Concrete Plant Quality Control Technician Course
Tennessee Department of Transportation
2020 Manual
Concrete Plant Quality Control Technician Course

Tennessee Department of Transportation

2020 Manual

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Classroom Rules

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

- Name
- Company
- Experience
- Why are you here?

Purpose of Certification

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

- Slide presentations
- Written Exam (No Phones Allowed)
  - Open-book
  - Must get 75% overall to pass
- Results
- Recertification - Every 5 years

Resources

- Course materials
  - Course textbook
  - Presentation slides and videos
- TDOT
  - Standard Specifications, January 1, 2015
  - Special Provisions
ADA Notice of Requirements

• Can be found at the following website:
  • https://www.tn.gov/tdot/government/g/public-accessibility-office/ada.html

• 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 Np. 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
Quality Control Program
(Producer)
- Training
  - Every person (TDOT, Producer, & Contractor) on the project contributes to quality
  - Individuals who oversee batching, sampling, testing, and inspections for quality control must be at least a TDOT Concrete Plant Quality Control Technician
- Testing Material
  - Before and after it is batched
  - Concrete and individual materials during production
- Quality Control Plan
  - A detailed description of the type and frequency of inspection, sampling, and testing to measure the various properties described in the specifications
  - Procedures to prevent quality deficiencies and actions for when deficiencies occur

Quality Assurance
(TDOT)
- Associated with Acceptance and Verification
- Performed by a TDOT representative
- Complies with federal requirements
- Independent of QC
Quality Assurance Testing
(SOP 1-1)

• Field QA acceptance test(s) shall be performed with same sample of concrete that cylinders are made:
  • Air Content
    • Entrained air adds to the durability of hardened concrete and the workability of fresh mixtures
  • Slump
    • Measures consistency of freshly mixed concrete
  • Temperature
    • Within tolerances
• QA acceptance test (for pay):
  • Concrete Cylinders (28 day)
# Acceptance Testing Frequencies (SOP 1-1)

<table>
<thead>
<tr>
<th>CONCRETE</th>
<th>Non-Critical Structures</th>
<th>Project Inspector</th>
<th>Placement Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready Mix, Closure Pour,</td>
<td>Cylinders (28-day),</td>
<td>Every 25 cubic</td>
<td>Refer to Standard Specification</td>
</tr>
<tr>
<td>Grout, Pre-Packaged Mix,</td>
<td>Slump, Air Content,</td>
<td>yards or less</td>
<td>604.03</td>
</tr>
<tr>
<td>Flowable Fill, Precast,</td>
<td>&amp; Mix Temperature</td>
<td>weakly</td>
<td></td>
</tr>
<tr>
<td>Class A, A</td>
<td>Complete set of tests</td>
<td>Every 100 cubic</td>
<td>Determined depth measurement per</td>
</tr>
<tr>
<td>Paving, S, X</td>
<td>shall be performed on</td>
<td>yards placed per</td>
<td>Standard Specification 501.24.</td>
</tr>
<tr>
<td>Class CP</td>
<td>the initial load for</td>
<td>day per structure</td>
<td></td>
</tr>
<tr>
<td>Class D, DS, L</td>
<td>informational purposes,</td>
<td>unless otherwise</td>
<td></td>
</tr>
<tr>
<td>Class SCC, SH-SCC</td>
<td>not for</td>
<td>specified (i.e.</td>
<td></td>
</tr>
<tr>
<td>Closure Mix</td>
<td>acceptance</td>
<td>Class X)</td>
<td></td>
</tr>
<tr>
<td>Structural Grout Pre</td>
<td>Cylinders (28-day)</td>
<td>Test first three</td>
<td>Refer to SOP 4-1 for acceptance of</td>
</tr>
<tr>
<td>packaged Mix</td>
<td></td>
<td>loads and every</td>
<td>concrete for bridge decks.</td>
</tr>
<tr>
<td>Flowable Fill</td>
<td>Cylinders (28-day)</td>
<td>50 cubic yards</td>
<td></td>
</tr>
<tr>
<td>Prestressed Completed Mix</td>
<td></td>
<td>thereafter per day</td>
<td></td>
</tr>
<tr>
<td>Structural Grout</td>
<td>Slump, Air Content,</td>
<td>One pair of</td>
<td></td>
</tr>
<tr>
<td>Prestressed</td>
<td>&amp; Mix Temperature</td>
<td>cylinders shall</td>
<td></td>
</tr>
<tr>
<td>Prestressed Completed Mix</td>
<td>for Beams</td>
<td>be cast from one</td>
<td></td>
</tr>
<tr>
<td>Prestressed</td>
<td>Cylinders (28-Day)</td>
<td>of the first three</td>
<td></td>
</tr>
<tr>
<td>Prestressed</td>
<td>for Panels/Pillar</td>
<td>passing loads.</td>
<td></td>
</tr>
<tr>
<td>Prestressed</td>
<td>Cylinders (28-Day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prestressed</td>
<td>for Tension Release</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prestressed Products</td>
<td>Visual Inspection</td>
<td>M&amp;T</td>
<td>Perform additional tests when slump</td>
</tr>
<tr>
<td>Precast Products</td>
<td>Acceptance by</td>
<td>After casting and</td>
<td>change is apparent or as directed.</td>
</tr>
<tr>
<td></td>
<td>Certification in</td>
<td>before shipment</td>
<td>One pair of backup cylinders shall</td>
</tr>
<tr>
<td></td>
<td>accordance with SOP 5-3</td>
<td></td>
<td>be made.</td>
</tr>
</tbody>
</table>

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

- TDOT requires Concrete Field Testing Technician OR ACI Level 1 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
- All personnel involved with QA and QC must receive proper training

**Record Keeping**

- **ALL records shall be available and organized for review at the facility/mobile mixer**
- 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
Ready Mix Concrete Producers
Ready Mix Concrete Producers

Ready Mix Plants

- Central-mixed
  - Concrete is mixed in a stationary mixer
- Truck-mixed
  - Concrete is mixed in a truck mixer
Initial Requirements
(SOP 4-3 : Procedures for Ready Mix Concrete Plant Certification)

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

NRMCA Certifications
(SOP 4-3)

- NRMCA Plant Certification
  - Every 2 years
- NRMCA Delivery Fleet Certification
  - Every 12 months
  - Display in window of EACH TDOT truck
- Submit copies to HQMT
Ready Mix Producers

Truck Certification Card

Certification of Concrete Production Facilities

This delivery vehicle met the requirements of the NRMCA certification program at the time of inspection.

Company: 
Truck #: 
NRMCA Cert ID # 
Exp. Date

NRMCA Plant Certification

• Conforms with requirements:
  • ASTM C 94
  • AASHTO M 157
  • CPMB 100
  • TMMB Standards

• Initial Version – Sept. 1965
• Current – 12th revision 2015
  • Electronic version May 2018

• More info on www.nrmca.org
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
Paperwork
(Ready Mix Inspection Checklist)

- Ready Mix Process Control Plan
  - Are gradations and moistures run in accordance?
- Previous Ready Mix Inspection Checklist
  - Deficiencies listed
- Concrete Truck Checklist
- Certified Technician Form
- Materials List
- Records of delivery tickets of all materials
- Records of all QC tests and inspections
- Post (board, binder, etc.) all paperwork at plant for ease of inspections

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
Ready Mix Inspection Checklist

- HQMT random audits also use this checklist
  - Plant inspection
  - Laboratory inspection
  - Must be posted at plant
- 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 AND signing each ticket for TDOT projects
Plant Equipment
(Ready Mix Inspection Checklist)

- Type of plant: central mixed or truck mixed
- Latest calibration date of aggregate and cement scales
  - Required every 6 months
- Latest calibration date of chemical admixtures
  - Required annually
- 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

- Truck Numbers
- Manufacturers Plates
- Revolution Counters
- Mixer Blade Wear
- Water Gauges
- Tag #
- Base County

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

Manufacturer’s Plate
(Concrete Truck Checklist)
## Water Meter
(Concrete Truck Checklist)

![Water Meter Image]

## Certified Technician Form

### Concrete Certified Technicians

<table>
<thead>
<tr>
<th>CONCRETE PRODUCER</th>
<th>LOCATION</th>
</tr>
</thead>
</table>

### Technician Qualifications

**Concrete Field Testing Technicians (TDOT Level 1 or equivalent)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Certification Number</th>
<th>Expiration Date</th>
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<tbody>
<tr>
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</table>

**Concrete Plant Quality Control Technicians (TDOT Level 2)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Certification Number</th>
<th>Expiration Date</th>
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<tbody>
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</tbody>
</table>

**Concrete Mix Design Technicians (TDOT Level 3 or State of TN PE)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Certification Number</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
Ready Mix Producers

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

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>TYPE/BRAND</th>
<th>PRODUCER</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Aggregate 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse Aggregate 2</td>
<td></td>
<td></td>
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<tr>
<td>Coarse Aggregate 3</td>
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<td></td>
<td></td>
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<tr>
<td>Coarse Aggregate 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Aggregate 1 (Nat.)</td>
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<td></td>
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<tr>
<td>Fine Aggregate 2 (Nat.)</td>
<td></td>
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<tr>
<td>Fine Aggregate 3 (Mfg.)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fine Aggregate 4 (Mfg.)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Cement (specify Type)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flyash (specify Class)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slag (specify Grade)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Reducer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reducer/Retarder</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High-Range Reducer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-Range Reducer/Retarder</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Entrainer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mix Designs

- Each plant shall have an approved (current year) concrete mix design as outlined in SOP 4-4: Procedures for Submittal and Approval of Concrete Mixture
- 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

(S01.03.B.12)

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

- Date
- Contract Number
- County
- Class of concrete
- TDOT Concrete design number
- Number of cubic yards
- Load Number
- Truck Number
- Max Water Allowed by Design
- Actual water added on a project
- Number of revolutions at mixing speed at plant
- Number of revolutions at mixing speed at project
- Time Loaded
- Time Discharged
- Actual target batch weights of each component including each aggregate, chemical, and mineral admixture used
- TDOT Concrete Plant Quality Control Technician signature
Ready Mix Producers

Delivery Ticket
(Format DT-1756)

- 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
  - T-50
  - Visual Stability Index
  - Passing Ability

Project Specific Checks
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

• 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
### Typical Applications

- Volumetric Mobile Mixers lend themselves to a wide variety of applications, which TDOT does not limit.
  - Minor structures – Small Deliveries
  - Mixtures with Short Working Times – Rapid Set
  - Bridge Deck Repairs - Latex-modified overlays (PMC)
  - Remote Sites – Long Haul Times
- Typical Volumetric Mobile Mixers carry enough materials to produce 6 to 10 yd$^3$ of concrete.

### Volumetric Specification (Specification 604.04.B)

- TDOT Specification 604.04.B for volumetric continuous mixers
  - Equipment requirements
  - Calibration/Operation
    - Must be performed by an individual with BOTH certifications:
      - **TDOT Concrete Field Testing Technician**
      - **VMMB Volumetric Mixer Operator**
  - Aggregate moisture contents and gradations
    - Must be performed by an individual with Either Certification:
      - **TDOT Plant Quality Control Technician**
      - **TDOT Aggregate Technician**
Volumetric Notables

- Each mobile unit considered its own unique producer
- Paperwork to be kept in each mobile unit
  - Process Control Plan
  - Certified Technicians
  - Approved mix designs
  - Materials list
  - Calibration procedure
- Batch/delivery tickets must be signed by VMMB Certified Volumetric Mixer Operator
- Contractor Daily Reports are still required

Calibration and Yield

- Calibrations are done on each material to make sure proportions are correct for:
  - Cement
  - Fine aggregate
  - Coarse aggregate
  - Water
  - Admixtures
- Yield checks are used to verify precise calibration
Volumetric Concrete Video
4

Precast & Prestressed Concrete Producers
Precast & Prestressed Concrete Producers

Precast Concrete

- Concrete products cast at facility and shipped to field
  - 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: Manufacture and Acceptance of Precast Concrete Products)

- 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
  - 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
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 (or equivalent)
  - 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 according to Process Control Plant (at least once per month per SOP 5-3)
**Laboratory & Testing Equipment**
*(Precast Inspection Checklist)*

- Type A Lab required
- Testing equipment shall be calibrated annually
  - 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 and repaired products shall be marked
Verification Testing
(SOP 5-3)

- 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: Procedures for Pre-stress Concrete Construction)

- 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
  - Report which show failures based on design used, not the product requirements
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 6 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
5

Best Management Practices for Concrete
Best Management Practices for Concrete

- 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

High Ambient Temperatures
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

- 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
- Sensitive to additional water
  - Additional moisture testing
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
- Belt Template
- Mechanical Sampling Systems
- Sample Containers
- Tags
Purpose

- Sampling is equally as important as the testing of the aggregate
- Proper sampling is crucial to obtain representative samples for tests to have meaning

Revised Reasons for sampling aggregate:

- Preliminary investigation of the potential source of supply
- Control of the product at the source
- Control of the operations at the site of use
  - Project site
  - Asphalt or Concrete Plant
- Acceptance or rejection of the materials
  - TDOT Standard Specifications
<table>
<thead>
<tr>
<th>Nominal Maximum Aggregate Size</th>
<th>Minimum Field Sample Mass, lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>#8</td>
<td>22</td>
</tr>
<tr>
<td>#4</td>
<td>22</td>
</tr>
<tr>
<td>3/8”</td>
<td>22</td>
</tr>
<tr>
<td>1/2”</td>
<td>35</td>
</tr>
<tr>
<td>3/4”</td>
<td>55</td>
</tr>
<tr>
<td>1”</td>
<td>110</td>
</tr>
<tr>
<td>1 1/2”</td>
<td>165</td>
</tr>
<tr>
<td>2”</td>
<td>220</td>
</tr>
<tr>
<td>2 1/2”</td>
<td>275</td>
</tr>
<tr>
<td>3”</td>
<td>330</td>
</tr>
<tr>
<td>3 1/2”</td>
<td>385</td>
</tr>
</tbody>
</table>
Methods of Sampling

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

Flowing Aggregate Stream (by mechanical means)

- Three increments
- Each increment obtained using a suitable sampling device
- Device must be capable of interrupting the entire flow of material as it passes off the belt
Sampling

**Conveyor Belt**

- Three increments
- Production must be suspended while sampling
- Lockout-tagout (MSHA required)
- Templates useful for defining sampling area
- All material within sampling area is removed including fines (with a brush)

**Stockpiles**

- Stockpiles have a tendency to segregate during their construction
  - Segregation is the separation of varying sizes of aggregate
  - Sampling with power equipment is the preferred method
With Power Equipment

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

With Power Equipment

- The loader is then used to backblade the smaller stockpile one time
- Divide the sample pad into four 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

Without Power Equipment

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 in. 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

**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 the stockpile

---

**Sampling Tubes**

- 6 ft minimum
- 1 ¼ in. minimum
Roadways

- Three increments from random locations
- Sample obtained from uncompacted or loosely-compacted base or subgrade material
- Full depth of layer must be sampled
- Avoid contamination from underlying material

Transportation Units

- Railroad cars, barges, trucks
- Avoid if at all possible, due to segregation during transport
- Power equipment is recommended
- Various levels and random locations
- Three or more trenches
  - Three increments from each trench
Sample Containers

- Durable
- OSHA requirement \( \leq 50 \text{ lbs} \)
- Portion the sample if necessary
- Use an appropriate container for the test to be performed

Tagging a Sample

- Project Number: 55001-3231-18
- Date Sampled: 11 Mar 02  Submitted: 12 Mar 02
- Sampled by: F. Flintstone
- Submitted by: F. Flintstone
- Producer: Stone Materials, Inc.
- Pit Number: 185  Sampled from: Stockpile
- County: Davidson  Region: 3
Submitting a Sample

Questions
Reducing Samples of Aggregates 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

Purpose

• It may not be practical to use the entire representative field sample for a particular test
• Properly reducing the field sample to the required test size will ensure it remains a representative sample
Methods of Reduction

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

Moisture condition of the aggregate

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

Size of aggregate

- Coarse
- Fine
- Combined
## Determine Method

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

- **Method A** - Mechanical Splitter
- **Method B** - Cone and Quarter
- **Method C** - Miniature Stockpile
Mechanical Splitter/Method A (Coarse & Combined)

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

Mechanical Splitter/Method A (Fine Aggregate)

- Even number of chutes
- Chutes of equal width
- At least 12 chutes
- Individual chutes ½ in. to ¾ in. 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)

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

---

**Purpose**

- Accurately determine how much water is in the aggregate
- Used to make moisture corrections for batching concrete
- Indicates to asphalt producers how much water they will have to dry
- TDOT will deduct weight of total moisture of base material in excess of 3% of optimum moisture content (303.14.B)
Apparatus

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

Sample Size

<table>
<thead>
<tr>
<th>TABLE 1 Sample Size for Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Maximum Size of Aggregate, mm (in.)</td>
</tr>
<tr>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>4.75 (0.187) (No. 4)</td>
</tr>
<tr>
<td>9.5 (%)</td>
</tr>
<tr>
<td>12.5 (%)</td>
</tr>
<tr>
<td>19.0 (%)</td>
</tr>
<tr>
<td>25.0 (1)</td>
</tr>
<tr>
<td>37.5 (1½)</td>
</tr>
<tr>
<td>50 (2)</td>
</tr>
<tr>
<td>63 (2½)</td>
</tr>
<tr>
<td>75 (3)</td>
</tr>
<tr>
<td>90 (3½)</td>
</tr>
<tr>
<td>100 (4)</td>
</tr>
<tr>
<td>150 (6)</td>
</tr>
</tbody>
</table>

* Based on sieves meeting Specification E11.

a Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m³ (determined using Test Method C29/C29M) and dividing by 1600.
Samples

Determine Sample Mass

- Weigh the sample to the nearest 0.1%

Example:
- 6285.6 g will be reported as 6286 g
**Dry the Sample**

- Dry the aggregate to a constant mass (does not vary more than 0.1%) in an oven at 230 ± 9°F.
- If using a heat source other than oven, stir periodically to accelerate drying and prevent localized overheating.
- Allow the material to cool.

**Reweigh the Sample**

- Weigh the sample to the nearest 0.1%.

6164 g
Moisture Content (MC) Calculations

\[ MC(\%) = \frac{(M_{\text{Original}} - M_{\text{Dry}})}{M_{\text{Dry}}} \times 100 \]

\[ MC(\%) = \frac{(W - D)}{D} \times 100 \]

Given:
• Weight of the original sample (W) = 1206 g
• Weight of sample after drying (D) = 1132 g

Determine:
• Total Moisture Content of the aggregate
Solution

\[ MC(\%) = \frac{W - D}{D} \times 100 \]

\[ MC(\%) = \]

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>568.3</td>
<td>560.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1357</td>
<td>1342</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>924.0</td>
<td>920.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1828</td>
<td>1739</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Moisture Content

Practice

- Determine the percent moisture content in the wet condition:

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

Practice

- Determine the percent of free moisture on the sample:
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:**

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

---

**Formulas**

**Corrected Aggregate Batch Weight:**

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

**Corrected Batch Water:**

\[ Batch\ Water = Design\ Water - MWC \]
<table>
<thead>
<tr>
<th>Moisture Correction Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Calculate Percent Free Moisture in Aggregates</td>
</tr>
<tr>
<td>2. Determine SSD Batch Weights</td>
</tr>
<tr>
<td>3. Calculate Aggregate Moisture Corrections</td>
</tr>
<tr>
<td>4. Calculate Mix Water Correction</td>
</tr>
<tr>
<td>5. Calculate the Corrected Aggregate Batch Weights</td>
</tr>
<tr>
<td>6. Calculate the Corrected Batch Water</td>
</tr>
</tbody>
</table>
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 (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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>30</td>
<td></td>
<td></td>
<td>1912</td>
<td>1138</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
### Example #2

<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>m³ (yd³)</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></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>1.1%</td>
<td>2.5%</td>
</tr>
<tr>
<td>SSD Batch Wts.</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td>1810</td>
<td>1229</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

Purpose

- Accurately determine the amount of material finer than No. 200 sieve (dust)
- Dust can be separated from larger particles by wet sieving completely and more efficiently as compared to dry sieving
- Too much dust could be detrimental to concrete and asphalt mixtures
Apparatus

- Balance
- Sieves (No. 16 & No. 200)
- Container
- Oven
- Wetting Agent
- Mechanical Washer (optional)

Sample Size

<table>
<thead>
<tr>
<th>Nominal Maximum Size&lt;sup&gt;A&lt;/sup&gt;</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>

<sup>A</sup> Based on sieve sizes meeting Specification E11.
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%
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 (decant) the wash water with suspended solids over the nested sieves
- Take care to avoid decanting coarse aggregate
Procedure

• Repeat the washing with plain water until wash water is clear
• Use wetting agent on the 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
• Do not decant excess water from container, must evaporate by drying

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%

Percent (P) ≤ No. 200 Calculations

\[ P_{\text{≤ No. 200}} = \left( \frac{M_{\text{Dry After}} - M_{\text{Dry Before}}}{M_{\text{Dry Before}}} \right) \times 100 \]
Results

- If the percent (P) of material finer than No. 200 is less than 10%, then report the results to the nearest 0.1

- If the percent (P) of material finer than No. 200 is greater than 10%, then report the results to the nearest whole number

Problem

Given:
- Original mass of the sample = 475.6 g
- Mass of the sample after washing = 439.3 g

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

\[ P_{\leq \text{No. 200}} = \frac{(M_{\text{Dry, Before}} - M_{\text{Dry, After}})}{M_{\text{Dry, Before}}} \times 100 \]

\[ P_{\leq \text{No. 200}} = \]

Practice

Given:
• Original mass of the sample = 5893 g
• Mass of the sample after washing = 5017 g

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

\[
P_{\text{S.No.200}} = \frac{(M_{\text{Dry,Before}} - M_{\text{Dry,After}})}{M_{\text{Dry,Before}}} \times 100
\]

\[
P_{\text{S.No.200}} =
\]
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

Purpose

- Determine particle size distribution of an aggregate
- Determine compliance of specification requirements
- Quality control of crushing and screening process
- In aggregate products and mixtures, it is useful for determining relationships with porosity and density
Aggregate Gradation

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

Apparatus

- Balance
- Oven
- Sieves
- Mechanical Shaker
# 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 ((\frac{3}{8}))</td>
<td>1 (2)</td>
</tr>
<tr>
<td>12.5 (1(\frac{1}{2}))</td>
<td>2 (4)</td>
</tr>
<tr>
<td>19.0 ((\frac{3}{4}))</td>
<td>5 (11)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>10 (22)</td>
</tr>
<tr>
<td>37.5 (1(\frac{1}{2}))</td>
<td>15 (33)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>20 (44)</td>
</tr>
<tr>
<td>63 (2(\frac{1}{2}))</td>
<td>35 (77)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>60 (130)</td>
</tr>
<tr>
<td>90 (3(\frac{1}{2}))</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%
Sieves

- Select appropriate sieves and check before use

Overloaded Sieve

Options for Overloading
- Use larger sieve
- Portion the sample
- Place another sieve size 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>Sieving Area, m²</th>
<th>203.2-mm, dia&lt;sup&gt;b&lt;/sup&gt;</th>
<th>254-mm, dia&lt;sup&gt;b&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>125 mm (5 in.)</td>
<td>c</td>
<td>0.0285</td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>67.4</td>
</tr>
<tr>
<td>100 mm (4 in.)</td>
<td>c</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>53.9</td>
</tr>
<tr>
<td>90 mm (3 ½ in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>48.5</td>
</tr>
<tr>
<td>75 mm (3 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>40.5</td>
</tr>
<tr>
<td>63 mm (2 ½ in.)</td>
<td>c</td>
<td></td>
<td></td>
<td></td>
<td>0.1225</td>
<td>0.2158</td>
<td>34.0</td>
</tr>
<tr>
<td>50 mm (2 in.)</td>
<td>c</td>
<td></td>
<td></td>
<td></td>
<td>0.1225</td>
<td>0.2158</td>
<td>27.0</td>
</tr>
<tr>
<td>37.5 mm (1 ½ in.)</td>
<td>3.6</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>20.2</td>
</tr>
<tr>
<td>25.0 mm (1 in.)</td>
<td>1.8</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>13.5</td>
</tr>
<tr>
<td>19.0 mm (1/4 in.)</td>
<td>1.4</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>10.2</td>
</tr>
<tr>
<td>12.5 mm (1/2 in.)</td>
<td>0.89</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>6.7</td>
</tr>
<tr>
<td>9.5 mm (3/8 in.)</td>
<td>0.67</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>5.1</td>
</tr>
<tr>
<td>4.75 mm (No. 4)</td>
<td>0.33</td>
<td></td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
<td>2.6</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 the original sample mass
- May weigh sieves individually or cumulatively
AASHTO Loss

- 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

- Cumulative %Retained = \( \frac{\text{Cumulative Wt Retained}}{\text{Original Sample Wt}} \times 100 \)

- Cumulative %Passing = 100 – Cumulative %Retained

- Report results to the nearest whole number
  - Except the No. 200 sieve when it is less than 10%
Sample Problem #1

<table>
<thead>
<tr>
<th>Natural Sand for Concrete</th>
<th>503.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Sample Weight (g)</td>
<td></td>
</tr>
<tr>
<td>No. 4</td>
<td>0.0</td>
</tr>
<tr>
<td>No. 8</td>
<td>49.0</td>
</tr>
<tr>
<td>No. 16</td>
<td>146.0</td>
</tr>
<tr>
<td>No. 30</td>
<td>259.0</td>
</tr>
<tr>
<td>No. 50</td>
<td>368.0</td>
</tr>
<tr>
<td>No. 100</td>
<td>466.0</td>
</tr>
<tr>
<td>No. 200</td>
<td>494.0</td>
</tr>
<tr>
<td>Pan</td>
<td>503.0</td>
</tr>
</tbody>
</table>

Sieve Analysis

- AASHTO Loss = \( \frac{\text{Original Sample Wt} - \text{Total Cumulative Wt}}{\text{Original Sample Wt}} \times 100 \)
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Retained (g)</th>
<th>Cumulative % Retained</th>
<th>Specification 903.01</th>
<th>Meets? Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4</td>
<td>0.0</td>
<td>95 - 100</td>
<td>503.01</td>
<td>-</td>
</tr>
<tr>
<td>No. 8</td>
<td>49.0</td>
<td>50 - 90</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>No. 16</td>
<td>146.0</td>
<td>50 - 90</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>No. 30</td>
<td>259.0</td>
<td>5 - 35</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>No. 50</td>
<td>368.0</td>
<td>5 - 35</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>No. 100</td>
<td>466.0</td>
<td>0 - 20</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>No. 200</td>
<td>494.0</td>
<td>0 - 3</td>
<td>95 - 100</td>
<td>-</td>
</tr>
<tr>
<td>Pan</td>
<td>503.0</td>
<td></td>
<td>95 - 100</td>
<td>-</td>
</tr>
</tbody>
</table>

Original Sample Weight: 503.5 g
Fineness Modulus (FM)

- Numerical value to indicate fineness of aggregate
- Higher fineness modulus means material is more coarse
- Aggregate with same fineness modulus will require the same quantity of water to produce a mix of the same consistency and strength
- For concrete sand, 2.3 - 3.1 is specified
<table>
<thead>
<tr>
<th>Sieve Diameter</th>
<th>3 in.</th>
<th>1 1/2 in.</th>
<th>3/4 in.</th>
<th>3/8 in.</th>
<th>No. 4</th>
<th>No. 8</th>
<th>No. 16</th>
<th>No. 30</th>
<th>No. 50</th>
<th>No. 100</th>
<th>Total</th>
<th>FM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Add Cumulative Percent Retained on</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Divide by 100</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sample Problem #2

<table>
<thead>
<tr>
<th>#57 Limestone</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Sample Weight (lbs)</td>
<td>25.60</td>
</tr>
<tr>
<td>Sieve Size</td>
<td>Cumulative Weight Retained</td>
</tr>
<tr>
<td>1 1/2 in.</td>
<td>0.00</td>
</tr>
<tr>
<td>1 in.</td>
<td>0.00</td>
</tr>
<tr>
<td>3/4 in.</td>
<td>0.60</td>
</tr>
<tr>
<td>1/2 in.</td>
<td>8.80</td>
</tr>
<tr>
<td>3/8 in.</td>
<td>16.50</td>
</tr>
<tr>
<td>No. 4</td>
<td>24.30</td>
</tr>
<tr>
<td>No. 8</td>
<td>24.60</td>
</tr>
<tr>
<td>Pan</td>
<td>25.40</td>
</tr>
</tbody>
</table>

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

AASHTO Loss =
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Cumulative Wt Retained (lbs)</th>
<th>Cumulative % Retained</th>
<th>Specification 903.22</th>
<th>Meets? Yes/No</th>
<th>Cumulative %Passing</th>
<th>Retained (lbs)</th>
<th>Cumulative %Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ½ in</td>
<td>0.00</td>
<td>0.00</td>
<td>95 - 100</td>
<td>-</td>
<td>95 - 100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1 in</td>
<td>0.60</td>
<td>0.60</td>
<td>25 - 60</td>
<td>-</td>
<td>25 - 60</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>¾ in</td>
<td>8.80</td>
<td>8.80</td>
<td>0 - 10</td>
<td>0</td>
<td>0 - 10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>½ in</td>
<td>16.50</td>
<td>16.50</td>
<td>0 - 5</td>
<td>5</td>
<td>0 - 5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>3/8 in</td>
<td>22.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 4</td>
<td>24.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 8</td>
<td>25.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pan</td>
<td>25.60 lbs</td>
<td>Original Sample Weight</td>
<td>25.60 lbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TDOT Materials and Tests Website User Guide

To View Concrete Information

Click here
Field Operations

- Scroll down to see the following

Concrete Ready Mix Information
- Concrete Producer Comment Form (PDF)
- Concrete Track Checklist
- Certified Technician Form
- Materials List
- Batch Plant Process Control Plan
- Placement Site Process Control Plan
- Process Control Inspection Checklist (PDF) February 28, 2014

Concrete Precast and Prestressed Information
- List of Approved Precast Suppliers
- Precast/Prestressed Mix Design Template (Excel) June 6, 2019
- Concrete Design Contract Association Request Form (Excel)
- Precast Inspection Checklist (PDF) December 19, 2013

To View SOPs

Click here
Appendix

Contacts

• Regional Contacts
  • Region 1: Brad Baskette - 865-594-4552
  • Region 2: Tony Renfro - 423-510-1190
  • Region 3: Kevin Isenberg - 615-350-4312
  • Region 4: Mitch Blankenship - 731-935-0215

• HQMT Training Coordinator
  • Kim Whitby – 615-350-4158; Kimberly.Whitby@tn.gov
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.cmecc.org/
- Portland Cement Association
  - www.cement.org/
## SOP 1-1 Table

### Part Three: Verification/Check Samples and Tests

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Material</th>
<th>Test</th>
<th>Sampled by</th>
<th>Frequency</th>
<th>Location or Time of Sampling</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONCRETE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beach fill,承土料, fill, coarse, fine, coarse aggregate, fine aggregate,</td>
<td>Laboratory analysis</td>
<td>BST</td>
<td>Every two months</td>
<td>Concrete plant</td>
<td>Eight to ten pounds sample shall be sent to NG NSI Lab.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Precast Products

<table>
<thead>
<tr>
<th>Material</th>
<th>Grading</th>
<th>Project Inspector or BST</th>
<th>Verification in accordance with SOP 5-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preplaced in Place (PL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Coarse &amp; Fine</td>
<td>Per month</td>
<td>Concrete plant</td>
<td>Perform such test on fine aggregate only when percent passing the No. 200 sieve dry exceeds 2.5%.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SOP 5-3 Table

### Appendix A: Minimum Testing Frequencies for Product Acceptance

<table>
<thead>
<tr>
<th>Product</th>
<th>D Load (0.4% strain)</th>
<th>Ultimate Load</th>
<th>Absorption</th>
<th>Compressive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box Culvert</td>
<td>N/A</td>
<td>N/A</td>
<td>1/year</td>
<td>1/day min.</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>N/A</td>
<td>N/A</td>
<td>1/year</td>
<td>1/day min.</td>
</tr>
<tr>
<td>Concrete Block - Gravity, MSE, Noise, MSE, and Retaining Wall Panels</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1/day min.</td>
</tr>
<tr>
<td>Structural Spans</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1/day min.</td>
</tr>
<tr>
<td>Reinforced Concrete Pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round Pipe: Diameter ≥36&quot;</td>
<td>1/day</td>
<td>1/month</td>
<td>1/year</td>
<td>D-Load</td>
</tr>
<tr>
<td>Round Pipe: Diameter &lt;36&quot;</td>
<td>1/month</td>
<td>1/year</td>
<td>1/week or compressive strength</td>
<td>1/year</td>
</tr>
<tr>
<td>Elliptical Pipe: &lt;29&quot; x 45&quot;</td>
<td>1/month</td>
<td>1/year</td>
<td>1/week or compressive strength</td>
<td>1/year</td>
</tr>
<tr>
<td>Elliptical Pipe: ≥29&quot; x 45&quot;</td>
<td>1/week</td>
<td>1/month</td>
<td>1/year</td>
<td>D-Load</td>
</tr>
</tbody>
</table>

**TN**
## SOP 5-3 Table

### Appendix B: Minimum Testing Frequencies for Product Verification

<table>
<thead>
<tr>
<th>Product</th>
<th>D-Load (ft-lb/cu ft)</th>
<th>Ultimate Load</th>
<th>Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast Products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box Culverts</td>
<td>N/A</td>
<td>N/A</td>
<td>1/week</td>
</tr>
<tr>
<td>Endwalls</td>
<td>N/A</td>
<td>N/A</td>
<td>1/week</td>
</tr>
<tr>
<td>Manholes</td>
<td>N/A</td>
<td>N/A</td>
<td>1/week</td>
</tr>
<tr>
<td>Concrete Block Gravity, MSE, Noise Walls, Noise, MSE, and Retaining Wall Panels</td>
<td>N/A</td>
<td>N/A</td>
<td>1/week</td>
</tr>
<tr>
<td>Structural Spans</td>
<td>N/A</td>
<td>N/A</td>
<td>1/week</td>
</tr>
<tr>
<td>Reinforced Concrete Pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round Pipe - Diameter ≥30&quot;</td>
<td>1/week</td>
<td>1/6 months</td>
<td>D-Load</td>
</tr>
<tr>
<td>Round Pipe - Diameter ≥30&quot;</td>
<td>1/week or compressive strength</td>
<td>1/month or compressive strength</td>
<td>1/week or D-Load</td>
</tr>
<tr>
<td>Arch Pipe - 26½&quot; x 43½&quot; (239.07 x 426.73)</td>
<td>1/month</td>
<td>1/6 months</td>
<td>D-Load</td>
</tr>
<tr>
<td>Arch Pipe - ≥36½&quot; x 43½&quot; (329.87 x 426.73)</td>
<td>1/month or compressive strength</td>
<td>1/month or compressive strength</td>
<td>1/month or Ultimate Load</td>
</tr>
<tr>
<td>Elliptical Pipe - 30&quot; x 45&quot;</td>
<td>1/month</td>
<td>1/6 months</td>
<td>D-Load</td>
</tr>
<tr>
<td>Elliptical Pipe - ≥29&quot; x 45&quot;</td>
<td>1/month or compressive strength</td>
<td>1/month or compressive strength</td>
<td>1/month or Ultimate Load</td>
</tr>
</tbody>
</table>