Concrete Plant Quality Control Technician Course
Tennessee Department of Transportation
Volume 19.0
# Concrete Plant Quality Control Technician Course

**Tennessee Department of Transportation**

**Volume 19.0**

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Welcome!

Concrete Plant Quality Control Technician Course

Classroom Rules

• Be Respectful
• Facility Information
• Keep It Clean
• Phone Etiquette
Who Are YOU?

- Name
- Company
- Experience

Technician Certification Program

- Asphalt Roadway Inspector
- Asphalt Plant Inspector
- Asphalt Mix Design
- Concrete Field Testing
- Concrete Plant Quality Control
- Concrete Mix Design
- Aggregate
- Nuclear Gauge Safety
**Purpose of Certification**

- To ensure proper performance of tests
- To improve reliability of results
- For quality control
- To comply with federal requirements

**Course Highlights**

- Course schedule
  - Slide presentations
  - Written exam
  - Results
  - Certification
- Recertification
  - Every 5 years
Introduction

Examination

• Written Exam (No Phones Allowed)
  • Open-book
  • To Pass
    • Must get 75% overall

Results

• Available within one week of completion
• Contact the Headquarters Materials & Tests (HQMT) Training Coordinator, Kim Whitby
  • kimberly.whitby@tn.gov
  • 615-350-4158
**Resources**

- Course materials
  - Course textbook
  - Presentation slides and videos
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
- Contacts
  - Region 1: Brad Baskette
  - Region 2: Tony Renfro
  - Region 3: Kevin Isenberg
  - Region 4: Mitch Blankenship

**AASHTO / ASTM Resources**

- Sampling of Aggregates: R 90/D75
- Reducing Samples of Aggregate to Testing Size: R 76/C702
- Total Evaporable Moisture Content of Aggregate by Drying: T 255/C566
- Materials Finer than #200 Sieve in Mineral Aggregate by Washing: T 11/C117
- Sieve Analysis of Fine & Coarse Aggregate: T 27/C136
Resources

- Tennessee Department of Transportation
  - https://www.tn.gov/tdot.html
- American Road & Transportation Builders Association
  - https://www.artba.org/
- Tennessee Road Builders Association
  - www.trba.org/
- Tennessee Ready Mixed Concrete Association
  - www.tnconcrete.org/
- American Association of State Highway Transportation Officials
  - https://www.transportation.org
- American Society for Testing and Materials
  - https://www.astm.org/
- American Concrete Institute
  - https://www.concrete.org/
- Construction Materials Engineering Council
  - https://www.cmec.org/
- Portland Cement Association
  - www.cement.org/

ADA Notice of Requirements

- Can be found at the following website:

- To be in compliance with TDOTs requirements listed on the website above, it is our goal to provide reasonable accommodations to those who identify themselves as having a disability and request such accommodations

- Please feel free to bring it to any of the course instructors and accommodations will be administered as discretely as possible
Questions
1

Quality Assurance & Quality Control
Introduction to
Quality Control & Quality Assurance

References
TDOT Standard Specifications
Standard Operating Procedures (SOP)
FHWA Publication Nr. HIF-07-004

QC / QA

• Quality Control (QC)
  A set of activities conducted by the contractor to monitor the process to ensure that the concrete will meet or exceed the QA test requirements

• Quality Assurance (QA)
  A set of activities conducted by the owner to ensure that the product delivered complies with the specifications
QC Program (Producer)

- Training
  - Every person (TDOT, Producer, & Contractor) on the project contributes to quality
  - Individuals who conduct sampling, testing, and inspections for quality control must be at least a TDOT Concrete Plant Quality Control Technician

- Testing Material
  - Test material before it is batched
  - Testing of concrete and individual materials during production

- Quality Control Plan
  - Procedures to prevent quality deficiencies and actions for when deficiencies occur
  - A detailed description of the type and frequency of inspection, sampling, and testing to measure the various properties described in the specifications

Quality Assurance (TDOT)

- Associated with Acceptance and Verification
- Performed by TDOT or TDOT representative
- Complies with federal requirements
Concrete QA Testing  
(SOP 1-1)

• Field QA acceptance test(s) shall be performed with same sample of concrete that cylinders are made:
  • Air Content  
    • Achieving the target air content and air void system is one of the most challenging aspects of controlling concrete mixtures  
    • Entrained air adds to the durability of hardened concrete and the workability of fresh mixtures  
  • Slump  
    • Measures consistency of freshly mixed concrete  
  • Temperature  
    • Check that temps are within tolerances

• QA acceptance test (for pay):
  • Concrete Cylinders (28 day)
# Acceptance Testing Frequencies

## (SOP 1-1)

<table>
<thead>
<tr>
<th>CONCRETE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, &amp; Precast</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Non-Critical Structures</strong></td>
<td><strong>Cylinders (28-day), Slump, Air Content, &amp; Mix Temperature</strong></td>
</tr>
<tr>
<td>Class A, A Paving, S, X</td>
<td>Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance</td>
</tr>
<tr>
<td>Class CP</td>
<td></td>
</tr>
<tr>
<td>Class D, DS, L</td>
<td>Cylinders (28-day), Slump, Air Content, &amp; Mix Temperature</td>
</tr>
<tr>
<td>Class SCC, SH-SCC</td>
<td>Cylinders (28-day), Slumpflow, Air Content, Mix Temperature, Passing Ability by J-Ring, VS1, &amp; T-50</td>
</tr>
<tr>
<td>Closure Pour Mix</td>
<td>Cylinders (28-day)</td>
</tr>
<tr>
<td>Structural Grout</td>
<td></td>
</tr>
<tr>
<td>Pre-packaged Mix</td>
<td></td>
</tr>
<tr>
<td>Flowable Fill</td>
<td>Stumpflow, Mix Temperature, &amp; Cylinders (28-day)</td>
</tr>
<tr>
<td>Prestressed Completed Mix</td>
<td>Stump, Air Content, and Mix Temperature</td>
</tr>
<tr>
<td></td>
<td>Cylinders (28-Day) for Beams</td>
</tr>
<tr>
<td></td>
<td>Cylinders (28-Day) for Panels/Filing</td>
</tr>
<tr>
<td></td>
<td>Cylinders (26-Day) for Tension Release</td>
</tr>
<tr>
<td>Prestressed Products</td>
<td>Visual Inspection</td>
</tr>
<tr>
<td>Precast Products</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Placement Site</strong></th>
<th><strong>Refer to Standard Specification 604.03.</strong></th>
<th><strong>Determine depth measurement per Standard Specification 501.24.</strong></th>
<th><strong>Refer to SOP 4-1 for acceptance of concrete for bridge decks.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Inspector</strong></td>
<td><strong>Every 25 cubic yards or less weekly</strong></td>
<td><strong>Every 100 cubic yards placed per day</strong></td>
<td><strong>Every 400 cubic yards placed per day</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Test first three loads and every 50 cubic yards thereafter per day per structure</strong></td>
<td><strong>One pair of cylinders shall be cast from one of the first three passing loads.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Beginning, middle, and end of the pour</strong></td>
<td><strong>Per day</strong></td>
<td><strong>Use limited to 2 cubic yards per day.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Every 100 cubic yards placed per day per use</strong></td>
<td><strong>Cylinders required for excavatable only.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Per pour</strong></td>
<td><strong>Prostressed plant</strong></td>
<td><strong>Perform additional tests when slump change is apparent or as directed.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Beginning, middle and end of the bed</strong></td>
<td><strong>Beginning and end of the pour</strong></td>
<td><strong>One pair of backup cylinders shall be made.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>As needed</strong></td>
<td><strong>After casting and before shipment</strong></td>
<td></td>
</tr>
</tbody>
</table>

Acceptance by Certification in accordance with SOP 5-3

Each item shall be inspected after delivery to the project for cracks, spalls and/or appearance by project personnel prior to incorporating product into the project.
State Required Training

- All personnel involved with QA and QC should receive proper training
- TDOT requires Concrete Field Testing Technician certification as a prerequisite to the Concrete Plant Quality Control Technician certification
- If SCC is being produced and ACI Grade I is used in lieu of TDOT Concrete Field Testing Technician, ACI SCC Testing Technician Certification is also required
- If prerequisite certification expires, subsequent certifications are no longer valid

Record Keeping

- All records shall be available and organized for review at the facility/truck
- Proper documentation is a key factor for interpreting data, making informed decisions, and troubleshooting problems that may arise
- The concrete plant must be continuously monitored and regularly calibrated
- Checklist items covered later in presentation
- Supplied materials from other Producers
2

Ready Mix Concrete Producers
Ready Mix Concrete Producers

- Central-mixed
  - Concrete is mixed in a stationary mixer

- Truck-mixed
  - Concrete is mixed in a truck mixer

Ready Mix Plants
Initial Requirements
(SOP 4-3)

- National Ready Mixed Concrete Association (NRMCA)
  - Plant Certification
  - Delivery Fleet Certification
- Regional M&T Inspections
  - Plant inspection
  - Laboratory inspection
    - (Type A Lab – Spec Book 106.06.A)
    - Concrete truck inspection
- Certified Personnel
- Approved material sources
- Process Control Plan (Quality Control)

NRMCA Certifications
(SOP 4-3)

- NRMCA Plant Certification
  - Every two years
- NRMCA Delivery Fleet Certification
  - Every 12 months
  - Option A: The truck is inspected by the company under the supervision of a company official (person who has the authority to make changes). NRMCA inspector audits paperwork and procedures
  - Option B: Inspected by NRMCA inspector
- Submit copies to HQMT
Quality Monitoring
(SOP 4-3)

• Regional M&T
  • Inspects every ready mix facility at least once a year
  • Reports findings to HQMT for review

• HQMT
  • Inspects ready mix facilities randomly
  • Follows up on regional audits as needed

• Post (board, binder, etc.) all paperwork at plant for ease of inspections

Paperwork
(Ready Mix Inspection Checklist)

• Previous Ready Mix Inspection Checklist
  • Deficiencies listed

• Ready Mix Process Control Plan
  • Are gradations and moistures ran in accordance

• Concrete Truck Checklist

• Certified Technician Form

• Materials List

• Records of delivery tickets of all materials

• Records of all QC tests and inspections
Ready Mix Inspection Checklist

- Regional M&T inspections are documented on this checklist
  - Plant inspection
  - Laboratory inspection
  - Must be posted at plant
- HQMT random audits also use this checklist
- Any comments or concerns will be noted
  - Regional M&T will ensure all deficiencies are corrected
  - Recurring deficiencies will be addressed immediately

General Observations
(Ready Mix Inspection Checklist)

- Method for lowering mix temperature
- Method for raising mix temperature
- TDOT Concrete Plant Quality Control Technician performing the tests when concrete is being batched
Annual Ready Mix Process Control Plan

- Process controls to ensure concrete delivered meets TDOT Specifications
- Specifies testing and inspection minimum frequencies such as:
  - Aggregate Gradations
  - Scale and Admixture Calibrations
  - Aggregate Moisture Contents
- Sampling, testing, and inspections to be performed by a TDOT Concrete Plant Quality Control Technician

Project Specific Checks (Ready Mix Inspection Checklist)

- Water allowed to add on delivery ticket
- Delivery ticket contain all necessary information
- Contractor daily report being sent with first load
- Slump, temperature, and air tests being performed and recorded for the first concrete truck
- When self-consolidating concrete is being batched, the following tests are performed
  - Slump Flow
  - Visual Stability Index
  - T-50
  - Passing Ability
Plant Equipment
(Ready Mix Inspection Checklist)

- Type of plant: central mixed or truck mixed
- Latest calibration date of aggregate and cement scales
  - Required every six months
- Latest calibration date of chemical admixtures
  - Required yearly
- Stockpile and bin maintenance
  - Labeled
  - Overflowing
  - Partitions
  - Segregated

Calibrations
(Ready Mix Inspection Checklist)
Stockpile Maintenance
(Ready Mix Inspection Checklist)

Bin Maintenance
(Ready Mix Inspection Checklist)
**Laboratory Equipment**  
*(Ready Mix Inspection Checklist)*

- Type A Lab – Spec Book 106.06.A
- Lab equipment for fresh concrete testing
- Lab space floored, roofed, sealed inside, weather-tight, furnished with electricity
- Heat source capable of maintaining 230°F ± 9°F
  - Oven
  - Stovetop
  - Hot Plate
- Scales: 2 kg capacity and 100 lb capacity
- Appropriate sieves to run gradations
- Coarse and fine aggregate sieve shaker
- Water supply to perform wash tests if necessary

**Concrete Trucks**  
*(Ready Mix Inspection Checklist)*

- Check trucks against approved truck list
- Working revolution counter
- Weight limits marked on driver’s side and visible at (50 feet)
- Manufacturer’s identification plate showing drum volume and minimum and maximum speeds when charging, mixing, or agitating
- Working water meter
- NRMCA certification card or sticker in each truck
Concrete Truck Checklist

<table>
<thead>
<tr>
<th>Date</th>
<th>Producer</th>
<th>Place Location</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Truck No.</th>
<th>Owner Name</th>
<th>Model</th>
<th>Revolution Counter</th>
<th>Tag #</th>
<th>Base County</th>
<th>Axel Info</th>
<th>Tare Weight</th>
<th>Allowable Gross Weight</th>
<th>NRMCA Expiration</th>
<th>NRMCA Card</th>
</tr>
</thead>
</table>

- Truck Numbers
- Manufacturers Plates
- Revolution Counters
- Mixer Blade Wear
- Water Gauges
- Tag #
- Base County
- Axel Info
- Tare Weight
- Allowable Gross Weight
- Information
- NRMCA Expiration
- NRMCA Card

Revolution Counter
(Concrete Truck Checklist)
Allowable Gross Weights
(Concrete Truck Checklist)

Manufacturer’s Plate
(Concrete Truck Checklist)
Ready Mix Producers

**Water Meter**
(Concrete Truck Checklist)

**Certified Technician Form**

<table>
<thead>
<tr>
<th>Concrete Certified Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCRETE PRODUCER: LOCATION:</td>
</tr>
</tbody>
</table>

**TECHNICIAN QUALIFICATIONS**

<table>
<thead>
<tr>
<th>Concrete Field Testing Technicians (TDOT Level 1 or equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Concrete Plant Quality Control Technicians (TDOT Level 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
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<tr>
<td>------</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Concrete Mix Design Technicians (TDOT Level 3 or State of TN PE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
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</tbody>
</table>
Materials
(Ready Mix Inspection Checklist)

- Municipal or non-municipal water
  - If non-municipal, test records kept on file
    - 921.01: Testing every 3 months then annually after 4 consecutive passing tests
- Material sources on approved mix design
- Specific Gravity and Absorption for aggregates

Materials List

- Complete list of Producers and materials used for TDOT mix
Mix Designs

- Each plant shall have an approved (current year) concrete mix design as outlined in SOP 4-4
- Use project specific approved mix design when producing concrete for TDOT project
- Water/Cementitious material ratio
- Materials can change; trial batch information submitted along with mix design template

Delivery Ticket

A concrete delivery ticket shall accompany each load to the placement site. The ticket shall include as a minimum the following:

1. Date
2. Contract Number
3. County
4. Class of concrete
5. Concrete design number
6. Number of cubic yards
7. Load Number
8. Truck Number
9. Max Water Allowed by Design
10. Actual water added on a project
11. Number of revolutions at mixing speed at plant
12. Number of revolutions at mixing speed at project
13. Time Loaded
14. Time Discharged
15. Actual and target batch weights of each component including each aggregate, chemical and mineral admixture used
16. TDOT Concrete Plant Quality Control Technician signature
Batching Tolerances

- Standard Specifications 501.09
- Aggregate
  - 1.5% of the required weight
- Cementitious Materials
  - No less than 1% nor no more than 4% of the required weight
- Water
  - Accuracy of measuring the water shall be within a range of error of not over 1%
- Admixture
  - Batch in accordance with manufacturer’s recommendations
Volumetric Concrete Producers
Volumetric Concrete Producers

Volumetric Concrete

• Concrete materials batched by volume not weight
• Continuous mixing happens as the concrete is poured and placed
• Volumetric mixers, stockpiles, bins, and tanks all fit on a truck making an entire plant portable
Volumetric Producers

Volumetric Specification

- TDOT Specification 604.04.B for volumetric continuous mixers
  - Equipment requirements
  - Calibration
    - Must be performed by an individual with BOTH certifications:
      - TDOT Concrete Mix Design Technician
      - VMMB Volumetric Mixer Operator
  - Operation
    - Must be performed by an individual with BOTH certifications:
      - TDOT Concrete Plant Quality Control Technician
      - VMMB Volumetric Mixer Operator

Volumetric Mobile Mixer Approval
(SOP 4-5)

- Approved material sources
- Certified personnel
- Volumetric Mobile Mixer Process Control Plan
- Calibration procedure
- Process control inspections
  - Mobile unit inspection by HQMT
  - Central facility inspection by Regional M&T
- Mix designs are specific to each mobile unit
- Delivery ticket
- All paperwork must be kept with each mobile unit
4

Precast & Prestressed Concrete Producers
Precast & Prestressed Concrete Producers

Precast Concrete

- Concrete products cast at facility and shipped to field
- Precast products
  - Catch basins, box culverts, manholes, junction boxes, noise walls, retaining wall panels, etc.
- Reinforced concrete pipe
- Mixing equipment varies
  - Central mixer
  - Use of a ready mix plant
  - Volumetric mixer
Precast Concrete Products
(SOP 5-3)

- NPCA, ACPA, or PCI Certification
- Approved material sources
- Quality Control Program
  - Precast Inspection Checklist
- Mix designs
- Product labeling
- Shipment
- Verification

Precast Inspection Checklist

- Regional M&T inspections are documented on this checklist
- HQMT random audits also use this checklist
- Any comments or concerns will be noted
  - Regional M&T will ensure all deficiencies are corrected
  - Recurring deficiencies will be addressed immediately
## Materials

*(Precast Inspection Checklist)*

- Municipal or non-municipal water
  - If non-municipal, test records kept on file
    - 921.01: Testing every 3 months then annually after 4 consecutive passing tests
- Material sources on approved mix design
- Specific Gravity and Absorption for aggregates
- Steel is from an approved Producer
  - Steel certifications readily available
- Patching material listed on Qualified Products List (QPL)

## QC Program

*(Precast Inspection Checklist)*

- TDOT specific QC Manual
- Current organizational chart
- QC inspector certifications, including backup QC
  - TDOT Concrete Field Testing Technician
  - TDOT Concrete Plant Quality Control Technician
  - Training from certifying agency
    - NPCA Production Quality School Level 1
    - ACPA Quality School
    - PCI Level 1 – Certified Technician
- Record of QC inspections and tests
  - Pre-pour
  - During
  - Post-pour
  - Gradations at least once per month
Laboratory & Testing Equipment
(Precast Inspection Checklist)

• Type A Lab required
• Testing equipment shall be calibrated every 12 months
  • Compression machine used for precast products and larger diameter reinforced concrete pipe
  • Three-edge bearing used for reinforced concrete pipe

Plant Equipment
(Precast Inspection Checklist)

• Concrete batched at the precast facility
  • Latest calibration date of aggregate and cement scales
    • Required every six months
  • Latest calibration date of chemical admixtures
    • Required yearly
  • Stockpile and Bin maintenance
    • Labeled
    • Overflowing
    • Partitions
    • Segregated

• Concrete from a ready mix producer
  • On TDOT Producer List
  • NRMCA certification
Mix Design
(Precast Inspection Checklist)

- Mix design shall be approved by HQMT for current year
- Each type of precast product requires an approved mix design
- All materials on mix design must be listed on Producer List or QPL

Acceptance Testing
(Precast Inspection Checklist)

- Acceptance tests shall be performed at the minimum frequencies in SOP 5-3
  - Compressive Strength
  - Absorption
  - D-Load
  - Ultimate Load
- Daily reports documenting type and quantity of produce made each day shall be made available
  - All acceptance test results
  - Inspection of dimensional tolerances
- Acceptable products shall be marked by stamp, etch, or label
- Unacceptable products shall be marked
Verification Testing

• TDOT accepts precast by certification and verifies:
  • Compressive Strength
  • D-Load
  • Ultimate Load

• Quarterly, TDOT Regional M&T performs:
  • Nondestructive testing
  • Inspection of dimensional tolerances

Discussion of Findings
(Precast Inspection Checklist)

• Any comments or concerns will be noted
• Regional M&T will ensure all deficiencies are corrected
• Recurring deficiencies will be addressed immediately
Prestressed Concrete

• Structures are cast at the facility with stressing strands incorporated during the casting operation
  • Bridge beams
  • Concrete piles
  • Bridge deck panels

Producer Requirements
(SOP 5-4)

• Plant must be certified by PCI (Precast/Prestressed Concrete Institute)
• TDOT specific Quality Control Plan
  • Current organizational chart
  • Pre-pour and post-pour processes
  • Testing procedures
  • Detailed marking for TDOT products
• Daily reporting of prestressed concrete plant inspection on Form DT-0283
• Final reporting for acceptance on Form DT-0289
Materials
(SOP 5-4)

• Municipal or non-municipal water
  • If non-municipal, test records kept on file
    • 921.01: Testing every 3 months then annually after 4 consecutive passing tests

• Material sources on approved mix design

• Specific Gravity and Absorption for aggregates

• Steel is from an approved Producer
  • Steel certifications readily available

Mix Design
(SOP 5-4)

• Each plant shall have an approved (current year) concrete mix design as outlined in SOP 4-4

• All materials on mix design must be listed on Producer List or QPL

• An approved mix design will designate the maximum strength requirement for which the design is approved
  • The producer may choose to use a concrete mix design approved for a higher strength requirement than that specified
Quality Control Program
(SOP 5-4)

• Quality control of materials
• Testing equipment and laboratory
• Quality control personnel
• Concrete central mixing plant

Quality Control of Materials
(SOP 5-4)

• Form release agents
  • Must dry sufficiently to not contaminate strands
  • Clean strands are critical to obtain a good bond
• Cylinders made in accordance with SOP 1-1
• Concrete temperature
  • 50°F - 90°F during pouring operations
• Ambient temperature
  • Do not pour if below 26°F or during precipitating weather (TDOT Specification 615.10.A)
• Aggregate Stockpiles
  • Labeled
  • Overflowing
  • Partitions
  • Segregated
Testing Equipment & Laboratory  
(SOP 5-4)

- Type A Lab required
  - Gradations on each aggregate used at least once per week
- Testing equipment calibrated every 12 months
- Hydraulic jacks and pressure gauges shall be calibrated every 6 months
- Producer shall maintain documentation and records of all equipment certifications

Quality Control Personnel  
(SOP 5-4)

- Each production facility shall have an individual responsible for quality production
- A TDOT Concrete Plant Quality Control Technician shall be on site anytime that a TDOT product is being produced
Plant Equipment
(SOP 5-4)

- Concrete batched at the prestressed facility
  - Latest calibration date of aggregate and cement scales
    - Required every six months
  - Latest calibration date of chemical admixtures
    - Required yearly
  - Stockpile and Bin maintenance
    - Labeled
    - Overflowing
    - Partitions
    - Segregated

- Concrete from a ready mix producer
  - On TDOT Producer List
  - NRMCA certification

Prior to Shipping
(SOP 5-4)

- Ensure products meet the requirements of the specifications and shop drawings
  - Dimensional tolerances in Table 615.17-1 of TDOT Standard Specifications

- Ready for shipment
  - 28 day required strength shall be met
  - Honeycombed areas shall be repaired

- Acceptance and verification testing in accordance with SOP 1-1

- For acceptance, Regional M&T performs a final inspection after loading and prior to shipment
Stamping
(SOP 5-4)

- Acceptable products will be stamped on the top surface with the following:
  - Project number
  - County
  - Bridge number
  - Unit mark number
  - Date made
Best Management Practices for Concrete
Best Management Practices for Concrete

High Ambient Temperatures

- Field observations:
  - Increased water demand to maintain workability
  - Faster set time
  - Increase danger of plastic and early-age shrinkage cracking
  - Lower ultimate strength

- Standard Specification 604.11
  - The temperature of the concrete at point of discharge shall not exceed 90°F

- Options for lowering temperature of concrete
  - Cool aggregate by shading stockpile and sprinkling with water
  - Chill mixing water or use ice
Low Ambient Temperatures

- Field Observations
  - Freezing of concrete before it sets
  - Slower set time
  - Shrinkage cracking
  - Reduced early strength

- Standard Specifications 501.11
  - Pour if temperature is 35°F and rising
  - Do Not Pour if 40°F and falling

- Options for raising temperature of concrete
  - Heat aggregate
  - Heat mixing water

Lightweight Concrete

- Contains lightweight aggregate
  - Expanded shale, slate, or clay used for structural concrete
  - Approved sources on QPL 35

- Pre-saturation of the aggregate is critical
  - Standard Specification 604.11.A

- Must use the volumetric method to determine the air content
  (AASHTO T 196/ASTM C173)
Self-Consolidating Concrete

- Sensitive to additional water
  - Additional moisture testing
- ACI SCC Testing Technician Certification required in addition to ACI Field Testing Technician Certification
- Different testing methods and equipment
- Curing, batching, and producing is the same as conventional concrete
6

Sampling of Aggregates

AASHTO R 90
ASTM D75
TDOT Standard Method of Test for Sampling of Aggregates

References
TDOT Standard Specifications
AASHTO R 90
ASTM D75

Apparatus

- Shovel, Scoops
- Brushes
- Sampling Tubes
- Sample Containers
- Tags
Purpose

- Preliminary investigation of the potential source of supply
  - Sample at source
  - Complete quality testing (dependent upon application)
- Control of the product at the source
- Control of the operations at the site of use
  - Project site
  - **Concrete Plant**
- Acceptance or rejection of the materials
  - TDOT Standard Specifications
## Sizes of Coarse Aggregate Table 903.22-1

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<th>3”</th>
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(1) Screenings
Sampling

Size of Aggregate

- **Nominal maximum size** of aggregate is the smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

- **Maximum size** of aggregate is the smallest sieve opening through which the entire amount of aggregate is required to pass.

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Minimum Field Sample Size

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<th>Minimum Field Sample Mass, lb</th>
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<td>3 1/2&quot;</td>
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Methods of Sampling

- Flowing aggregate stream
- Conveyor belt
- **Stockpiles**
  - With power equipment
  - Without power equipment
- Roadways
- Transportation units

Stockpiles

- Stockpile must be checked for segregation and noted in log
- Segregation is the separation of varying sizes of aggregate
- Power equipment is recommended
- Portions collected at various locations around the main stockpile
With Power Equipment

- After re-blending, loader enters stockpile with bucket approximately 6” above ground level
- Loader bucket is raised perpendicular to the ground
- Bucket is tilted forward to roll material out into a separate stockpile

With Power Equipment

- The loader is then used to backblade the smaller stockpile ONE time
- Divide the sample pad into 4 quadrants and sample equal amounts
- Avoid sampling within 1 ft. of sample pad edge
- The FOUR increments are then combined to comprise the final field sample
Sampling

If power equipment is not available:

- The pile is visually divided into three even sections: top third, mid-point, and bottom third of the elevation of the stockpile
- Portions are obtained from each section at least 12” below the surface by removing the outer layer of material
- The three increments are then combined to comprise the final field sample
- Note that although this is a recognized sampling method, many producers may not allow people on stockpiles for safety reasons.

Sampling Tubes

- Fine aggregate only
- Sample shall be taken at a minimum height of 3 ft from the surrounding grade
- At least five tube insertions randomly spaced across face of stockpile
- Note that although this is a recognized sampling method, many producers may not allow people on stockpiles for safety reasons.
Sampling Tubes

- 1¼" min.
- 6 ft min.
- Durable
- OSHA requirement
  - [≤ 50 lbs]
- Portion the sample if necessary
- Appropriate container for test to be performed
- Ensure sample is labeled if applicable

Sample Containers
Questions
Reducing Samples of Aggregate to Testing Size

AASHTO R 76
ASTM C702
**TDOT Standard Method of Test for**
Reducing Samples of Aggregate to Testing Size

**References**
- TDOT Standard Specifications
- AASHTO R 76
- ASTM C702

**Methods of Reduction**
- Method A - Mechanical Splitter
- Method B - Cone and Quarter
- Method C - Miniature Stockpile
To Determine Method

Moisture condition of the aggregate

- Dry
- Moist
- Saturated-Surface-Dry (SSD/Absorption)
- Wet/Free Moisture

To Determine Method

Size of aggregate

- Coarse
  - Retained on #4
- Fine
  - Passing #4
- Combined
#4 Sieve

- The #4 sieve has 4 openings per linear inch
- How many openings per square inch?

Determine Method

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Aggregate Size</th>
<th>Coarse</th>
<th>Combined</th>
<th>Fine</th>
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<td>A, B</td>
<td>A, B</td>
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<td>Free moisture on surface</td>
<td>A, B</td>
<td>B</td>
<td>B, C</td>
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</tr>
</tbody>
</table>

- Method A - Mechanical Splitter
- Method B - Cone and Quarter
- Method C - Miniature Stockpile
Mechanical Splitter / Method A

For Coarse and Combined Aggregate

- Even number of chutes
- Chutes of equal width
- At least 8 chutes
- Individual chutes about 50% larger than largest particles

Mechanical Splitter / Method A

For Fine Aggregate

- Even number of chutes
- Chutes of equal width
- At least 12 chutes
- Individual chutes ½" to ¾" wide
Cone and Quarter / Method B

- Cone the sample on a hard, clean, level surface
- Turn sample over 3 times and place into a cone
- Flatten the cone to a uniform thickness
- Diameter = 4 to 8 times the thickness

Cone and Quarter / Method B

- Divide the flattened cone
- After dividing, remove two diagonal quarters (including fines)
- Mix and quarter the remaining material until sample is adequately reduced
Cone and Quarter / Method B
Fine Aggregate

1
2
3
4

Method B Alternative

Mix by rolling on canvas
Flatten aggregate pile to a diameter 4 to 8 times the thickness
**Method B Alternative**

- Divide the aggregate into four separate quarters using a shovel or stick
- Remove two diagonally opposite quarters including fines

**Miniature Stockpile / Method C**

- Place sample on hard, clean, level surface
- Mix thoroughly by turning over three times
- Form a cone with the last turning
- Flatten, if desired, to a uniform thickness
- Select at least five increments at random locations using a shovel, scoop, or spoon
Miniature Stockpile / Method C
Total Evaporable Moisture Content of Aggregate by Drying

AASHTO T 255
ASTM C566
TDOT Standard Method of Test for Total Evaporable Moisture Content of Aggregate by Drying

References
TDOT Standard Specifications
AASHTO T 255
ASTM C566

Apparatus

- Balance
- Heat Source
- Sample Container
- Stirring Spoon
- Brush
- Gloves
Sample Size

TABLE 1 Sample Size for Aggregate

<table>
<thead>
<tr>
<th>Nominal Maximum Size of Aggregate, mm (in.)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Mass of Normal Weight Aggregate Sample, min, kg&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 (0.187) (No. 4)</td>
<td>0.5</td>
</tr>
<tr>
<td>9.5 (½)</td>
<td>1.5</td>
</tr>
<tr>
<td>12.5 (⅝)</td>
<td>2</td>
</tr>
<tr>
<td>19.0 (¾)</td>
<td>3</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>4</td>
</tr>
<tr>
<td>37.5 (1¾)</td>
<td>6</td>
</tr>
<tr>
<td>50 (2)</td>
<td>8</td>
</tr>
<tr>
<td>63 (2½)</td>
<td>10</td>
</tr>
<tr>
<td>75 (3)</td>
<td>13</td>
</tr>
<tr>
<td>90 (3½)</td>
<td>16</td>
</tr>
<tr>
<td>100 (4)</td>
<td>25</td>
</tr>
<tr>
<td>150 (6)</td>
<td>50</td>
</tr>
</tbody>
</table>

<sup>a</sup> Based on sieves meeting Specification E11.

<sup>b</sup> Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m<sup>3</sup> (determined using Test Method C29/C29M) and dividing by 1600.

Samples
Determine Sample Mass

- Weigh the sample to the nearest 0.1g

Dry the Sample

- Dry the aggregate to a constant mass (does not vary more than 0.1%) in an oven at 230 ± 9°F
- Allow the material to cool
Moisture Content

Reweigh the Sample

- Weigh the sample to the nearest 0.1 g

Calculations

\[ P_{\text{Moisture,Total}} = \frac{M_{\text{Original}} - M_{\text{Dry}}}{M_{\text{Dry}}} \times 100 \]

\[ P = \frac{W - D}{W} \times 100 \]
Moisture Content

Problem

Given:
• Weight of the original sample \( W \) = 1092.4 g
• Weight of sample after drying \( D \) = 1080.5 g

Determine:
Total percent \( P \) moisture content of the aggregate

Solution

\[
P = \frac{W - D}{D} \times 100
\]

\( P = \)
### Practice

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Original Weight</th>
<th>Dry Weight</th>
<th>( \frac{W - D}{D} \times 100 )</th>
<th>Moisture Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>588.3</td>
<td>570.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1556.8</td>
<td>1540.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1225.0</td>
<td>1220.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1665.2</td>
<td>1650.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DRY** 900g  **MOIST** 930g  **SSD** 955g  **WET** 975g

Determine the percent moisture content in the wet condition:

Determine the percent moisture of the aggregate at SSD (Absorption):
Moisture Content

Determine the percent of free moisture on the sample:

Determine the amount of water the aggregate has in the wet condition:
Aggregate Moisture Corrections for Concrete Batching
Aggregate Moisture Corrections for Concrete Batching

References
TDOT Standard Specifications

Purpose

- Control the amount of mixing water that actually ends up in mix
- Biggest source of water to be accounted for:
  - Coarse Aggregate
  - Fine Aggregate
- Aggregates contain both absorbed and free water
Aggregate Moisture Content

• Absorbed Water
  • Not included in the mixing water
  • Mix design batch weights in SSD condition (Saturated Surface Dry)

• Wet Condition
  • Contains both free and absorbed water
  • Free water must be included in the design as mixing water

Formulas

%Free Moisture:

\[ %FM = %Moisture - %Absorption \]

• Use %Absorption values given by the aggregate facility
Formulas

Aggregate Moisture Correction:

\[ Agg\ MC = SSD\ Weight \times \%Free\ Moisture \]

Mix Water Correction:

\[ MWC = \frac{MC_{CA} + MC_{FA}}{8.34 \frac{lbs}{gal}} \]

Formulas

Corrected Aggregate Batch Weight:

\[ W_{Agg} = SSD\ Weight + Agg\ MC \]

Corrected Batch Water:

\[ Batch\ Water = Design\ Water - MWC \]
Moisture Correction Procedure

1. Calculate Percent Free Moisture in Aggregates
2. Determine SSD Batch Weights
3. Calculate Aggregate Moisture Corrections
4. Calculate Mix Water Correction
5. Calculate the Corrected Aggregate Batch Weights
6. Calculate the Corrected Batch Water
Example #1

1. Calculate Percent Free Moisture in Aggregates

<table>
<thead>
<tr>
<th></th>
<th>Coarse Aggregate</th>
<th>Fine Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Weight</td>
<td>4306</td>
<td>1232</td>
</tr>
<tr>
<td>Dry Weight</td>
<td>4259</td>
<td>1176</td>
</tr>
<tr>
<td>Calculate Total Moisture Content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Absorption given by aggregate facility</td>
<td>0.6%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Calculate % Free Moisture</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Use SSD Batch Weights from mix design

Coarse Aggregate: 1912 lb
Fine Aggregate: 1138 lb
Water: 30 gal
Example #1

<table>
<thead>
<tr>
<th>Batch Size</th>
<th>Water</th>
<th>Cement</th>
<th>Fly Ash</th>
<th>GGBFS</th>
<th>Coarse Aggregate</th>
<th>Fine Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>yd³ (m³)</td>
<td>gal (L)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
<td>lbs. (kg)</td>
</tr>
<tr>
<td>Agg. Size / Other Material</td>
<td>Percent Free Moisture</td>
<td>SSD</td>
<td>Batch Wts.</td>
<td>30</td>
<td>1912</td>
<td>1138</td>
</tr>
<tr>
<td>Moisture Corrections</td>
<td>Actual Batch Wts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Calculate Aggregate Moisture Corrections
   **Coarse Aggregate**          **Fine Aggregate**

4. Calculate Mix Water Correction

5. Calculate the Corrected Aggregate Batch Weights
   **Coarse Aggregate**          **Fine Aggregate**

6. Calculate the Corrected Batch Water
### Example #2

<table>
<thead>
<tr>
<th>Batch Size \ m³ (yd³)</th>
<th>Water gal (L)</th>
<th>Cement lbs. (kg)</th>
<th>Fly Ash lbs. (kg)</th>
<th>GGBFS lbs. (kg)</th>
<th>Coarse Aggregate lbs. (kg)</th>
<th>Fine Aggregate lbs. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agg. Size / Other Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Free Moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSD Batch Wts.</td>
<td>25</td>
<td>1810</td>
<td>1229</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture Corrections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Batch Wts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Calculate Aggregate Moisture Corrections
   - **Coarse Aggregate**
   - **Fine Aggregate**

4. Calculate Mix Water Correction

5. Calculate the Corrected Aggregate Batch Weights
   - **Coarse Aggregate**
   - **Fine Aggregate**

6. Calculate the Corrected Batch Water
Materials Finer than #200 Sieve in Mineral Aggregate by Washing

AASHTO T 11
ASTM C117
TDOT Standard Method of Test for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

References
TDOT Standard Specifications
AASHTO T 11
ASTM C117

Apparatus
- Balance
- Sieves (#16 & #200)
- Container
- Oven
- Wetting Agent
- Mechanical Washer (optional)
## Sample Size

<table>
<thead>
<tr>
<th>Nominal Maximum Size(^A)</th>
<th>Minimum Mass, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 mm (No. 4) or smaller</td>
<td>300</td>
</tr>
<tr>
<td>9.5 mm (3/8&quot;)</td>
<td>1000</td>
</tr>
<tr>
<td>12.5 mm to 19.0 mm (½&quot; to ¾&quot;)</td>
<td>2500</td>
</tr>
<tr>
<td>25 mm (1&quot;) or larger</td>
<td>5000</td>
</tr>
</tbody>
</table>

\(^A\) Based on sieve sizes meeting Specification E11.

## Minus #200 Material
Dry the Sample

- Dry the aggregate to a constant mass (does not vary more than 0.1%) in an oven at 230 ± 9°F
- Allow the material to cool

Determine the Sample Mass

- Weigh the sample to the nearest 0.1g
Two Procedures

Procedure A - Washing with plain water
• Dust of Fracture

Procedure B - Washing using a wetting agent
• Clay Particles

Procedure
• Place the sample in the container
• Add water to cover the sample
• Add wetting agent if performing Procedure B
**Procedure**

- Agitate the sample
- Use a spoon to stir, if desired
- Ensure complete separation of particles

**Procedure**

Pour the wash water with suspended solids over the nested sieves
Procedure

- Repeat the washing with plain water
- Repeat until wash water is clear
- Use wetting agent first wash only

Alternate Procedure

- Mechanical washing is allowable as long as the results are consistent with hand washing
- Some samples may degrade in mechanical washers
**Procedure**

- Flush material retained on sieves back into container
- Do not splash as this may lose material

**Dry the Sample**

- Dry the aggregate to a constant mass (does not vary more than 0.1%) in an oven at $230 \pm 9^\circ F$
- Allow the material to cool
Determine the Sample Mass

Weigh the sample to the nearest 0.1g

Calculations

\[ P_{\leq \#200} = \frac{M_{\text{Dry, Before}} - M_{\text{Dry, After}}}{M_{\text{Dry, Before}}} \times 100 \]
Results

• If the percentage of material finer than #200 is less than 10%, then report the results to the nearest 0.1
• If the percentage of material finer than #200 is greater than 10%, then report the results to the nearest whole number

Problem

Given:
• Original mass of the sample = 595.6 g
• Mass of the sample after washing = 579.3 g

Determine:
• The percent (P) of material finer than the #200 sieve in the sample
Solution

\[
P \leq \#200 = \frac{M_{\text{Dry, Before}} - M_{\text{Dry, After}}}{M_{\text{Dry, Before}}} \times 100
\]

Practice

Given:

- Original mass of the sample = 6895.5 g
- Mass of the sample after washing = 6045.0 g

Determine:

- The percent (P) of material finer than the No. 200 sieve in the sample
Solution

\[ P_{\leq #200} = \frac{M_{Dry, Before} - M_{Dry, After}}{M_{Dry, Before}} \times 100 \]

\[ P_{\leq #200} = \]
Sieve Analysis of Fine & Coarse Aggregate

AASHTO T 27
ASTM C136
TDOT Standard Method of Test for
Sieve Analysis of Fine and Coarse Aggregates

References
TDOT Standard Specifications
AASHTO T 27
ASTM C136

Apparatus

• Balance
• Oven
• Sieves
• Mechanical Shaker
Sieve Analysis

Aggregate Gradation

- Well-Graded
- Gap-Graded
- Uniformly-Graded

Test Sample Size

7.3 Fine Aggregate—The size of the test sample, after drying, shall be 300 g minimum.

7.4 Coarse Aggregate—The size of the test sample of coarse aggregate shall conform with the following:

<table>
<thead>
<tr>
<th>Nominal Maximum Size, Square Openings, mm (in.)</th>
<th>Test Sample Size, min, kg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 (⅜)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>12.5 (1½)</td>
<td>2 (4)</td>
</tr>
<tr>
<td>19.0 (¾)</td>
<td>5 (11)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>10 (22)</td>
</tr>
<tr>
<td>37.5 (1⅛)</td>
<td>15 (33)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>20 (44)</td>
</tr>
<tr>
<td>63 (2⅛)</td>
<td>35 (77)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>60 (130)</td>
</tr>
<tr>
<td>90 (3⅜)</td>
<td>100 (220)</td>
</tr>
</tbody>
</table>
Dry the Sample

- Dry the aggregate to a constant mass (does not vary more than 0.1%) in an oven at 230 ± 9°F
- Allow the material to cool

Determine the Sample Mass

Weigh the sample to the nearest 0.1 of a unit of the original sample mass
Sieves

Loose Mesh

Clogged

Hole/Tear

Overloaded Sieve

Options for Overloading
- Use larger sieve
- Portion the sample
- Place another sieve in the nest
# Maximum Loading of Sieves

## Table 1—Maximum Allowable Quantity of Material Retained on a Sieve, kg

<table>
<thead>
<tr>
<th>Sieve Opening Size</th>
<th>Nominal Dimensions of Sieve&lt;sup&gt;a&lt;/sup&gt;</th>
<th>203.2-mm, dia&lt;sup&gt;ab&lt;/sup&gt;</th>
<th>254-mm, dia&lt;sup&gt;ab&lt;/sup&gt;</th>
<th>304.8-mm, dia&lt;sup&gt;b&lt;/sup&gt;</th>
<th>350 by 350, mm</th>
<th>372 by 580, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seiving Area, m&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.0285</td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
</tr>
<tr>
<td>125 mm (5 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 mm (4 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 mm (3 1/2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 mm (3 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63 mm (2 1/2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>15.1</td>
<td>27.6</td>
<td>48.5</td>
</tr>
<tr>
<td>50 mm (2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>8.6</td>
<td>12.6</td>
<td>23.0</td>
</tr>
<tr>
<td>37.5 mm (1 1/2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>3.6</td>
<td>5.7</td>
<td>15.3</td>
</tr>
<tr>
<td>25.0 mm (1 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>2.7</td>
<td>4.3</td>
<td>6.3</td>
</tr>
<tr>
<td>19.0 mm (3/4 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>1.8</td>
<td>2.9</td>
<td>4.2</td>
</tr>
<tr>
<td>12.5 mm (1/2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>1.4</td>
<td>2.2</td>
<td>3.2</td>
</tr>
<tr>
<td>9.5 mm (3/8 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>0.89</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>4.75 mm (No. 4)</td>
<td>c</td>
<td></td>
<td></td>
<td>0.67</td>
<td>1.1</td>
<td>1.6</td>
</tr>
</tbody>
</table>

<sup>a</sup> Sieve frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

<sup>b</sup> The sieve area for round sieves is based on an effective diameter 12.7 mm (1/2 in.) less than the nominal frame diameter, because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm (1/4 in.) over the sieve cloth. Thus the effective sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm (7.5 in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm (1/4 in.).

<sup>c</sup> Sieves indicated have less than five full openings and should not be used for sieve testing.
Mechanical Shaker

• Shake thoroughly
• Agitating for more than 10 minutes may degrade the sample

Weighing

Weigh the sample to the nearest 0.1 of a unit of the original sample mass
AASHTO Loss

\[
\text{AASHTO Loss} = \frac{\text{Original Sample Wt.} - \text{Total Cumulative Wt.}}{\text{Original Sample Wt.}} \times 100
\]

AASHTO Loss must be \( \leq 0.3\% \)

Calculations

\[
\text{Cumulative}\%\ \text{Retained} = \frac{\text{Cumulative Wt. Retained}}{\text{Original Sample Wt.}} \times 100
\]

\[
\text{Cumulative}\%\ \text{Passing} = 100 - \text{Cumulative}\%\ \text{Retained}
\]
Sample Problem #1

Natural Sand for Concrete

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Weight Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>0.0</td>
</tr>
<tr>
<td>No. 8</td>
<td>51.0</td>
</tr>
<tr>
<td>No. 16</td>
<td>149.0</td>
</tr>
<tr>
<td>No. 30</td>
<td>255.0</td>
</tr>
<tr>
<td>No. 50</td>
<td>372.0</td>
</tr>
<tr>
<td>No. 100</td>
<td>467.0</td>
</tr>
<tr>
<td>No. 200</td>
<td>496.0</td>
</tr>
<tr>
<td>Pan</td>
<td>507.0</td>
</tr>
</tbody>
</table>

Sample Problem #1

AASHTO Loss = \[ \frac{\text{Original Sample Wt.} - \text{Total Cumulative Wt.}}{\text{Original Sample Wt.}} \times 100 \]

AASHTO Loss =

AASHTO Loss = \leq 0.3\%
**Sample Problem #1**

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Retained (g)</th>
<th>Cumulative % Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>No. 8</td>
<td>51.0</td>
<td>100%</td>
</tr>
<tr>
<td>No. 16</td>
<td>149.0</td>
<td>50%</td>
</tr>
<tr>
<td>No. 30</td>
<td>255.0</td>
<td>50%</td>
</tr>
<tr>
<td>No. 50</td>
<td>372.0</td>
<td>50%</td>
</tr>
<tr>
<td>No. 100</td>
<td>467.0</td>
<td>50%</td>
</tr>
<tr>
<td>No. 200</td>
<td>496.0</td>
<td>50%</td>
</tr>
<tr>
<td>Pan</td>
<td>507.0</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Original Sample Weight:** 507.8 g

**Cumulative Wt Retained (g):**

- No. 4: 0.0
- No. 8: 51.0
- No. 16: 149.0
- No. 30: 255.0
- No. 50: 372.0
- No. 100: 467.0
- No. 200: 496.0
- Pan: 507.0

**Cumulative % Retained:**

- No. 4: 0%
- No. 8: 100%
- No. 16: 50%
- No. 30: 50%
- No. 50: 50%
- No. 100: 50%
- No. 200: 50%
- Pan: 50%

**Specification 903.01:**

- 95 - 100
- 50 - 90
- 5 - 35
- 0 - 20
- 0 - 3

**Meets?**

- Yes/No: No

**% Passing:**

- 95 - 100: -
- 50 - 90: -
- 5 - 35: -
- 0 - 20: -
- 0 - 3: -

**Cumulative % Retained:**

- No. 4: 0%
- No. 8: 100%
- No. 16: 50%
- No. 30: 50%
- No. 50: 50%
- No. 100: 50%
- No. 200: 50%
- Pan: 50%

**Original Sample Weight:** 507.8 g

**Specification 903.01:**

- 95 - 100
- 50 - 90
- 5 - 35
- 0 - 20
- 0 - 3

**Meets?**

- Yes/No: No

**% Passing:**

- 95 - 100: -
- 50 - 90: -
- 5 - 35: -
- 0 - 20: -
- 0 - 3: -
**Fineness Modulus**

- Numerical value to indicate fineness of aggregate
- Aggregate with same fineness modulus will require the same quantity of water to produce a mix of the same consistency and strength
- Higher fineness modulus means material is more coarse
- Cumulative percent retained on No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8 inch, 3/4 inch, 1 ½ inch and 3 inch sieves (Divide by 100)
- For concrete sand, 2.3 - 3.1

**FM Sample #1**

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Cumulative Percent Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in</td>
<td></td>
</tr>
<tr>
<td>1 1/2 in</td>
<td></td>
</tr>
<tr>
<td>3/4 in</td>
<td></td>
</tr>
<tr>
<td>3/8 in</td>
<td></td>
</tr>
<tr>
<td>No. 4</td>
<td></td>
</tr>
<tr>
<td>No. 8</td>
<td></td>
</tr>
<tr>
<td>No. 16</td>
<td></td>
</tr>
<tr>
<td>No. 30</td>
<td></td>
</tr>
<tr>
<td>No. 50</td>
<td></td>
</tr>
<tr>
<td>No. 100</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>FM</td>
<td></td>
</tr>
</tbody>
</table>
Sample Problem #2

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Weight Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1/2 in</td>
<td>0.0</td>
</tr>
<tr>
<td>1 in</td>
<td>0.0</td>
</tr>
<tr>
<td>3/4 in</td>
<td>0.6</td>
</tr>
<tr>
<td>1/2 in</td>
<td>8.8</td>
</tr>
<tr>
<td>3/8 in</td>
<td>16.5</td>
</tr>
<tr>
<td>No. 4</td>
<td>24.3</td>
</tr>
<tr>
<td>No. 8</td>
<td>24.6</td>
</tr>
<tr>
<td>Pan</td>
<td>25.4</td>
</tr>
</tbody>
</table>

Sample Problem #2

\[
\text{AASHTO Loss} = \frac{\text{Original Sample Wt.} - \text{Total Cumulative Wt.}}{\text{Original Sample Wt.}} \times 100
\]

\[
\text{AASHTO Loss} \leq 0.3\% 
\]
## Sample Problem # 2

### Sieve Size

<table>
<thead>
<tr>
<th>Size</th>
<th>Cumulative Retained (lb)</th>
<th>Cumulative % Retained</th>
<th>% Passing</th>
<th>Specification</th>
<th>Meets?</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ½ in</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>8.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1 in</td>
<td>0.0</td>
<td>0.6</td>
<td>8.8</td>
<td>16.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>¾ in</td>
<td>0.6</td>
<td>8.8</td>
<td>16.5</td>
<td>22.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>½ in</td>
<td>8.8</td>
<td>16.5</td>
<td>22.3</td>
<td>24.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3/8 in</td>
<td>16.5</td>
<td>22.3</td>
<td>24.6</td>
<td>Pan</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Original Sample Weight**: 25.6 lb

**Cumulative Weight**: 25.6 lb
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