for the following stipulations:

1. Include the following Montana Materials Manual references.

   MT Materials Manual
   MT 609 Field Numbering Concrete Cylinders

2. In general, tamping via rodding or vibration is eliminated from the method for the testing of self-consolidating concrete. Specifically:

   A. Replace Section 1.1 with the following:

      "This method covers procedures for making and curing cylindrical and beam specimens from representative samples of fresh self-consolidating concrete (SCC) for a construction project."

   B. Eliminate Sections 5.4 and 5.5

   C. Replace Section 5.9 with the following:

      "Slump Flow Apparatus--The apparatus for measurement of slump flow shall conform to the requirements of AASHTO T 347".

   D. Eliminate Section 9.4

3. Replace Section 11.1 with the following:

   Prior to transporting, cure and protect specimens as required in Section 10. Specimens shall not be transported until at least 8 h after final set. For transporting, efforts shall be made to protect the specimens from jarring, extreme changes in temperature, freezing, and moisture loss. Before transporting specimens from the field to the laboratory for testing, place specimens in sturdy boxes surrounded by a suitable cushioning material to prevent damage from jarring. During cold weather, protect the specimens from freezing with suitable insulation material. Prevent moisture loss during transportation by wrapping the specimens in plastic or wet burlap and by surrounding them with wet sand or sawdust or using tight-fitting plastic caps for plastic molds.

METHODS OF SAMPLING AND TESTING
MT 119-04
MOISTURE CORRECTION FOR CONCRETE MIX DESIGNS
(*Montana Method*)

1 Scope

1.1 This method describes the procedure for making a correction in the moisture requirement of a concrete mix, due to absorbed moisture. Concrete mix designs furnished by the Materials Bureau are based on saturated surface dry aggregate and the moisture correction must be made when concrete is produced. Moisture may be figured on a one sack basis or on a one cubic meter (one cubic yard) basis. A typical Class "A" mix for one sack of cement would be shown as: 94 - 213 - 190 - 190.

2 Moisture Requirement

2.1 The example mix makes no mention of water as it is controlled by slump requirements, but for the purpose of mix designs it is assumed to be 22.7 liters (6 gallons) per sack of cement. 22.7 liters (6 gallons) is not a specified amount to be used, and in fact, a lesser amount will most generally obtain the required slump. 22.7 liters (6 gallons) per sack is the maximum net amount of water which may be used under Montana Specifications, and includes free water in excess of water absorbed by the aggregates, additives, air entraining agents, etc.

2.2 It is impossible for the Materials Bureau to know in advance what the moisture condition of the aggregate stockpiles will be when concrete is ultimately produced, so the following procedure is to be observed.

3 Absorption of Fine Aggregate

3.1 Fine aggregate will always require an adjustment for the moisture content. Moisture content will seldom be less than 3% or more than 7%. The moisture correction is made by multiplying the aggregate weight shown by 100 plus the percentage of moisture in the material. If a moisture determination shows that the sand has 5% total moisture, multiply the sand weight shown by 105%. This would make the new sand weight about 102 Kg (224 pounds), which would total about 5 Kg (11 pounds) of water (free and absorbed) or approximately 5.0 liters (1-1/3 gallons) per sack.

3.2 If the fine aggregate has an absorption of 1.0%, the amount of water that can be counted as free water (mix water) would be computed as follows:

3.2.1 5.0% (total moisture) minus 1.0% (absorption) equals 4.0% free water.

3.2.2 96.6 Kg (213 lbs.) x .04 (4% free water) equals approximately 3.9 Kg (8.5 lbs.) free water.

3.2.3 Therefore, only 3.9 Kg (8.5 lbs.) of water would be counted as mix water.

4 Absorption of Coarse Aggregate

4.1 Medium and coarse aggregate are open-graded and free draining and will not usually require a correction for moisture unless they are being used directly from a washing plant or are being heated with live steam.

4.2 If a correction is deemed necessary, the procedure shown for fine aggregate will be followed.

5 Corrected Mix

5.1 The corrected mix would be: 94 - 224 - 190 - 190.

METHOD OF SAMPLING AND TESTING
MT 121-16
EFFECT OF ORGANIC IMPURITIES IN FINE AGGREGATE ON STRENGTH OF MORTAR
(*Modified* AASHTO T 71)

MT 121 is identical to AASHTO T 71 except for the following stipulations:

1. Section 5.5.2 – Remove

2. Section 5.5.4 – Replace with the following:

   “*Rinsing the Aggregate* – Continuously rinse the aggregate in a compact aggregate drum washer for two hours. Set the flow rate and angle of the wash water such that there are no losses of fine materials during the washing cycle.”

3. Section 5.5.5 – Remove

4. Section 6.3 – Remove

5. Sections 7.5 and 7.6 – Remove

METHODS OF SAMPLING AND TESTING
MT 122-17
OPTIMIZED AGGREGATE GRADATION FOR HYDRAULIC CEMENT CONCRETE MIX DESIGNS

1 Scope

1.1 This method outlines the procedure for analyzing combined aggregate gradations for optimized concrete mix designs.

2 Referenced Documents

MT Materials Manual

MT 201 Sampling Roadway Materials
MT 202 Sieve Analysis for Fine and Coarse Aggregate

3 Apparatus

3.1 The apparatus required for sampling aggregates and performing sieve analysis will be as stated in MT 201 and MT 202.

4 Procedure:

4.1 Submit sieve analysis reports showing the cumulative combined percent passing, the cumulative combined percent retained, and the combined percent retained as shown in the sieve analysis Table 1. Include in the report, each individual aggregate gradation starting with the largest appropriate sieve for that material and including all the consecutive smaller sieve sizes through the #200 (75-µm) sieve. They are to include: 1 1/2-in. (37.5-mm), 1-in. (25-mm.), 3/4-in. (19-mm), 1/2-in. (12.5-mm), 3/8-in. (9.5-mm), #4 (4.75-mm), #8 (2.3-mm), #16 (1.18-mm), #30 (60-µm), #50 (300-µm), #100 (150-µm), and #200 (75-µm) sieves. For coarse and intermediate aggregates, the #16 (1.18-mm) through #100 (150-µm) sieves may be determined mathematically.

4.2 Submit the following charts used to perform aggregate gradation analysis:

- Coarseness Factor Chart (Figure 1)
- 0.45 Power Chart (Figure 2)
- Percent Retained Chart (Figure 3)

4.3 Perform a sieve analysis according to MT 202 for each aggregate that will be used in the optimized mix design. Complete a sieve analysis with the percent passing and the relative percent volume of each aggregate used in the proposed mix design as shown in Table 1.

Table 1: Sieve Analysis

% Passing Agg (P)	Coarse Aggregate			Mid	Fine Aggregate		Combined Aggregate		Each Sieve
	1	2	3	1	1	2			
Sieve	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	**% Passing (C_P)**	**% Retained (C_R)**	**% Retained (C)**
2 in.	100.0%	0.0%	0.0%	100.0%	100.0%	0.0%	100.0%	0.0%	0.0%
1 1/2 in.	100.0%	0.0%	0.0%	100.0%	100.0%	0.0%	100.0%	0.0%	0.0%
1 in.	100.0%	0.0%	0.0%	100.0%	100.0%	0.0%	100.0%	0.0%	0.0%
3/4 in.	96.0%	0.0%	0.0%	100.0%	100.0%	0.0%	97.8%	2.2%	2.2%
1/2 in.	63.0%	0.0%	0.0%	100.0%	100.0%	0.0%	79.7%	20.4%	**18.2%**
3/8 in.	28.0%	0.0%	0.0%	95.0%	100.0%	0.0%	60.0%	**40.1%**	19.7%
No. 4	9.0%	0.0%	0.0%	65.0%	100.0%	0.0%	46.8%	53.2%	13.2%
No. 8	2.0%	0.0%	0.0%	3.0%	96.0%	0.0%	**35.9%**	**64.1%**	10.9%
No. 16	1.0%	0.0%	0.0%	1.0%	76.0%	0.0%	28.0%	72.0%	7.9%
No. 30	0.0%	0.0%	0.0%	0.0%	45.0%	0.0%	16.2%	83.8%	11.8%
No. 50	0.0%	0.0%	0.0%	0.0%	17.0%	0.0%	6.1%	93.9%	10.1%
No. 100	0.0%	0.0%	0.0%	0.0%	6.0%	0.0%	2.2%	97.8%	4.0%
No. 200	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.4%	99.6%	1.8%
Pan	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.4%
Blend % (R)	**55.0%**	**0.0%**	**0.0%**	**9.0%**	**36.0%**	**0.0%**	100.0%		

5 Calculations

5.1 Calculate the cumulative combined percent passing each sieve using the following equation:

$$C_P = \sum\{(P_A)(R_A)\}$$

where:

C_P = Cumulative Combined % Passing
P_A = % Passing of Aggregate
R_A = Relative % of Aggregate

5.2 Calculate the cumulative combined percent retained on each sieve using the following equation:

$$C_R = 100\% - C_P$$

where:

C_R = Cumulative Combined % Retained
C_P = Cumulative Combined % Passing

5.3 Calculate the combined percent retained on each sieve using the following equation:

$$C = C_R - C_{RX}$$

where:

C = Combined % Retained
C_R = Cumulative Combined % Retained
C_{Rx} = Cumulative Combined % Retained of next larger sieve size

6 Charts

6.1 *Coarseness Factor Chart*—Use the cumulative combined sieve analysis to determine the coarseness and workability factors. Plot the coarseness and workability factors on the Coarseness Factor Chart (Figure 1).

Determine the coarseness factor using the following equation:

$$\mathrm{CF} = \left(\frac{\mathrm{S}}{\mathrm{T}}\right) \mathrm{x}\ 100$$

where:

CF = Coarseness Factor
S = Cumulative % Retained on the 3/8 in. Sieve
T = Cumulative % Retained on the No. 8 Sieve

The workability factor is the cumulative combined percent passing the No. 8 sieve. Increase the workability factor by 2.5 percentage points for every 94 lb. per cubic yard of cementitious material used in excess of 564 lb. per cubic yard in the mix design. Decrease the workability factor by 2.5 percentage points for every 94 lb. per cubic yard of cementitious material used below 564 lb. per cubic yard in the mix design. Do not adjust the workability factor if the amount of cementitious material is 564 lb. per cubic yard.

For Class Pave concrete, the coarseness factor and workability factor must plot within the workability box defined as follows:

- coarseness factor must not be greater than 68 or less than 52
- workability factor must not be greater than 38 or less than 34 when the coarse factor is 52
- workability factor must not be greater than 36 or less than 32 when the coarseness factor is 68.

For other classes of concrete the Workability Factor must plot within Zone II.

Aggregate blends that plot in Zone III may be considered for approval of a mix design if a ¾-inch nominal maximum or smaller size aggregate is utilized.

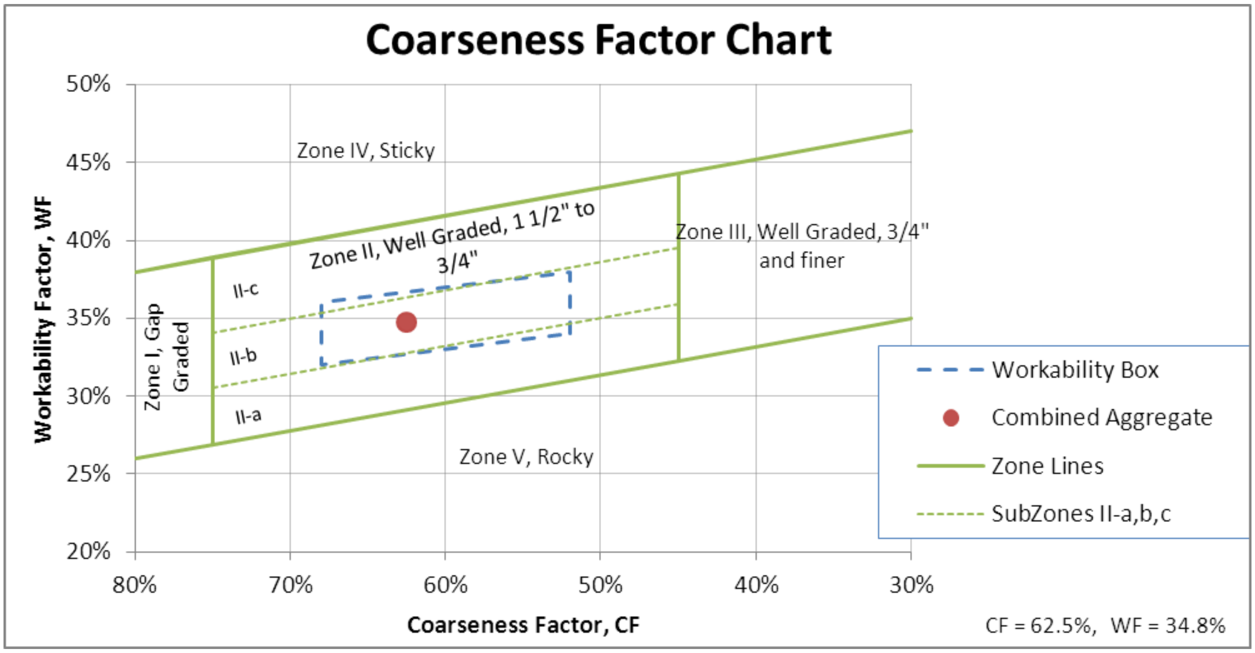


Figure 1: Coarseness Factor Chart

6.2 *0.45 Power Chart*—The 0.45 Power Chart (Figure 2) is created by plotting the cumulative percent passing (y-axis) vs. the sieve sizes raised to the power of 0.45 (x-axis). The cumulative percent passing should generally follow the maximum density line and should not deviate beyond the maximum and minimum tolerance lines. There may be a “hump,” beyond the tolerance line and above the maximum density line around the No. 16 sieve. There will always be a dip below the maximum density line around the No. 30 sieve. These deviations are typical and should not be cause for rejection of a gradation unless results from trial batches indicate workability problems.

The maximum density line is a straight line calculated with the following equation:

$$P = \left(\frac{d}{D}\right)^{0.45}$$

where:

P = % Passing
d = sieve size being considered
D = nominal maximum sieve size

The nominal maximum sieve size is one sieve larger than the first sieve to retain ≥10%.

The tolerance lines are straight lines drawn on either side of the maximum density line. Draw the tolerance lines from the origin of the chart to 100% of the next sieve size smaller and larger than the maximum density sieve size.

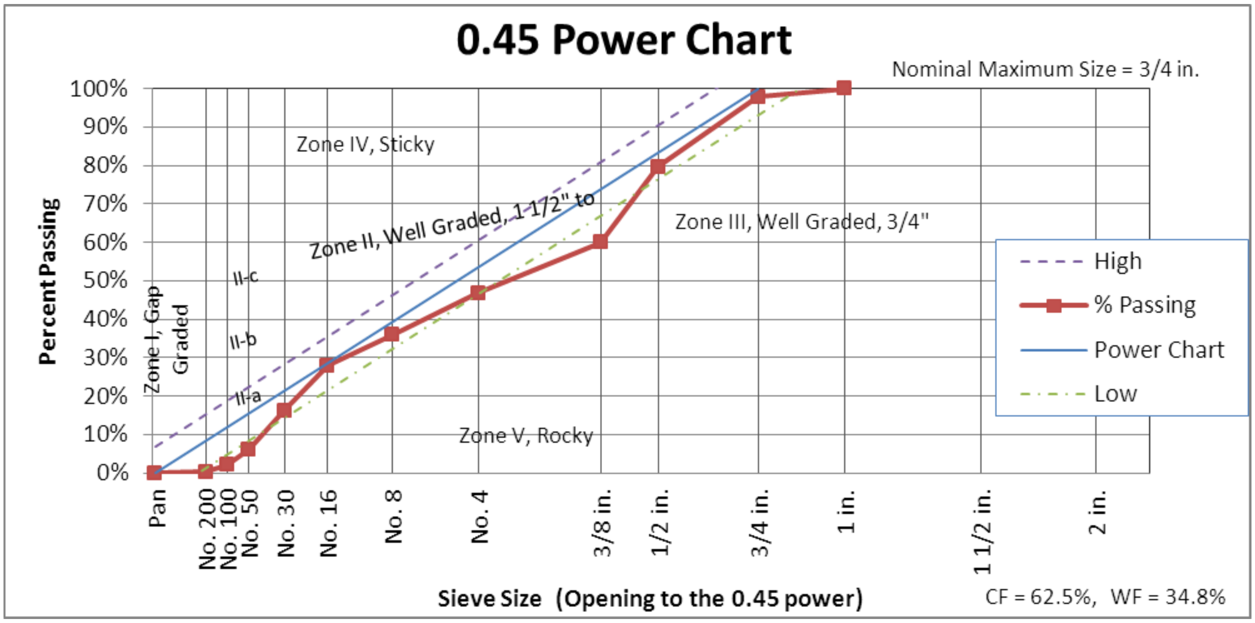


Figure 2: 0.45 Power Chart

6.3 *Percent Retained Chart*—Create the Percent Retained Chart (Figure 3) by plotting the combined percent-retained (y-axis) vs. the sieve sizes (x-axis). The sum of the percent retained on any two adjacent sieves, excluding the first and last sieve that retains material, must not be less than 13%.

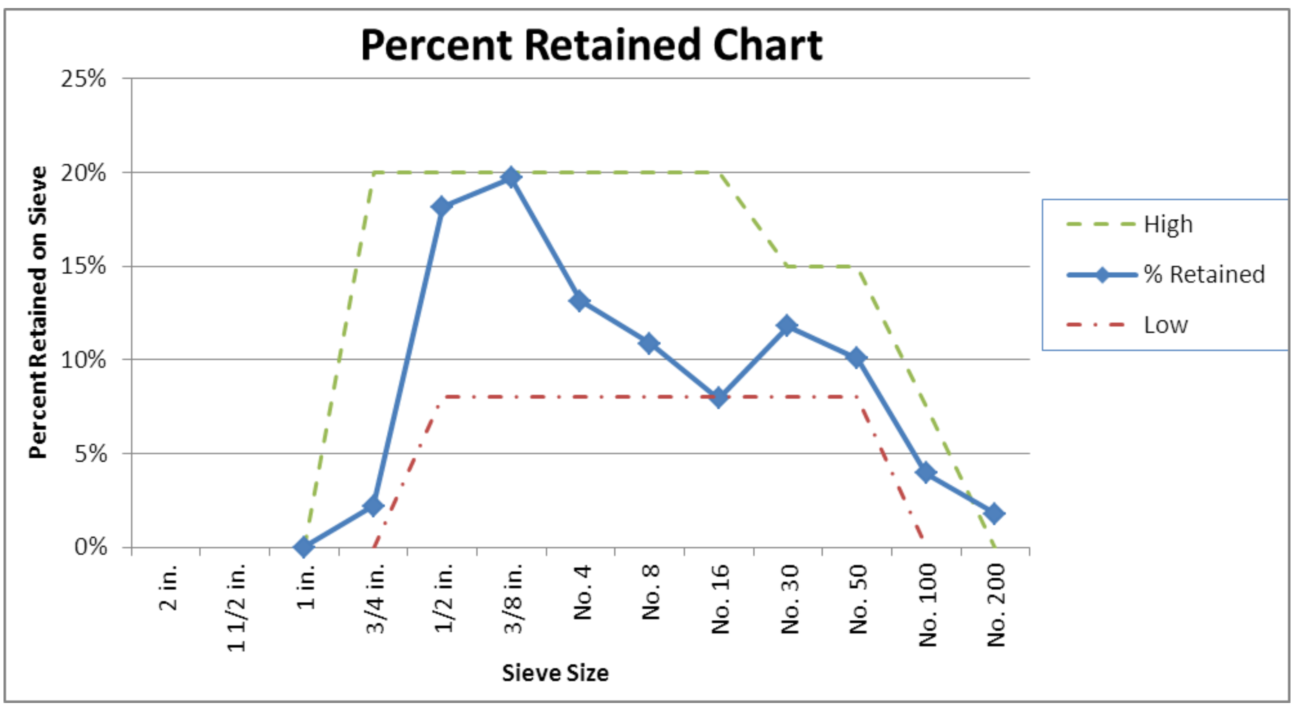


Figure 3: Percent Retained Chart

6.4 *MDT Optimized Gradation Worksheet* — May be used to perform the aggregate gradation analysis. It allows the user to input sieve analysis results and aggregate percentages, generating all of the previous charts.

MDT Optimized
Gradation Charts.XLS

6.5 *Selection of Optimized Aggregate Gradation* — Use the aggregate gradations and proportions that plot within the limits of the three charts described above as the basis for trial batches. Perform trial batches with varying aggregate proportions meeting the limits of the three previous charts to determine which concrete mix proportions meet contract requirements.

The Materials Bureau may allow the use of aggregate gradations and proportions that exceed the limits of the 0.45 Power Chart and the percent-retained chart. This may be permitted if the coarseness and workability factors plot within the workability box on the Coarseness Factor Chart and the trial batch results meet all contact requirements.

6.6 *Aggregate Gradation Monitoring and Aggregate Proportion Adjustment* — Monitor the aggregate gradation by plotting the results of each sieve analysis on the three previous charts. Perform sieve analysis on a lot by lot basis determined by MT 601.

Any adjustments to the aggregate proportions during concrete production to keep the coarseness factor and workability factor plotted within the workability box on the Coarseness Factor Chart are subject to the Project Manager's approval.