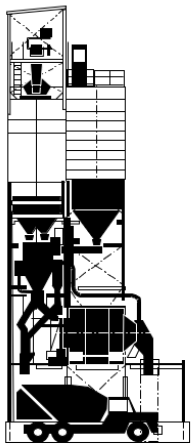
TN TDOT Department of Transportation



Concrete Plant Quality Control Technician Course

Division of Materials and Tests

2024

Concrete Plant Quality Control Technician Course

Tennessee Department of Transportation

2024 Manual

Table of Contents

TN TDOT Department of Transportation

WELCOME!

Concrete Plant Quality Control Technician Course

Purpose of Certification

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

TN TDOT Department of Transportation

Course Highlights

- Slide presentations
- Written Exam (No Phones Allowed)
  - Closed Book – Multiple Choice
  - Must get 70% overall
- Results sent within 30 days

TN TDOT Department of Transportation

Recertification – SOP 1-3 Update

Certification Program	Required for:	Certification Valid for:	Required Per Specification:	Description of Workshop
Asphalt Level 1 Roadway Paving Inspector	TDOT, CEI, and Contractor paving inspectors and foreman	5 years	407.14	Classroom presentation and written exam.
Asphalt Level 1 Roadway Paving Inspector RECERTIFICATION	TDOT, CEI, and Contractor paving inspectors and foreman	5 years	407.14	Online training and testing
Asphalt Level 2 Concrete Plant Technician	TDOT, CEI, and Contractor Acceptance and Process Control	5 years	407.03 (D)2(a)	Classroom presentation, laboratory/test demonstration, written exam, and laboratory/test proficiency demonstrations.
Asphalt Level 3 Concrete Mixture Design Technician	TDOT Verification and Contractor Mix Designers	5 years	407.03(C)1	Classroom presentation, written exam, and laboratory/test proficiency demonstrations.
Concrete Field Testing Technician	TDOT, CEI, and Contractor Field Acceptance and Process Control	5 years	501.03(B) 604.03(B)	Classroom presentation, test method demonstration, written exam, and performance exam.
Concrete Field Testing Technician RECERTIFICATION	TDOT, CEI, and Contractor Field Acceptance and Process Control	5 years	501.03(B) 604.03(B)	Classroom workshop/presentation, written exam, and performance exam.
Concrete Plant Quality Control Technician	Contractor Concrete Plant Process Control	5 years	501.03(B) 604.03(B)	Classroom presentation of test methods, and written exam
Concrete Plant Quality Control Technician RECERTIFICATION	Contractor Concrete Plant Process Control	5 years	501.03(B) 604.03(B)	Continuing Education Units (CEU) via annual attendance at TDOT Annual OR Regional Producer's Meeting

TN TDOT Department of Transportation

Resources

- Course materials
  - Course manual
  - Presentation slides and videos
- TDOT
  - Standard Specifications
    - Supplemental Specifications
  - Special Provisions
  - https://www.tn.gov/tdot/materials-and-tests.html

TN TDOT Department of Transportation

ADA Notice of Requirements

- To be in compliance with TDOT's 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
- Can be found at the following website:
  - https://www.tn.gov/tdot/government/g/ada-office0.html

TN TDOT Department of Transportation

Tell Us About Yourself

- Who are you?
- Where do you work?
- What experience do you have?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

1

Quality Assurance & Quality Control

Introduction to

Quality Control & Quality Assurance

References

Standard Specifications

Standard Operating Procedure (SOP)

FHWA-HIF-07-004

TN TDOT Department of Transportation

FHWA Definition of 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
- How often should TDOT discover failing material?
  - Rarely if ever

TN TDOT Department of Transportation

Quality Control Program (Producer)

- Training
  - Every person (TDOT, Producer, & Contractor) on the project contributes to quality
  - Individuals who oversee producing, sampling, testing, and inspections for quality control must be at least a certified TDOT Aggregate Technician
- Testing Materials
  - Before and after it is produced
  - 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

TN TDOT Department of Transportation

Quality Assurance (TDOT)

- Associated with Acceptance and Verification Performed by a TDOT representative
- Complies with Code of Federal Regulations
  - 23 CFR 637
- Independent of QC

TN TDOT Department of Transportation

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 (freeze/thaw) of hardened concrete and the workability of fresh mixtures
  - Slump/ Slump Flow
    - Measures consistency of freshly mixed concrete
  - Temperature
    - Within tolerances
- QA acceptance test (for pay):
  - Concrete Cylinders (28 day)

TN TDOT Department of Transportation

Acceptance Testing Frequencies (SOP 1-1)

CONCRETE						
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified	Minor Structures	Cylinders (28-day), Slump, Air Content, & Mix Temperature Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance	Project Inspector	Every 25 cubic yards or less weekly	Placement site	Refer to Standard Specification 604.11. B.
	Class A, A Paving, S, X			Every 100 cubic yards placed per day per structure		Sampling frequency for Class X may be otherwise specified
	Class CP			Every 400 cubic yards placed per day		Determine depth measurement per Standard Specification 501.24.
	Class PEM	Cylinders (28-day), Slump, Air Content, & Mix Temperature		Every 100 cubic yards placed per day per structure		Refer to Standard Specification 604.03 A.1. d.
	Class D, DS, L	Cylinders (28-day), Slump, Air Content, & Mix Temperature		Test first three loads and every 50 cubic yards thereafter per day per structure One pair of cylinders shall be cast from one of the first three passing loads		Refer to SOP 4-1 for acceptance of concrete for bridge decks
	Class SCC, SH-SCC	Cylinders (28-day), Slumpflow, Air Content, Mix Temperature, Passing Ability by J-Ring, VSI, & T-50				
	Closure Pour Mix	Cylinders (28-day)		Beginning, middle, and end of the pour		
	Structural Grout	Cylinders (28-day)		Per day		Test/Record acceptance cylinders in accordance with AASHTO T22
	Pre-packaged Concrete Mixture	Cylinders (28-day)				Use limited to 2 cubic yards per day
	Flowable Fill	Slumpflow, Mix Temperature, & Cylinders (28-day)		Every 100 cubic yards placed per day		Cylinders required for excavatable only
	Polymer Modified (PMC)	Cylinders (28-day), Slump, Air Content		Every 200 square yards placed per structure		
	Prestressed Completed Mix	Slump, Air Content, and Mix Temperature	M&T or Contractor monitored by TDOT personnel	Per pour	Prestress plant	Perform additional tests when slump change is apparent or as directed
		Cylinders (28-Day) for Beams		Per Beam		One pair of backup cylinders shall be made. The backup cylinders shall not be tested prior to 28 days
		Cylinders (28-Day) for Panels/Piling		Beginning and end of the pour		
		Cylinders (28-Day) for Tension Release		As needed		
	Prestressed Products	Visual Inspection	M&T	After casting and before shipment		Refer to SOP 5-4
Precast	Precast Products, Reinforced Concrete Pipe	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. After proper installation, the inspector shall determine if the product fitment is in accordance to contract plans.
		Visual Inspection	Project Inspector	Per Product	Project Site	
	Sound Absorbing Noise Walls	Acceptance by certification in accordance with SP 718NB				
	Noise Walls/ Reinforced Concrete Panels	Acceptance by certification that product meets compressive strength, air, slump or slump flow, and dimensional tolerances as outlined below				Producer to supply letter of certification with each lot Test results must meet the requirements of shop drawings, contract plans, and/or mix design requirements
		Cylinders (28-day)	Producer	A pair of 4"x8" cylinders shall be made at a minimum of three (3) random points during production.	Production Facility	
		Air, Slump or Slumpflow	Producer	One (1) test each per day	Production Facility	
		Dimensional Check	Producer	Per Product	Production Facility	
Shotcrete	Shotcrete	Production Test Panel OR Shotcrete facing	Producer/ Contractor	At beginning of project and every 5000 SF thereafter	Project Site	Minimum nine 3-inch diameter cores are required for testing Producer/Contractor shall provide third party test results for compressive strength (28-day) and boiled water absorption testing

TN TDOT Department of Transportation

TDOT Required Training

- TDOT requires Concrete Field Testing Technician **OR** ACI Concrete Field Testing Technician - Grade 1 certification as a prerequisite to the Concrete Plant Quality Control Technician certification
  - If SCC is being produced and ACI Concrete Field Testing Technician - 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

TN TDOT Department of Transportation

Record Keeping

- **ALL records shall be available and organized in a binder 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 facility must be continuously monitored and regularly calibrated
- Checklist items covered later in presentation

TN TDOT Department of Transportation

Let's Review

- Who performs quality assurance testing?
- What term describes a set of activities carried out by the contractor to ensure concrete meets requirements?
- Concrete facilities/truck records should be_____.

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

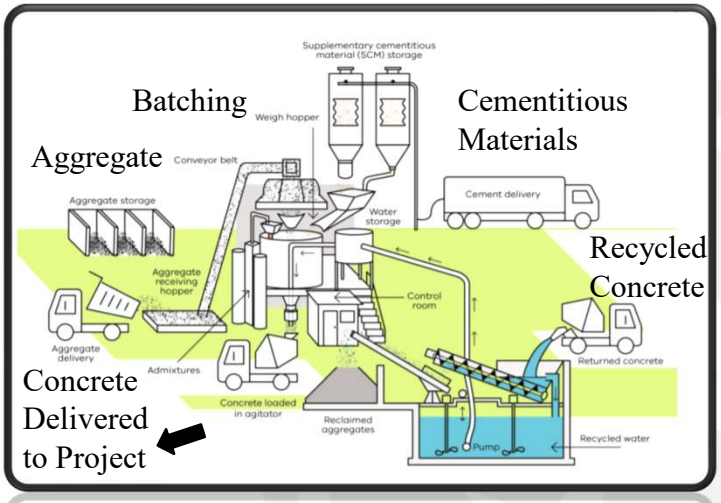
2

Ready Mix Concrete Producers

Ready Mix Concrete Producers

TN TDOT Department of Transportation

Concrete Production



TN TDOT Department of Transportation

Batching Concrete (604.11)

- Individual material weights, when compared to the mix design, shall be batched within the following tolerances:
  - Cementitious material: -1% to +4%
  - Aggregates: ±1.5%
  - Water: ±1% (not to exceed w/cm ratio)
  - Admixtures: ± 3%
- Both Central and Transit Mix plants can be computer assisted using a batch computer

TN TDOT Department of Transportation

Batching Concrete

- Transit Mix Plants
  - Ingredients (less water) are discharged into a truck
  - Water is discharged into the mixer truck
  - Concrete is mixed in trucks
- Central Mix Plants
  - Ingredients (including water) are discharged into a Central Concrete Mixer
  - Concrete is mixed in central mixer and then agitated on the way to job

TN TDOT Department of Transportation

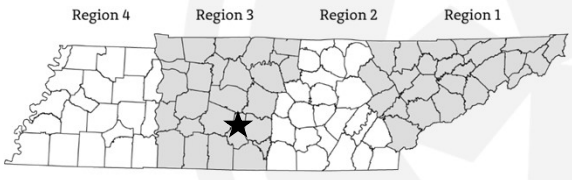
Initial Requirements (SOP 4-3)

- SOP 4-3: Procedures for Ready Mix Concrete Plant Certification
- Quality Monitoring (Regional M&T)
- Paperwork (ALL MUST BE KEPT IN A BINDER)

TN TDOT Department of Transportation

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



TN TDOT Department of Transportation

Paperwork (Ready Mix Inspection Checklist)

- Ready Mix Process Control Plan
  - Are gradations and moistures run in accordance?
- Previous Ready Mix Inspection Checklist
  - Deficiencies listed
  - Corrective Actions Response Form
- Concrete Truck Checklist
- Certified Technician Form
- Materials List
- Records of delivery tickets of all materials
- Records of all QC tests and inspections
- **Keep all paperwork in a binder at plant for ease of inspections**

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Ready Mix Inspection Checklist

- HQMT random audits also use this checklist
  - Plant inspection
  - Laboratory inspection
  - Must be kept in TDOT binder
- Any comments or concerns will be noted
  - All deficiencies must be corrected
  - HQMT partners with Regional M&T to ensure all deficiencies corrected

TN TDOT Department of Transportation

Corrective Action Response (CAR) Form

- Ready Mix Inspection Checklist
  - Producers have 30 days from the day of the audit to correct deficiencies.
  - Proof of correction must be sent to HQMT along with completed CAR form.
  - Producer may request an extension detailing why more time is needed for TDOT approval
  - Failure to correct deficiencies will result in no new mix designs being issued for the facility
  - Continued noncompliance could result in inactivation on Producer List at TDOT's discretion

TN TDOT Department of Transportation

General Observations (Ready Mix Inspection Checklist)

- Method for lowering mix temperature
- Method for raising mix temperature
- TDOT Concrete Plant Quality Control Technician verifies the tests when concrete is being batched **AND** signs each ticket for TDOT projects

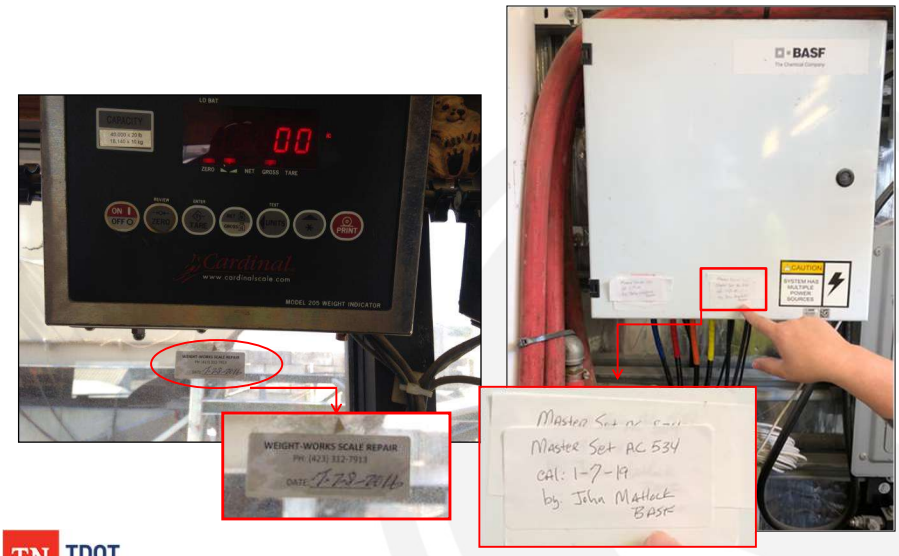
TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Calibrations (Ready Mix Inspection Checklist)



TN TDOT Department of Transportation

Stockpile Maintenance (Ready Mix Inspection Checklist)

TN TDOT Department of Transportation

Bin Maintenance (Ready Mix Inspection Checklist)

TN TDOT Department of Transportation

Laboratory Equipment (Ready Mix Inspection Checklist)

- Type A Lab – Standard Specification 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 lbs capacity
- Appropriate sieves to run gradations
- Coarse and fine aggregate sieve shaker
- Water supply to perform wash tests as needed

TN TDOT Department of Transportation

Concrete Trucks (Ready Mix Inspection Checklist)

- Check trucks against approved truck list
- Revolution counter
- Weight limits
- Manufacturer's identification plate
- Water meter
- NRMCA certification card or sticker in each truck

TN TDOT Department of Transportation

Concrete Truck Checklist

TENNESSEE DEPARTMENT OF TRANSPORTATION
CONCRETE TRUCK CHECKLIST

DATE _____ REGION: _____

PRODUCER _____ PLANT LOCATION _____

TRUCK NO.	VERIFY ITEMS MEET SPECIFICATIONS				TAG #	BASE COUNTY	NO. AXLES	DISTANCE FROM CL FRONT TO CL REAR AXLE	TARE WEIGHT	ALLOWABLE GROSS WEIGHT (LB)		MAXIMUM ALLOWABLE VOLUME (CY)	
	MANUFACTURER PLATE	REVOLUTION COUNTER	MIXER BLADE WEAR	WATER GAUGE						INTERSTATE	NON-INTERSTATE	INTERSTATE	NON-INTERSTATE

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

TN TDOT Department of Transportation

Revolution Counter (Concrete Truck Checklist)

TN TDOT Department of Transportation

Allowable Gross Weights (Concrete Truck Checklist)

TN TDOT Department of Transportation

Maximum Allowable Volume

- Several instances of trucks exceeding maximum allowable gross weights on the interstate
- Maximum allowable volume of concrete must be calculated for each truck assuming tare weights include the following:
  - A full tank of fuel
  - A full water tank
  - Operator seated in cab

TN TDOT Department of Transportation

Manufacturer's Plate (Concrete Truck Checklist)

TN TDOT Department of Transportation

Water Meter (Concrete Truck Checklist)

TN TDOT Department of Transportation

Certified Technician Form

Concrete Certified Technicians

CONCRETE PRODUCER _____ LOCATION: _____

TECHNICIAN QUALIFICATIONS

Concrete Field Testing Technicians (*TDOT Level 1 or ACI Grade I*) *(If SCC is being produced, TDOT Level 1 or ACI Grade I and ACI SCC)*		
Name	Certification Number	Expiration Date

Concrete Plant Technicians (*TDOT Concrete Plant Quality Control Technician*)		
Name	Certification Number	Expiration Date

Concrete Mix Design Technicians (*TDOT Concrete Mix Design or State of TN PE*)		
Name	Certification Number	Expiration Date

TN TDOT Department of Transportation

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
- Aggregate Quality Reports

TN TDOT Department of Transportation

Materials List

- Complete list of Producers and materials used for TDOT mix

Materials List

CONCRETE PRODUCER _____ LOCATION: _____

MATERIALS, SOURCES, LOCATIONS

MATERIAL	TYPE/BRAND	PRODUCER	LOCATION
Coarse Aggregate 1			
Coarse Aggregate 2			
Coarse Aggregate 3			
Coarse Aggregate 4			
Fine Aggregate 1 (Nat.)			
Fine Aggregate 2 (Nat.)			
Fine Aggregate 3 (Mfg.)			
Fine Aggregate 4 (Mfg.)			
Cement (specify Type)			
Flyash (specify Class)			
Slag (specify Grade)			
Water Reducer			
Retarder			
Accelerator			
Reducer/Retarder			
High-Range Reducer			
High-Range Reducer/Retarder			
Air Entrainer			
Latex Modifier			
Fibers			
Lithium Nitrate			
Corrosion Inhibitor			
Coloring			

TN TDOT Department of Transportation

Mix Designs

- Each plant shall have an approved concrete mix design each year as outlined in SOP 4-4: Procedures for Submittal and Approval of Concrete Mixture
  - Use approved project-specific mix design
  - Water/Cementitious material ratio (w/cm)
  - If materials change, trial batch information included in mix design
  - Most current mix design template found on the TDOT website

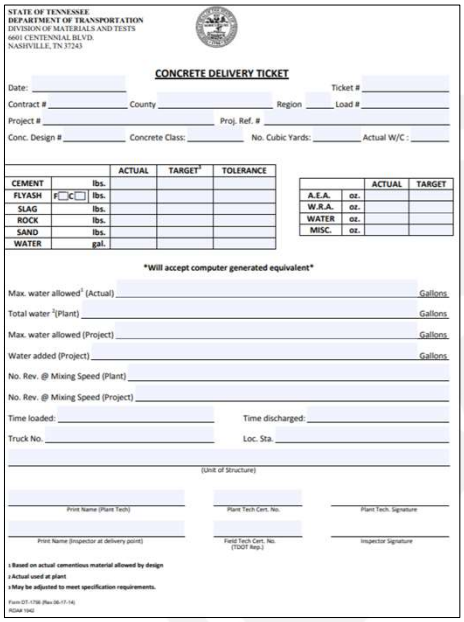
TN TDOT Department of Transportation

Delivery Ticket (604.03.B.12)

- Date
- Contract Number
- County
- Class of concrete
- TDOT Concrete design number
- Number of cubic yards
- Load Number
- Truck Number
- Max Water Allowed by Design
- Total water added at the plant
- Max Water Added on a Project
- Number of Revolutions at Mixing Speed at Plant
- Time Loaded
- Actual target batch weights of each component including each aggregate, chemical, and mineral admixture used
- TDOT Concrete Plant Quality Control Technician signature

TN TDOT Department of Transportation

Concrete Delivery Ticket (DT-1756)



STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TN 37243

CONCRETE DELIVERY TICKET

Date: _____ Ticket # _____

Contract # _____ County _____ Region ____ Load # _____

Project # _____ Proj. Ref. # _____

Conc. Design # _____ Concrete Class: _____ No. Cubic Yards: _____ Actual W/C : _____

		ACTUAL	TARGET[2]	TOLERANCE
CEMENT	lbs.			
FLYASH F☐C☐	lbs.			
SLAG	lbs.			
ROCK	lbs.			
SAND	lbs.			
WATER	gal.			

		ACTUAL	TARGET
A.E.A.	oz.		
W.R.A.	oz.		
WATER	oz.		
MISC.	oz.		

Will accept computer generated equivalent

Max. water allowed[1] (Actual) _____ Gallons

Total water [2](Plant) _____ Gallons

Max. water allowed (Project) _____ Gallons

Water added (Project) _____ Gallons

No. Rev. @ Mixing Speed (Plant) _____

No. Rev. @ Mixing Speed (Project) _____

Time loaded: _____ Time discharged: _____

Truck No. _____ Loc. Sta. _____

(Unit of Structure)

Print Name (Plant Tech) | Plant Tech Cert. No. | Plant Tech. Signature

Print Name (Inspector at delivery point) | Field Tech Cert. No. (TDOT Rep.) | Inspector Signature

1 Based on actual cementious material allowed by design
2 Actual used at plant
3 May be adjusted to meet specification requirements.

Form DT-1756 (Rev 06-17-14)
RDAR 1942

TN TDOT Department of Transportation

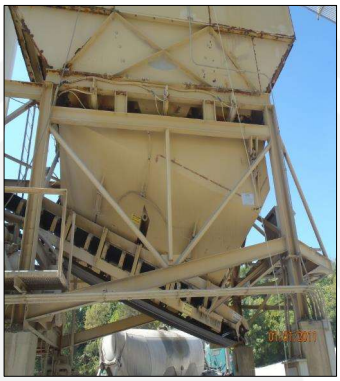
Project Specific Checks

- Delivery ticket contain all necessary information
  - Water allowed to add on delivery ticket
- 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

TN TDOT Department of Transportation

Batching Tolerances (604.11)

- 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



TN TDOT Department of Transportation

Let's Review

- Is the price per cubic yard required to be listed on the Concrete Delivery Ticket?
- How often does HQMT inspect ready mix facilities?
- Does TDOT require a Type B lab for ready mix facilities?
- How long do producers have to correct deficiencies found during a TDOT inspection?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

3

Precast & Prestressed Concrete Producers

Precast Concrete Producers

TN TDOT Department of Transportation

Precast Concrete

- Concrete products cast at facility and shipped to field
  - Catch basins, box culverts, manholes, junction boxes, etc.
  - Reinforced concrete pipe
- Mixing equipment varies
  - Central mixer
  - Use of a ready mix plant
  - Volumetric mixer

TN TDOT Department of Transportation

Precast Concrete Products (SOP 5-3)

- SOP 5-3: Manufacture and Acceptance of Precast Concrete Products
- Precast Inspection Checklist
- Approved material sources
- Quality Control Program
  - NPCA, ACPA, or PCI Certification
- Lab and plant equipment
- Mix designs
- Acceptance testing
- Verification

TN TDOT Department of Transportation

Precast Inspection Checklist

- HQMT and Regional M&T inspections are documented on this checklist
  - Plant inspection
  - Laboratory inspection
  - Kept in TDOT binder
- Any deficiencies will be noted
  - Regional M&T will ensure all deficiencies are corrected

TN TDOT Department of Transportation

Materials (Precast Inspection Checklist)

- Material sources on approved mix design
- 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
- Specific Gravity and Absorption for aggregates
- Steel is from an approved Producer
  - Steel certifications readily available
  - All steel reinforcement will be "Buy America"
- Patching material listed on Qualified Products List (QPL 13: Patching Material)

TN TDOT Department of Transportation

QC Program (Precast Inspection Checklist)

- TDOT specific QC Manual (to be kept in binder)
  - 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 Plan (at least once per month per SOP 5-3)

TN TDOT Department of Transportation

Laboratory & Testing Equipment (Precast Inspection Checklist)

- Type A Lab required – Standard Specification 106.06.A
- 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

TN TDOT Department of Transportation

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 the TDOT Producer List

TN TDOT Department of Transportation

Mix Design (Precast Inspection Checklist)

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

TN TDOT Department of Transportation

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 in the QC binder
  - 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

TN TDOT Department of Transportation

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
  - Report kept in TDOT binder

TN TDOT Department of Transportation

Prestressed Concrete

TN TDOT Department of Transportation

Prestressed Concrete

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

TN TDOT Department of Transportation

Producer Requirements (SOP 5-4)

- 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
- All paperwork kept in TDOT binder

TN TDOT Department of Transportation

Materials (SOP 5-4)

- Material sources on approved mix design and correct on Materials List
- 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
- Aggregate Quality Reports
- Steel is from an approved Producer
  - Steel certifications readily available
  - Complies with "Buy America"

TN TDOT Department of Transportation

Quality Control Program (SOP 5-4)

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

TN TDOT Department of Transportation

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)

TN TDOT Department of Transportation

Testing Equipment & Laboratory (SOP 5-4)

- Type A Lab required – Standard Specification 604.04.A
  - 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 in TDOT binder

TN TDOT Department of Transportation

Quality Control Personnel (SOP 5-4)

- A TDOT Concrete Plant Quality Control Technician shall be on site anytime that a TDOT product is being produced

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Mix Design (SOP 5-4)

- Each plant shall have an approved (current year) concrete mix design as outlined in SOP 4-4
- 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
  - All materials on mix design must be listed on Producer List or QPL

TN TDOT Department of Transportation

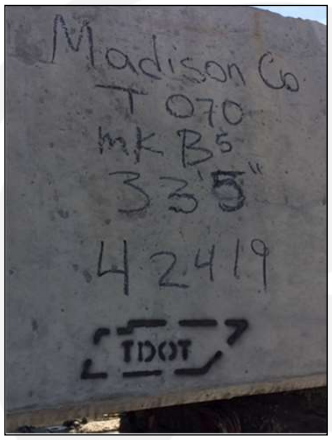
Prior to Shipping (SOP 5-4)

- 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 prior to shipment
- Acceptance and verification testing in accordance with SOP 1-1, Parts 2 & 3
  - For acceptance, Regional M&T performs a final inspection after loading and prior to shipment

TN TDOT Department of Transportation

Stamping (SOP 5-4)

- Products will be stamped on the top surface with the following:
  - Project number
  - County
  - Bridge number
  - Unit mark number
  - Date made



TN TDOT Department of Transportation

Let's Review

- True or False? TDOT accepts precast products based on 28 day breaks.
- Who approves mix designs for precast products?
- Acceptable prestressed products must be stamped with what information?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

4

Volumetric Mobile Mixers

Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment

References
Standard Specifications
ASTM C685
ACI 304.6R

TN TDOT Department of Transportation

Volumetric Mobile Mixers

- Materials batched by volume not weight
- Continuous mixing happens as the concrete is coming down chute
- Mixer, stockpiles, bins, and tanks all fit on a truck making an entire plant portable

TN TDOT Department of Transportation

Typical Applications

- Volumetric Mobile Mixers are used in a wide variety of applications
  - Minor structures – Small Deliveries
  - Mixtures with Short Working Times – Rapid Set
  - Bridge Deck Repairs - Latex-modified overlays (PMC)
  - Remote Sites – Long Haul Times
- Volumetric Mobile Mixers carry enough materials to produce 6 to 10 cubic yards of concrete

TN TDOT Department of Transportation

Volumetric Specification (604.04.C)

- Equipment requirements
- Calibration/Operation
  - Must be performed by an individual with BOTH certifications:
    - TDOT Concrete Field Testing Technician
      - OR ACI Equivalent
    - 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

TN TDOT Department of Transportation

Volumetric Requirements

- 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

TN TDOT Department of Transportation

Calibration

- Calibrations are done on each material to ensure proportions are correct for the constituent materials of the mix design
  - All materials are calibrated back to required cement
- Perform before starting work, then a minimum of:
  - 6 months
  - 2,500 cubic yards
  - Any time mix proportioning is off as indicated by yield checks

TN TDOT Department of Transportation

Yield Checks

- Yield checks are used to verify precise calibration
  - Minimum 0.25 cubic yard container
- Perform before starting work, then a minimum of:
  - Every 500 cubic yards
    OR
  - Once per week

TN TDOT Department of Transportation

Let's review

- Concrete materials are batched by _____ not weight.
- What are some applications of a volumetric mobile mixer?
- Batch/delivery tickets must be signed by who?
- _____ are done on each material to make sure proportions are correct.
- _____ _____ are used to verify precise calibration

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

5

Best Management Practices for Concrete

Best Management Practices for Concrete

TN TDOT Department of Transportation

High Ambient Temperature

- 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

TN TDOT Department of Transportation

Low Ambient Temperatures

- Field Observations
  - Freezing of concrete before it sets
  - Slower set time
  - Shrinkage cracking
  - Reduced early strength
- Standard Specifications 604.12
  - 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

TN TDOT Department of Transportation

Lightweight Concrete

- Contains lightweight aggregate
  - Expanded shale, slate, or clay used for structural concrete
  - Approved sources on the Producer List
- Pre-saturation of the aggregate is critical
  - Standard Specification 604.11
- Must use the volumetric method to determine the air content (AASHTO T 196/ASTM C173)

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Let's Review

- True or False? Pre-saturation of aggregate is critical for lightweight concrete.
- What are some adverse of affects of low ambient temperature on concrete?
- What type of test for air content must be performed on lightweight concrete?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

6

Sampling of Aggregates

AASHTO R 90
ASTM D75

TDOT Standard Method of Test for

Sampling of Aggregates

References

Standard Specifications

AASHTO R 90

ASTM D75

TN TDOT Department of Transportation

Purpose

- Proper sampling is critical
- Reasons for sampling aggregate:
  - Preliminary investigation of the potential source
  - 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

TN TDOT Department of Transportation

Equipment

- Shovel, Scoops
- Brushes
- Sampling Tubes
- Belt Template
- Mechanical Sampling Systems
- Sample Containers
- Tags

TN TDOT Department of Transportation

Minimum Field Sample Size

Nominal Maximum Aggregate Size	Minimum Field Sample Mass, lbs
#8	22
#4	22
3/8”	22
½”	35
¾”	55
1”	110
1 ½”	165
2”	220
2 ½”	275
3”	330
3 ½”	385

TN TDOT Department of Transportation

Methods of Sampling

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

TN TDOT Department of Transportation

Flowing Aggregate Stream

- 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

TN TDOT Department of Transportation

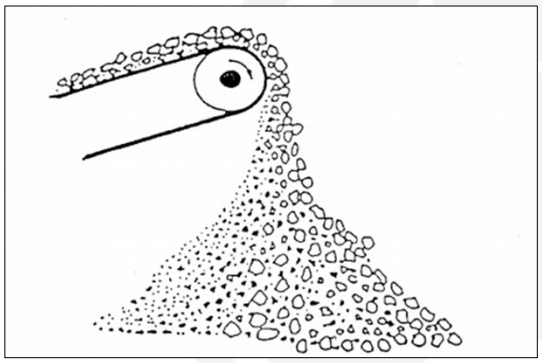
Conveyor Belt

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

TN TDOT Department of Transportation

Stockpiles

- Stockpiles have a tendency to segregate during their construction
  - Segregation is the separation of varying sizes of aggregate



TN TDOT Department of Transportation

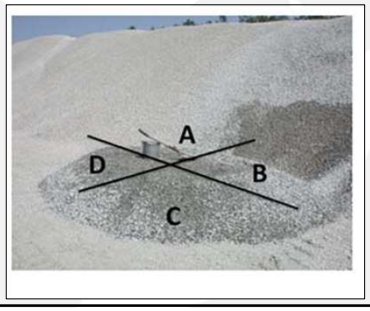
With Power Equipment

- 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

TN TDOT Department of Transportation

With Power Equipment

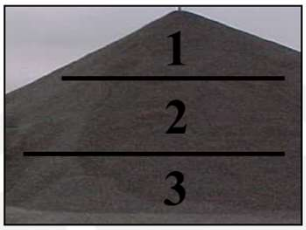
- The loader is then used to backblade the smaller stockpile one time
- Divide the sample pad into four quadrants and sample equal amounts
- Avoid sampling within 1 ft of sample pad edge
- The four increments are then combined to comprise the final field sample



TN TDOT Department of Transportation

Without Power Equipment

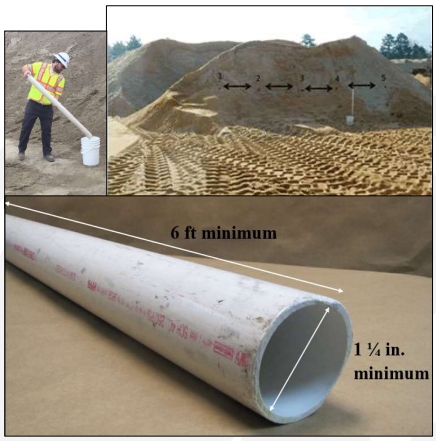
- Three increments
  - Visually divide stockpile into three even sections
- Portions are obtained from each section at least 12 in. below the surface by removing the outer layer of material
- A producer may not allow people on stockpiles for safety reasons



TN TDOT Department of Transportation

Sampling Tubes (Fine Aggregate)

- Five increments
  - Tube insertions randomly spaced across the stockpile
- Sample shall be taken at a minimum height of 3 ft from the surrounding grade



TN TDOT Department of Transportation

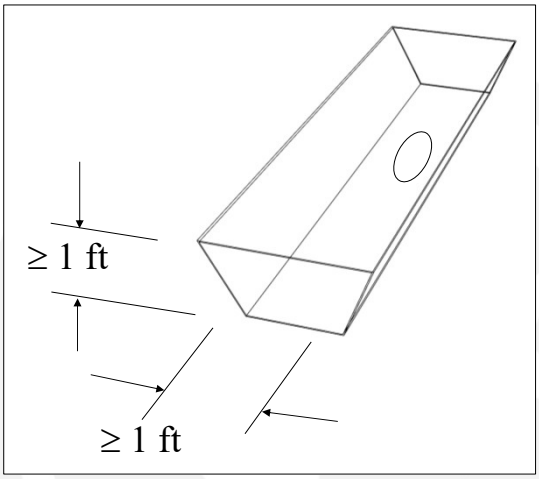
Roadways

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

TN TDOT Department of Transportation

Transportation Units

- Three increments
  - Three or more trenches
- Applicable for:
  - Railroad cars
  - Barges
  - Trucks



TN TDOT Department of Transportation

Sample Containers

- OSHA requirement
  [≤ 50 lbs]
- Use an appropriate container for the test to be performed
  - Durable
  - Moisture proof
- Portion the sample if necessary

TN TDOT Department of Transportation

Number of Sample Containers

$$Containers = (Field\ Sample\ Mass) \div (50\ lbs)$$

$$Containers_{3"} = (330\ lbs) \div (50\ lbs)$$

Nominal Maximum Aggregate Size	Minimum Field Sample Mass, lbs
#8	22
#4	22
3/8"	22
½"	35
¾"	55
1"	110
1 ½"	165
2"	220
2 ½"	275
→ 3"	→ 330
3 ½"	385

TN TDOT Department of Transportation

Labeling a Sample

- Tagging
- Directly on container

Project Number: 55001-3231-18
Date Sampled: 3/1/20 Submitted: 3/2/20
Sampled by: F. Flintstone
Submitted by: F. Flintstone
Producer: Stone Materials, Inc.
Pit Number: 185 Sampled from: Stockpile
County: Davidson Region: 3

TN TDOT Department of Transportation

Submitting a Sample

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

CONTRACTOR MATERIAL CERTIFICATION
AND/OR
SAMPLING AND TESTING RECORD

☐ Original Sample ☐ Check Sample

Project Reference No.
Project No.
Contractor
Date Sampled
Identification
Submitted by
Sampled from
Producer
Supplier
Lab Serial No.

County (Leave blank) Region
Contract No.
Heat No. Size
Date Received at Lab
Date Reported
Sampled by Phone
Amount Represented
Location
Location
Report No.

TN TDOT Department of Transportation

Let's Review!

- If sampling from an aggregate stream, how many increments must you take?
- How many inches should a loader's bucket be off the ground when taking aggregate from a stockpile?
- Name two methods of labeling your sample once it has been stored in a container.

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

7

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

Standard Specifications

AASHTO R 76

ASTM C702

TN TDOT Department of Transportation

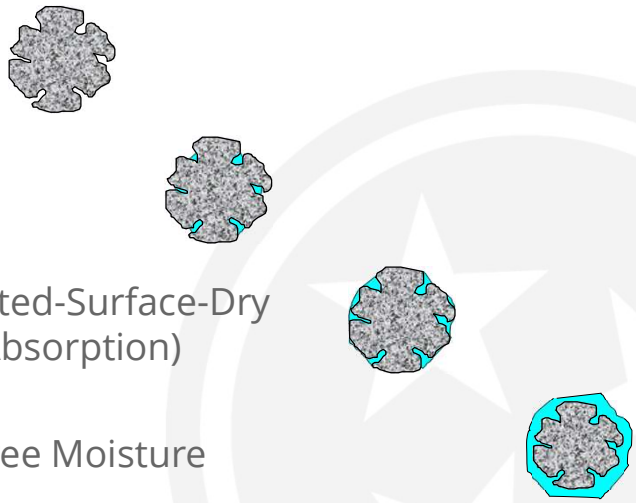
Purpose

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

TN TDOT Department of Transportation

Moisture Conditions

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



TN TDOT Department of Transportation

Size of Aggregate

- Coarse
- Fine
- Combined

TN TDOT Department of Transportation

Determine Method

Moisture \ Aggregate Size	Coarse	Combined	Fine
SSD and drier	A, B	A, B	A
Free moisture on surface	A, B	B	B, C

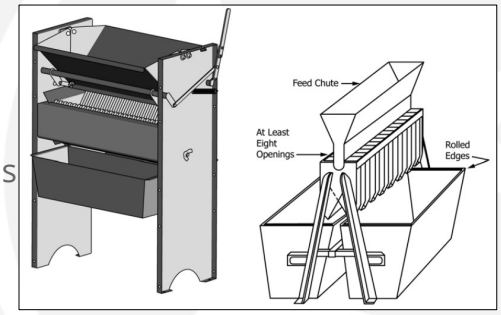
Splitting Method

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

TN TDOT Department of Transportation

Method A – Mechanical Splitter

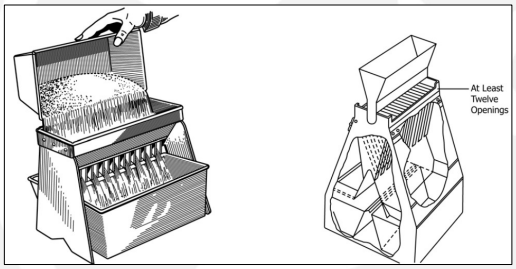
- Coarse & combined aggregate
- At least 8 chutes
  - Even number of chutes
  - Chutes of equal width
  - Individual chutes about 50% larger than largest particles



TN TDOT Department of Transportation

Method A – Mechanical Splitter

- Fine Aggregate setup
- At least 12 chutes
  - Even number of chutes
  - Chutes of equal width
  - Individual chutes ½ in. to ¾ in. wide



TN TDOT Department of Transportation

Method B – Cone and Quarter

Mix by rolling on canvas

Flatten aggregate pile to a diameter 4 to 8 times the thickness

TN TDOT Department of Transportation

Method B – Cone and Quarter

Divide the aggregate into four separate quarters using a shovel or stick

Remove two diagonally opposite quarters including fines

TN TDOT Department of Transportation

Method B – Cone and Quarter

TN TDOT Department of Transportation

Method C - Miniature Stockpile

- Five increments using a scoop or spoon

TN TDOT Department of Transportation

Let's Review

- What does SSD stand for?
- When can you use miniature stockpiling as a method of reducing your sample?
- How many chutes should you have in your mechanical splitter when sampling coarse aggregates and fine aggregates?
- When using the Cone and Quarter method, what diameter should you flatten your cone to?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

8

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

Standard Specifications

AASHTO T 255

ASTM C566

TN TDOT Department of Transportation

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
- Standard Specification 303.14.B
  - TDOT will deduct weight of material in excess of 3% of optimum moisture content

TN TDOT Department of Transportation

Equipment

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

TN TDOT Department of Transportation

Sample Size

TABLE 1 Sample Size for Aggregate

Nominal Maximum Size of Aggregate, mm (in.)[A]	Mass of Normal Weight Aggregate Sample, min, kg[B]
4.75 (0.187) (No. 4)	0.5
9.5 (⅜)	1.5
12.5 (½)	2
19.0 (¾)	3
25.0 (1)	4
37.5 (1½)	6
50 (2)	8
63 (2½)	10
75 (3)	13
90 (3½)	16
100 (4)	25
150 (6)	50

[A] Based on sieves meeting Specification E11.
[B] 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^3 (determined using Test Method C29/C29M) and dividing by 1600.

TN TDOT Department of Transportation

Samples (Wet and Dry)

TN TDOT Department of Transportation

Determine Sample Mass

- Weigh the sample to the nearest 0.1%

Example

- Wet mass: 6286 g

TN TDOT Department of Transportation

Dry the Sample

- Dry the aggregate to a constant mass in an oven at 230 ± 9°F
- Constant mass is reached when the sample weight changes <0.1% from the previous measurement
- When not using an oven, stir periodically to accelerate drying and prevent local overheating
- Allow the material to cool

TN TDOT Department of Transportation

Reweigh the Sample

- Weigh the sample to the nearest 0.1%

Example

- Dry mass: 6164 g

TN TDOT Department of Transportation

Moisture Content (MC) Calculations

$$MC(\%) = \frac{(M_{Original} - M_{Dry})}{M_{Dry}} \times 100$$

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

Example:

$$MC(\%) = \frac{(6286 - 6164)}{6164} \times 100 =$$

TN TDOT Department of Transportation

Problem

Given:

- Weight of the original sample (W) = 1206 g
- Weight of sample after drying (D) = 1132 g

Determine:

- Total Moisture Content of the aggregate

TN TDOT Department of Transportation

Solution

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

TN TDOT Department of Transportation

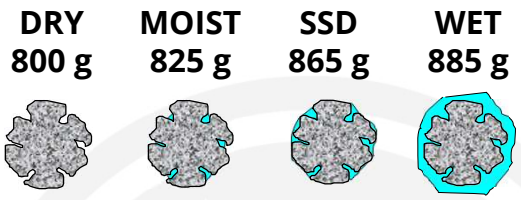
Practice

Sample Number	Original Weight	Dry Weight	$\frac{W - D}{D} x100$	Moisture Content
1	568.3	560.9		
2	1357	1342		
3	924.0	920.3		
4	1828	1739		

TN TDOT Department of Transportation

Practice

- Determine the percent moisture content in the
  - Wet condition:



$$MC(\%) = \frac{(885-800)}{800} \times 100 =$$

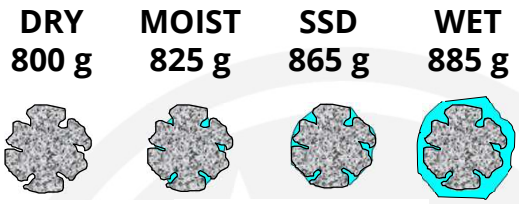
  - SSD (Absorption):

$$MC(\%) = \frac{(865-800)}{800} \times 100 =$$

TN TDOT Department of Transportation

Practice

- Determine the percent of free moisture on the sample:



- OR

TN TDOT Department of Transportation

Let's Review

- How long should you dry the aggregate?
- Determine the moisture content of the aggregate if it is 840 g in the wet condition, and 790 g in the dry condition:
- How can you determine the free moisture in an aggregate?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

9

Aggregate Moisture Corrections for Concrete Batching

Aggregate Moisture Corrections for Concrete Batching

References
Standard Specifications

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Formulas

% Free Moisture:

$$\%FM = \%Moisture - \%Absorption$$

- Use *%Absorption* values given by the aggregate facility

TN TDOT Department of Transportation

Formulas

- **Aggregate Moisture Correction:**

$$Agg\ MC = SSD\ Weight \times \%Free\ Moisture$$

- **Mix Water Correction:**

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

TN TDOT Department of Transportation

Formulas

- **Corrected Aggregate Batch Weight:**

$$W_{Agg} = SSD\ Weight + Agg\ MC$$

- **Corrected Batch Water:**

$$Batch\ Water = Design\ Water - MWC$$

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Example #1

1. Calculate Percent Free Moisture in Aggregates

	Coarse Aggregate	Fine Aggregate
Wet Weight	4306	1232
Dry Weight	4259	1176
Calculate Total Moisture Content	1.1%	4.8%
% Absorption given by aggregate facility	0.6%	0.8%
Calculate % Free Moisture	1.1% - 0.6% = **0.5%**	4.8% - 0.8% = **4.0%**

2. Use SSD Batch Weights from mix design

Coarse Aggregate: 1912 lbs
Fine Aggregate: 1138 lbs
Water: 30 gal

TN TDOT Department of Transportation

Example #1

Batch Size _____ yd³ (m³)	Water gal (L)	Water lbs. (kg)	Cement lbs. (kg)	Fly Ash lbs. (kg)	GGBFS lbs. (kg)	Coarse Aggregate lbs. (kg)		Fine Aggregate lbs. (kg)	
Agg. Size / Other Material									
Percent Free Moisture						0.5%		4.0%	
SSD Batch Wts.	30					1912		1138	
Moisture Corrections	6.6					9.56		45.52	
Actual Batch Wts.	23.4					1922		1184	

3. Calculate Aggregate Moisture Corrections

Coarse Aggregate

1912 x 0.5% = 9.56 lbs

Fine Aggregate

1138 x 4.0% = 45.52 lbs

4. Calculate Mix Water Correction

(9.56+45.52) / 8.34 lbs = 6.6 gals

5. Calculate the Corrected Aggregate Batch Weights

Coarse Aggregate

1912+ 9.56 = **1922 lbs**

Fine Aggregate

1138+ 45.52 = **1184 lbs**

6. Calculate the Corrected Batch Water

30 - 6.6 = **23.4 gals**

TN TDOT Department of Transportation

Example #2

Batch Size _____ m^3 (yd^3)	Water gal (L)	Water lbs. (kg)	Cement lbs. (kg)	Fly Ash lbs. (kg)	GGBFS lbs. (kg)	Coarse Aggregate lbs. (kg)		Fine Aggregate lbs. (kg)	
Agg. Size / Other Material									
Percent Free Moisture						1.1%		2.5%	
SSD Batch Wts.	25					1810		1229	
Moisture Corrections	6.1					19.91		30.73	
Actual Batch Wts.	**18.9**					1830		1260	

3. Calculate Aggregate Moisture Corrections

Coarse Aggregate

1810 x 1.1% = 19.91 lbs

Fine Aggregate

1229 x 2.5% = 30.73 lbs

4. Calculate Mix Water Correction

(19.91+30.73) / 8.34 lbs = 6.1 gals

5. Calculate the Corrected Aggregate Batch Weights

Coarse Aggregate

1810+ 19.91 = **1830 lbs**

Fine Aggregate

1229+ 30.73 = **1260 lbs**

6. Calculate the Corrected Batch Water

25 - 6.1 = **18.9 gals**

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

10

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

Standard Specifications

AASHTO T 11

ASTM C117

TN TDOT Department of Transportation

Purpose

- Accurately determine the amount of material finer than No. 200 sieve (dust of fracture)
  - 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

TN TDOT Department of Transportation

Equipment

- Balance
- Sieves
  - No. 16 on top to protect
  - No. 200 on bottom
- Container
- Oven
- Wetting Agent
- Mechanical Washer
  - Optional, saves time

TN TDOT Department of Transportation

Sample Size

Nominal Maximum Size[A]	Minimum Mass, g
4.75 mm (No. 4) or smaller	300
9.5 mm (3/8″)	1000
12.5 mm to 19.0 mm (½″ to ¾″)	2500
25 mm (1″) or larger	5000

[A] Based on sieve sizes meeting Specification E11.

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Determine the Sample Mass

- Weigh the sample to the nearest 0.1%

TN TDOT Department of Transportation

Two Procedures

- Procedure A - Washing with plain water
  - Dust of Fracture
- Procedure B - Washing using a wetting agent
  - Clay Particles
  - Only use the wetting agent on the first wash

TN TDOT Department of Transportation

Procedure

- Place the sample in the container
- Add water to cover the sample
- Add wetting agent if performing Procedure B
- Agitate the sample
  - Use a spoon to stir, if desired
- Ensure complete separation of particles

TN TDOT Department of Transportation

Procedure

- Pour the wash water with suspended solids over the nested sieves
- Take care to avoid spilling aggregate

TN TDOT Department of Transportation

Procedure

- Repeat the washing with plain water until wash water is clear
- Wetting agent is only used on the first wash

TN TDOT Department of Transportation

Alternate Procedures

- Mechanical washing is allowable
- Some samples may degrade in mechanical washers

TN TDOT Department of Transportation

Procedure

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

TN TDOT Department of Transportation

Procedure

- Be sure to wash material off spoon into container
- Do not pour excess water from container
  - Must evaporate by drying

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Determine the Sample Mass

- Weigh the sample to the nearest 0.1%

TN TDOT Department of Transportation

Percent (P) ≤ No. 200 Calculations

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

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

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Solution

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

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Solution

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

TN TDOT Department of Transportation

Let's Review!

- When should a wetting agent be used?
- How many times should you repeat washing the aggregate?
- What should you report your results to when the percent of material finer than No. 200 is **less** than 10%?
- What should you report your results to when the percent of material finer than No. 200 is **more** than 10%?

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

11

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

Standard Specifications

AASHTO T 27

ASTM C136

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

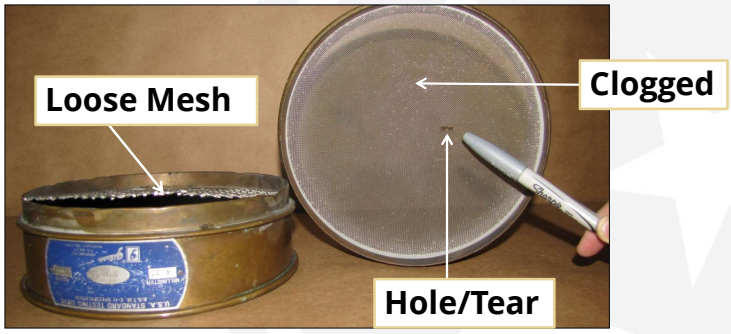
Equipment

- Balance
- Oven
- Sieves
- Mechanical Shaker

TN TDOT Department of Transportation

Sieve Selection

- Appropriate sieves must:
  - Provide required sizing information
  - Not be damaged and/or dirty
  - Be capable of regulating the amount on each sieve
    - i.e., prevent overloading of any individual sieve.



TN TDOT Department of Transportation

Overloaded Sieve

Prevent overloading by:

- Using larger sieves
- Portioning the sample
- Placing another sieve size in the stack

TN TDOT Department of Transportation

Maximum Loading of Sieves

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

Sieve Opening Size	Nominal Dimensions of Sieve[a]				
	203.2-mm, dia[b]	254-mm, dia[b]	304.8-mm, dia[b]	350 by 350, mm	372 by 580, mm
	Sieving Area, m^2				
	0.0285	0.0457	0.0670	0.1225	0.2158
125 mm (5 in.)	[c]	[c]	[c]	[c]	67.4
100 mm (4 in.)	[c]	[c]	[c]	30.6	53.9
90 mm (3 1/2 in.)	[c]	[c]	15.1	27.6	48.5
75 mm (3 in.)	[c]	8.6	12.6	23.0	40.5
63 mm (2 1/2 in.)	[c]	7.2	10.6	19.3	34.0
50 mm (2 in.)	3.6	5.7	8.4	15.3	27.0
37.5 mm (1 1/2 in.)	2.7	4.3	6.3	11.5	20.2
25.0 mm (1 in.)	1.8	2.9	4.2	7.7	13.5
19.0 mm (3/4 in.)	1.4	2.2	3.2	5.8	10.2
12.5 mm (1/2 in.)	0.89	1.4	2.1	3.8	6.7
9.5 mm (3/8 in.)	0.67	1.1	1.6	2.9	5.1
4.75 mm (No. 4)	0.33	0.54	0.80	1.5	2.6

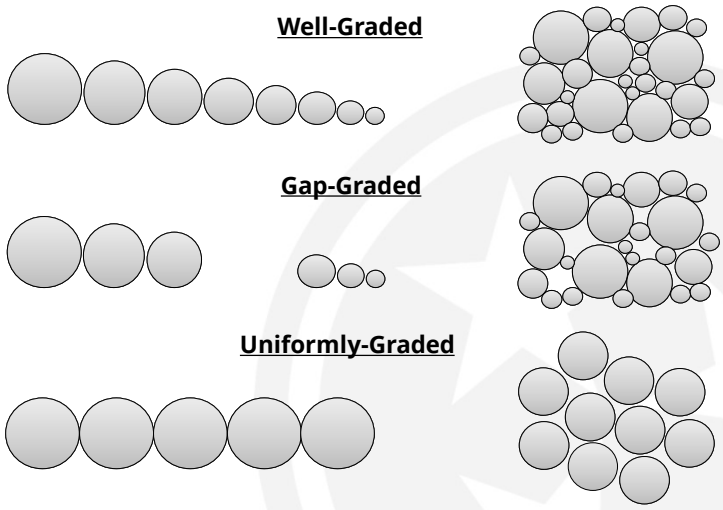
[a] Sieve frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

[b] 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.).

[c] Sieves indicated have less than five full openings and should not be used for sieve testing.

TN TDOT Department of Transportation

Aggregate Gradation



TN TDOT Department of Transportation

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:

Nominal Maximum Size, Square Openings, mm (in.)	Test Sample Size, min, kg (lb)
9.5 (⅜)	1 (2)
12.5 (½)	2 (4)
19.0 (¾)	5 (11)
25.0 (1)	10 (22)
37.5 (1½)	15 (33)
50 (2)	20 (44)
63 (2½)	35 (77)
75 (3)	60 (130)
90 (3½)	100 (220)

TN TDOT Department of Transportation

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

TN TDOT Department of Transportation

Determine the Sample Mass

TN TDOT Department of Transportation

Mechanical Shaker

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

TN TDOT Department of Transportation

Weigh Sieves Cumulatively

TN TDOT Department of Transportation

AASHTO Loss

- AASHTO Loss = $\frac{Original\ Sample\ Wt. - Total\ Cumulative\ Wt.}{Original\ Sample\ Wt.} x\ 100$
- AASHTO Loss must be ≤ **0.3%** of the original sample mass

TN TDOT Department of Transportation

Calculations

- Cumulative %Retained = $\frac{Cumulative\ Wt\ \ Retained}{Original\ Sample\ Wt} x\ 100$
- Cumulative %Passing = 100 – Cumulative %Retained
- Report percentages to the nearest whole number

TN TDOT Department of Transportation

Sample Problem #1

- AASHTO Loss $= \frac{Original\ Sample\ Wt\ - Total\ Cumulative\ Wt}{Original\ Sample\ Wt} x\ 100$

Natural Sand for Concrete	
Original Sample Weight (g)	503.5
Sieve Size	Cumulative Weight Retained
No. 4	0.0
No. 8	49.0
No. 16	146.0
No. 30	259.0
No. 50	368.0
No. 100	466.0
No. 200	494.0
Pan	503.0

TN TDOT Department of Transportation

Sample Problem #1

- AASHTO Loss $= \frac{Original\ Sample\ Wt\ - Total\ Cumulative\ Wt}{Original\ Sample\ Wt} x\ 100$

1. $503.5g - 503.0g = 0.5\ g$
2. $0.5g \div 503.5g = 0.00099$
3. $0.00099 \approx 0.001$
4. $0.001 \times 100 =$

Natural Sand for Concrete	
Original Sample Weight (g)	503.5
Sieve Size	Cumulative Weight Retained
No. 4	0.0
No. 8	49.0
No. 16	146.0
No. 30	259.0
No. 50	368.0
No. 100	466.0
No. 200	494.0
Pan	503.0

TN TDOT Department of Transportation

Sample Problem #1

- Max AASHTO loss = 0.3%
- 0.1% ≤ 0.3%
- This aggregate sample is within tolerance

Natural Sand for Concrete	
Original Sample Weight (g)	503.5
Sieve Size	Cumulative Weight Retained
No. 4	0.0
No. 8	49.0
No. 16	146.0
No. 30	259.0
No. 50	368.0
No. 100	466.0
No. 200	494.0
Pan	503.0

TN TDOT Department of Transportation

Sample Problem #1

Original Sample Weight	503.5 g

Original Data

Sieve Size	Cumulative Wt Retained (g)	Cumulative %Retained	Cumulative %Passing	Specification 903.01	Meets? Yes/No
No. 4	0.0			95 - 100	
No. 8	49.0			-	
No. 16	146.0			50 - 90	
No. 30	259.0			-	
No. 50	368.0			5 - 35	
No. 100	466.0			0 - 20	
No. 200	494.0			0 - 3	
Pan	503.0			-	

TN TDOT Department of Transportation

$$Cumulative\ \%\ Retained = \frac{Cumulative\ Wt\ Retained\ (Sieve\ Size)}{Original\ Sample\ Weight} * 100$$

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

TN TDOT Department of Transportation

FM Sample #1

- Add Cumulative Percent Retained on
  - **No. 100**
  - **No. 50**
  - **No. 30**
  - **No. 16**
  - **No. 8**
  - **No. 4**
  - **3/8 in.**
  - **¾ in.**
  - **1 ½ in.**
  - **3 in.**
- Divide by 100

Sieve	Cumulative Percent Retained
3 in.	
1 1/2 in.	
3/4 in.	
3/8 in.	
No. 4	
No. 8	
No. 16	
No. 30	
No. 50	
No. 100	

Total	
FM	

TN TDOT Department of Transportation

Sample Problem #2

- AASHTO Loss = $\frac{Original\ Sample\ Wt\ -Total\ Cumulative\ Wt}{Original\ Sample\ Wt.} x\ 100$

#57 Limestone	
Original Sample Weight (lbs)	25.60
Sieve Size	Cumulative Weight Retained
1 1/2 in.	0.00
1 in.	0.00
3/4 in.	0.60
1/2 in.	8.80
3/8 in.	16.50
No. 4	24.30
No. 8	24.60
Pan	25.40

TN TDOT Department of Transportation

Sample Problem #2

- AASHTO Loss $= \frac{Original\ Sample\ Wt\ - Total\ Cumulative\ Wt}{Original\ Sample\ Wt.} x\ 100$

- AASHTO Loss $= \frac{(25.60 - 25.40)}{25.60} x\ 100$

#57 Limestone	
Original Sample Weight (lbs)	25.60
Sieve Size	Cumulative Weight Retained
1 1/2 in.	0.00
1 in.	0.00
3/4 in.	0.60
1/2 in.	8.80
3/8 in.	16.50
No. 4	24.30
No. 8	24.60
Pan	25.40

TN TDOT Department of Transportation

Sample Problem #2

Original Sample Weight	25.60 lbs

Sieve Size	Cumulative Wt Retained (lbs)	Cumulative %Retained	Cumulative %Passing	Specification 903.22	Meets? Yes/No
1 ½ in	0.00			100	
1 in	0.00			95 - 100	
¾ in	0.60			-	
½ in	8.80			25 - 60	
3/8 in	16.50			-	
No. 4	22.30			0 - 10	
No. 8	24.60			0 - 5	
Pan	25.40			-	

TN TDOT Department of Transportation

$$Cumulative\ \%\ Retained = \frac{Cumulative\ Wt\ Retained\ (Sieve\ Size)}{Original\ Sample\ Weight} * 100$$

Let's Review!

- Agitating for more than ___ minutes can degrade the sample?
- What is the maximum allowable AASHTO loss?
- The higher the fineness modulus , the _____ the aggregate is.

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

12

Appendix

Appendix

TN TDOT Department of Transportation

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: Lindsey Skaggs- 731-935-0216
- HQMT Training Coordinator
  - Kim Whitby – 615-350-4158; Kimberly.Whitby@tn.gov

TN TDOT Department of Transportation

AASHTO/ASTM Resources

- Volumetric Mixers: C685/ACI 304.6R
- 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

TN TDOT Department of Transportation

SOP's

- 1-1: Quality Assurance for the Sampling, Testing of Materials and Products
- 1-3: Field Technician Certification Requirements
- 4-3: Procedures for Ready Mix Concrete Plant Certification
- 4-5: Volumetric Concrete Mobile Mixer Approval Procedures
- 5-3: Manufacture and Acceptance of Precast Concrete Products
- 5-4: Procedures for Prestressed Concrete Construction

TN TDOT Department of Transportation

Review Answer Slides

TN TDOT Department of Transportation

QA/QC Review

- Who performs quality assurance testing?

  TDOT or TDOT Representative

- What term describes a set of activities carried out by the contractor to ensure concrete meets requirements?

  Quality Control

- Concrete facilities/truck records should be made available and organized for review at facility/truck.

TN TDOT Department of Transportation

Ready Mix Review

- Is the price per cubic yard required to be listed on the Concrete Delivery Ticket?
  No
- How often does HQMT inspect ready mix facilities?
  At random
- Does TDOT require a Type B lab for ready mix facilities?
  No. TDOT requires a Type A lab for ready mix facilities.
- How long do producers have to correct deficiencies found during a TDOT inspection?
  30 days from the day of the audit

TN TDOT Department of Transportation

Precast Review

- True or False? TDOT accepts precast products based on 28 day breaks.
  False. TDOT accepts precast products on certification
- Who approves mix designs for precast products?
  HQMT
- Acceptable prestressed products must be stamped with what information?
  Project number, county, bridge number, unit mark number, and date made

TN TDOT Department of Transportation

Volumetric Review

- Concrete materials are batched by volume not weight.
- What are some applications of a volumetric mobile mixer?
  Minor structures, Mixtures with Short Working Times, Bridge Deck Repairs, Remote Sites….
- Batch/delivery tickets must be signed by who?
  VMMB Certified Volumetric Mixer Operator
- Calibrations are done on each material to make sure proportions are correct.
- Yield checks are used to verify precise calibration

TN TDOT Department of Transportation

Best Management Practices Review

- True or False? Pre-saturation of aggregate is critical for lightweight concrete.
  True
- What are some adverse of affects of low ambient temperature on concrete?
  Freezing of concrete before setting, slower set time, shrinkage cracking, reduced early strength
- What type of test for air content must be performed on lightweight concrete?
  The volumetric method

TN TDOT Department of Transportation

Sampling Review

- If sampling from an aggregate stream, how many increments must you take?
  3
- How many inches should a loader's bucket be off the ground when taking aggregate from a stockpile?
  6 inches
- Name two methods of labeling your sample once it has been stored in a container.
  label/tag –or- written on the container

TN TDOT Department of Transportation

Reducing Review

- What does SSD stand for?
  Saturated Surface Dry
- When can you use miniature stockpiling as a method of reducing your sample?
  If the aggregate is fine and wet
- How many chutes should you have in your mechanical splitter when sampling coarse aggregates and fine aggregates?
  At least 8 for coarse and 12 for fine
- When using the Cone and Quarter method, what diameter should you flatten your cone to?
  4 to 8 times the thickness

TN TDOT Department of Transportation

Moisture Content Review

- How long should you dry the aggregate?
  - Until it reaches a constant mass
- Determine the moisture content of the aggregate if it is 840 g in the wet condition, and 790 g in the dry condition:
  - 6.3%
- How can you determine the free moisture in an aggregate?
  - By subtracting the absorption from the total moisture

TN TDOT Department of Transportation

-#200 Review

- When should a wetting agent be used?
  - When there are clay particles present
- How many times should you repeat washing the aggregate?
  - Until the water is clear
- What should you report your results to when the percent of material finer than No. 200 is less than 10%?
  - The nearest 0.1
- What should you report your results to when the percent of material finer than No. 200 is more than 10%?
  - The nearest whole number

TN TDOT Department of Transportation

Sieve Analysis Review

- Agitating for more than ___ minutes can degrade the sample?

  10

- What is the maximum allowable AASHTO loss?

  0.3%

- The higher the fineness modulus , the _____ the aggregate is.

  Coarser

TN TDOT Department of Transportation

Questions

TN TDOT Department of Transportation

Materials & Tests Website

https://www.tn.gov/tdot/materials-and-tests.html

TN TDOT Department of Transportation

TN TDOT Department of Transportation

THANK YOU!