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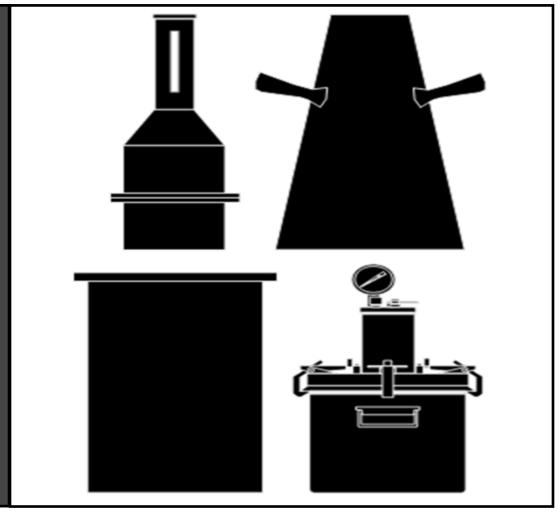

CONCRETE FIELD TESTING TECHNICIAN COURSE

Division of Materials and Tests 2024

Concrete Field Testing Technician Course

2024 Manual

Table of Contents

WELCOME!

Concrete Field Testing Technician Course

1

Purpose of Certification

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

2

Course Highlights

- Slide presentations
- Written Exam (No Phones Allowed)
  - Closed Book
  - Multiple Choice
  - Must get 70% overall
- Performance Exam
  - Closed Book
- Results
- Recertification – Every 5 years

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Course Highlights (Recertification)

- Attend respective course as needed
- Written Assessment REQUIRED
  - ≥80 requires no performance/demonstration
  - 70-79 requires performance/demonstration
  - ≤69 requires course to be repeated
- Performance/Demonstration
  - Proficient at ALL test methods per course requirements
  - Nonproficient requires performance/demonstration to be repeated

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Course Highlights

- TDOT & CEI/Industry
  - Course & Written Assessment
  - Performance/Demonstration Assessment(s)
    - REQUIRED within 6 months of course
    - ~Month 3 – First round performance exam
    - ~Month 5 – Second round performance exam (TBD)
- Region day(s) where the M&T Mobile Lab will be on site to support (As Needed)
    - R1/R2 will co-host to support the East
    - R3/R4 will co-host to support the West

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Resources

- Course materials
  - Course manual
  - Presentation slides and videos
- TDOT
  - 2021 Standard Specifications
    - Supplemental Specifications
  - Special Provisions
  - https://www.tn.gov/tdot/materials-and-tests.html

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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

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Tell Us About Yourself

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

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Quality Control

and

Quality Assurance

Introduction to

Quality Control & Quality Assurance

References

Standard Specifications

Standard Operating Procedures (SOP)

FHWA Publication Np. HIF-07-004

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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

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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

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Quality Assurance (SOP 1-1: Parts 2 & 3)

- Associated with Acceptance and Verification
- Complies with Code of Federal Regulations
  - 23 CFR 637
- Independent of QC

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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)

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Cleaning Procedures

- There is a substantial amount of cleanup required after QA Testing and before the concrete has time to harden:
  - Rinse out the equipment so that the residue from the tested concrete won't bond to the equipment
  - Clean all instruments used during the measurement procedure
  - Clean all the concrete off the testing surface and surrounding area
  - Dispose of all the concrete in the proper designated location
- **This procedure shall be followed for all equipment in the test methods covered herein**

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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

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Record Keeping

- ALL records shall be available and *organized* for review at the facility
  - **A binder including the most recent inspection checklist, plant paperwork, contract paperwork, scale calibrations, moistures, gradations, etc.**
- Proper documentation is a key factor for interpreting data, making informed decisions, and troubleshooting problems that may arise

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Acceptance Testing Frequencies (SOP 1-1)

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
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

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Acceptance Testing Frequencies (SOP 1-1)

Part Three: Verification/Check Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
CONCRETE						
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Cement, Fly Ash, Slag Cement	Laboratory Analysis	M&T	Every six months	Concrete plant	One-pint sample shall be sent to HQ M&T Lab.
	Aggregate: Coarse & Fine	Quality		Annually	Aggregate plant	Also, as appearance changes or locations in quarry are changed. Additional samples to be obtained when production exceeds normal output.
		Gradation and Wash (Not required for minor structures)		Per month	Concrete plant	Perform wash test on fine aggregate only when percent passing the No. 200 sieve dry exceeds 2.0%
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Precast Products, Reinforced Concrete Pipe	Fitment	Project Inspector	Per Product	Project Site	Verification is based on the final acceptance of the product(s) meeting the requirements of the contract plans.
		Verification in accordance with SOP 5-3				
	Class PEM	Super Air Meter number, Surface Resistivity, Resistance of Concrete to Rapid Freezing and Thawing, Resistivity of Concrete	M&T	With every PEM design submission	Project Site	Refer to Standard Specification 604.03 A.1.d. All information for data collection only
	All Classes	Maturity	M&T	During Trial Batch	Producer Facility	Refer to ASTM C1074 for guidance Must be witnessed be M&T Intended for data collection for designs on select projects
Polymer Modified (PMC)	Aggregate: Coarse & Fine	Gradation	Project Inspector or M&T	At beginning of project and every 500 tons	Project stockpile	Refer to Standard Specification 619.04.A
		Moisture		Per day		

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Questions

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Introduction to Concrete

Introduction to Concrete

References
Standard Specifications
Standard Operating Procedures (SOP)

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Concrete Use

- Concrete is used in many different places
  - Concrete Pavement
  - Structural Applications (Bridges, Walls, Barriers)
  - Drilled Shafts
  - Precast/Prestressed Bridge Members
  - Precast Products
    (pipes, catch basins, etc.)

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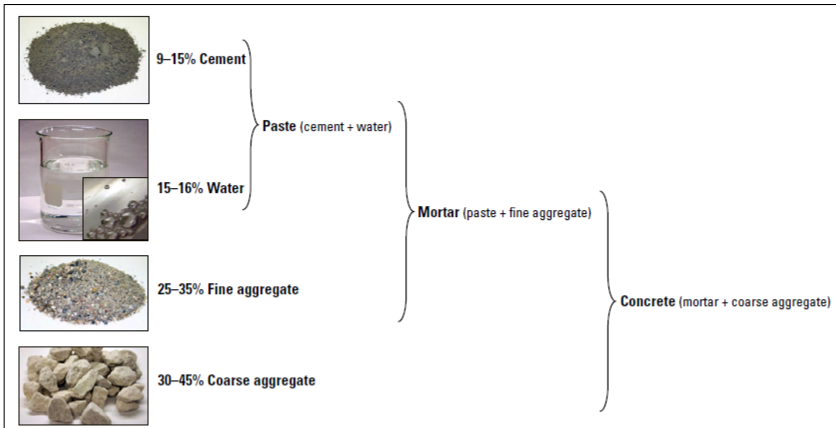
Basic Ingredients



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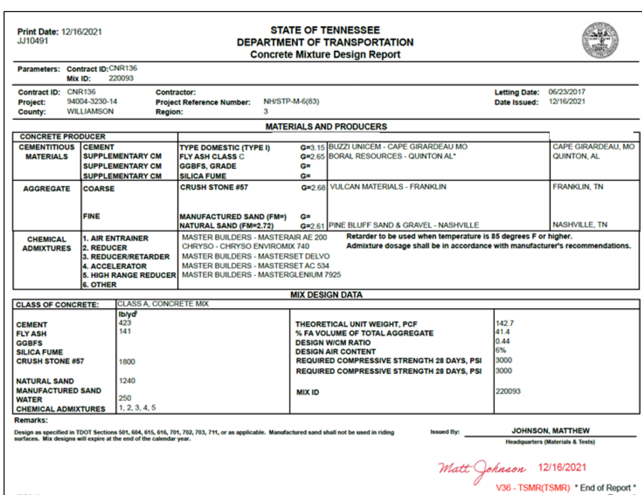
Approved Mix Design



Print Date: 12/16/2021
JJ10491

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
Concrete Mixture Design Report

Parameters: Contract ID: CNR136
Mix ID: 220093

Contract ID:	CNR136	Contractor:		Letting Date:	06/23/2017
Project:	94004-3230-14	Project Reference Number:	NH/STP-M-6(83)	Date Issued:	12/16/2021
County:	WILLIAMSON	Region:	3		

MATERIALS AND PRODUCERS

CONCRETE PRODUCER					
CEMENTITIOUS MATERIALS	CEMENT	TYPE DOMESTIC (TYPE I)	G=3.15	BUZZI UNICEM - CAPE GIRARDEAU MO	CAPE GIRARDEAU, MO
	SUPPLEMENTARY CM	FLY ASH CLASS C	G=2.65	BORAL RESOURCES - QUINTON AL*	QUINTON, AL
	SUPPLEMENTARY CM	GGBFS, GRADE	G=		
	SUPPLEMENTARY CM	SILICA FUME	G=		
AGGREGATE	COARSE	CRUSH STONE #57	G=2.68	VULCAN MATERIALS - FRANKLIN	FRANKLIN, TN
	FINE	MANUFACTURED SAND (FM=)	G=		
		NATURAL SAND (FM=2.72)	G=2.61	PINE BLUFF SAND & GRAVEL - NASHVILLE	NASHVILLE, TN
CHEMICAL ADMIXTURES	1. AIR ENTRAINER	MASTER BUILDERS - MASTERAIR AE 200		Retarder to be used when temperature is 85 degrees F or higher.	
	2. REDUCER	CHRYSO - CHRYSO ENVIROMIX 740		Admixture dosage shall be in accordance with manufacturer's recommendations.	
	3. REDUCER/RETARDER	MASTER BUILDERS - MASTERSET DELVO			
	4. ACCELERATOR	MASTER BUILDERS - MASTERSET AC 534			
	5. HIGH RANGE REDUCER	MASTER BUILDERS - MASTERGLENIUM 7925			
	6. OTHER				

MIX DESIGN DATA

CLASS OF CONCRETE:	CLASS A, CONCRETE MIX		
	lb/yd³		
CEMENT	423	THEORETICAL UNIT WEIGHT, PCF	142.7
FLY ASH	141	% FA VOLUME OF TOTAL AGGREGATE	41.4
GGBFS		DESIGN W/CM RATIO	0.44
SILICA FUME		DESIGN AIR CONTENT	6%
CRUSH STONE #57	1800	REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
		REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
NATURAL SAND	1240		
MANUFACTURED SAND		MIX ID	220093
WATER	250		
CHEMICAL ADMIXTURES	1, 2, 3, 4, 5		

Remarks:

Design as specified in TDOT Sections 501, 604, 615, 616, 701, 702, 703, 711, or as applicable. Manufactured sand shall not be used in riding surfaces. Mix designs will expire at the end of the calendar year.

Issued By: JOHNSON, MATTHEW
Headquarters (Materials & Tests)

Matt Johnson 12/16/2021

V36 - TSMR(TSMR) * End of Report *
Page: 1

RR043

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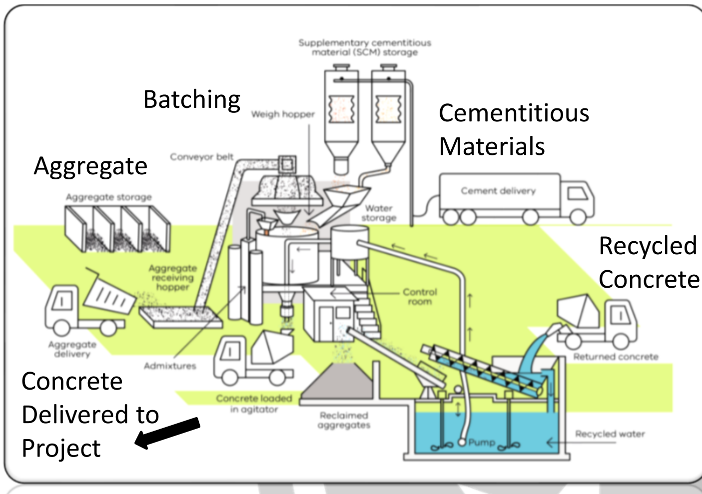
Concrete Production



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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

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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

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Mixing Concrete (604.13)

- Transit Mix Plants
  - 70 to 100 revolutions for drum mixers at mixing speed
    - Mixing/Agitating speed recommended by manufacturer and drum equipped with working revolution counter
- Central Mixer Plants
  - 60 to 90 seconds, time ends when discharge chute is opened
    - Operate mixer at the speed recommended by manufacturer

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Mixing Concrete (604.13)

- The contractor may withhold a portion of the mixing water or admixtures from transit mixers and add at the work site
  - Total amount of water in the mix shall not exceed the maximum in the approved mix design (w/cm Ratio)
  - If water, air entrainers, or chemical admixtures are added at the placement site, mix the concrete a minimum of 30 revolutions at mixing speed after making the additions
  - Acceptance tests invalid after the mix is modified

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Hauling Concrete (501.10 & 604.13)

- Concrete Pavement
  - Non-agitating trucks: No more than **30 minutes** shall elapse from the time *water is added to the mix*
  - Truck Mixers or Truck Agitators: No more than **60 minutes** shall elapse from the time *water is added to the mix*
- Concrete Structures
  - Truck Mixers: No more than **90 minutes** shall elapse from when the *water is added to the mix until the concrete is deposited in place*
  - When the temperature **exceeds 90°F**, no more than **60 minutes** shall elapse for concrete placed in bridge decks

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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

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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[3]	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)
RDA# 1942

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Batch Example

MIX DESIGN DATA

CLASS OF CONCRETE:	A SLIPFORM, CONCRETE MIX		
	lb/yd^3		
CEMENT	423	THEORETICAL UNIT WEIGHT, PCF	144.7
FLY ASH	141	% FA VOLUME OF TOTAL AGGREGATE	45.9
GGBFS		DESIGN W/CM RATIO	0.45
SILICA FUME		DESIGN AIR CONTENT	6%
CRUSH STONE #57	1725	REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
		REQUIRED COMPRESSIVE STRENGTH 28 DAYS, PSI	3000
NATURAL SAND	1364		
MANUFACTURED SAND		MIX ID	220029
WATER	254.40		
CHEMICAL ADMIXTURES	1, 2, 3, 4		

LOAD QUANTITY	CUMULATIVE QUANTITY	ORDERED QUANTITY	PROD ID	PRODUCT DESCRIPTION	UNIT	$/UNIT	EXTENDED
9.00	9.00	9.00	656025	3000 CL A SLIPFM	yd		

BATCH WEIGHTS

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat	Trim
57STONE	1725 lb	15680 lb	15660 lb	-0.13%	1.00% M	19 gl	
BUZZI	423 lb	3807 lb	3805 lb	-0.05%			
FLYASH	141 lb	1269 lb	1270 lb	0.08%			
NATURALSN	1364 lb	13135 lb	13120 lb	-0.12%	7.00% M	103 gl	
POLY900	22.56 oz	203.04 oz	205.00 oz	0.97%			
MICROAIR	1.50 oz	13.50 oz	13.50 oz	0.00%			
COLD	30.5 gl	115.3 gl	116.0 gl	0.58%		116.0 gl	-4.0 gl

Num Batches 1

Actual Load 34837 lb Design W/C 0.451 Water/Cement 0.390 A · Design 274.5 gl Actual 237.4 gl To Add 37.1 gl

Slump: 3.00 in # Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water -4.0 gl / CYI

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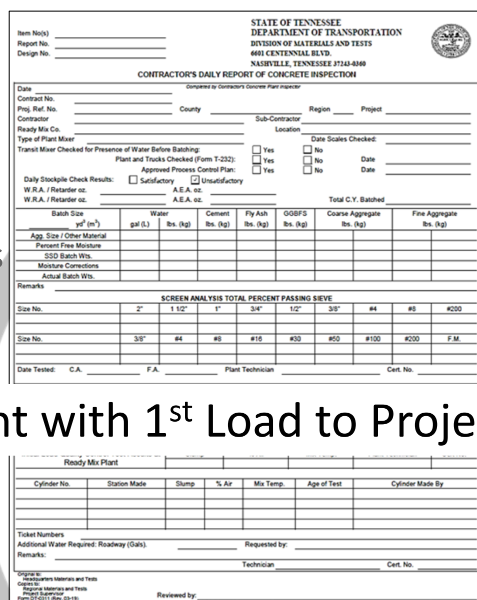
Contractor Daily Report (DT-0311)

- Date
- Contract #
- Project #
- Item Number(s)
- Batch Weights
- Moisture Corrections
- Admixtures
- Slump
- Air Content
- Temperatures
- Gradations



Sent with 1st Load to Project

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Questions

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Sampling Freshly Mixed Concrete

AASHTO R 60

ASTM C172

TDOT Standard Method of Test for

Sampling Freshly Mixed Concrete

References

Standard Specifications

AASHTO R 60

ASTM C172

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Significance and Use

- Procedure for obtaining representative samples of fresh concrete as delivered to the project site
- All required tests will be conducted on samples gathered by this procedure

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Sampling Sources

- Stationary Mixers & Agitators (Central) or Revolving Drum Truck Mixers (Transit)
  - Collect two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch and then composite into one sample for test purposes
  - No portion shall be taken before 10% or after 90% of the batch has been discharged
- Paving Mixers
  - Obtain portions from at least five different portions of the pile and then composite into one sample for test purposes

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Sampling Sources





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Obtain Composite Sample

- Within **15 minutes** of first portion
  - Obtain portions necessary to make composite sample
  - Transport portions to testing location
  - Combine and remix with shovel the minimum amount necessary to ensure uniformity

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Testing Composite Sample

- Start tests for slump, temperature, and air content within **5 minutes** after obtaining the final portion of the composite sample
- Begin molding cylinders for strength testing within **15 minute**s after obtaining the final portion of the composite sample

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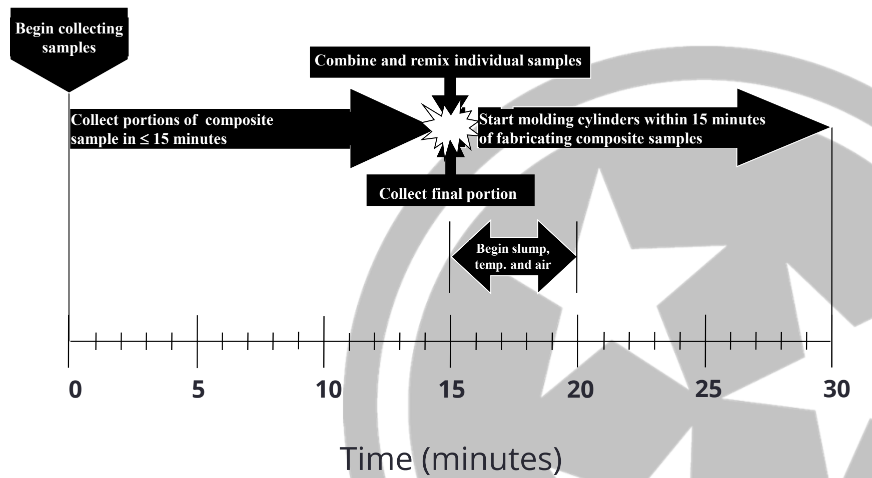
Sampling Timeline



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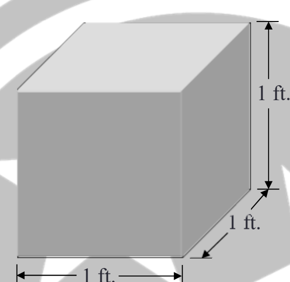
Minimum Sample Size

- Samples to be used for strength tests should be a minimum of one cubic foot (1 cf)
- Smaller samples are allowed for routine air content and slump tests if cylinders are not being made



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Best Management Practices

- Do **<u>not</u>** obtain samples until after all water and any admixtures have been added
- Protect the sample from:
  - Sun
  - Wind
  - Other sources of rapid evaporation
  - Contamination
- Minimize the time between obtaining and using the sample

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Sampling Video

https://youtu.be/geGqlzEe5gQ?t=11

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Let's Review!

- What part of the batch do we sample from?
- How many portions make up a sample when sampling from the truck? When sampling from a paver?
- What is the maximum allowable time to obtain a complete sample?
- When do we start slump, temperature, and air?
- When do we begin making cylinders? What is the minimum sample size we need to cast cylinders?

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?

Questions

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Making and Curing Concrete Test

Specimens in the Field

AASHTO R 100

ASTM C31

TDOT Standard Method of Test for

Making and Curing Concrete Test Specimens in the Field

References

Standard Specifications

AASHTO R 100

ASTM C31

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Significance and Use

- Concrete cylinders used for testing strength must be made by this method to ensure reliability of test results
- Standardized requirements for making, curing, protecting, and transporting concrete tests cylinders under field conditions

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Equipment

- Molds
- Scoop
- Tamping rod
- Vibrators
- Mallet
- Capping Material

Equipment

- Tamping rods must be at least 4 inches greater than the depth of the mold, but not greater than 24 inches long.

Tamping Rod Diameter Requirements	
Cylinder Diameter (in.)	Rod Diameter (in.)
< 6	3/8 ± 1/16
≥ 6	5/8 ± 1/16

Procedure

- Prior to filling, mark the side of the cylinder mold with the following:
  - Cylinder #
  - Date Made
  - Contract #
  - Design Strength
  - JJ Sample ID
- Do not mark on removable caps

Cylinder 23A

7 Nov 22

CNT123

JJ0283422AQ143518

3000 Class A

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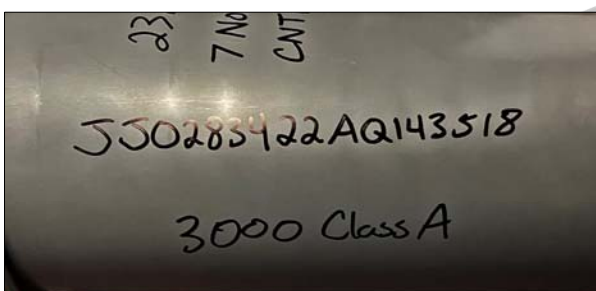
Example



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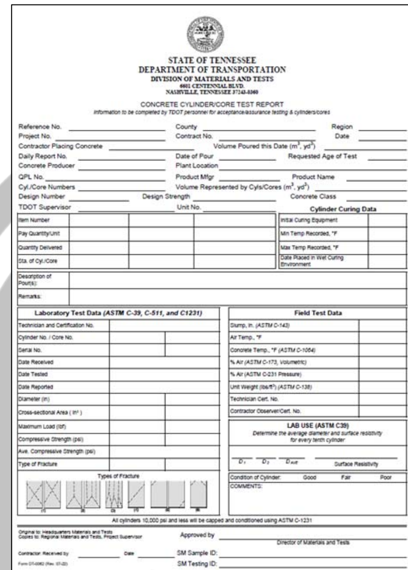
Concrete Cylinder Report (DT-0062)

- Fill out concrete cylinder test report with correct information!
  - Ensure SiteManager information is entered correctly
- Paperless will replace DT-0062



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

CONCRETE CYLINDER/CORE TEST REPORT

Information to be completed by TDOT personnel for acceptance/assurance testing & cylinders/cores

Reference No. ______ County ______ Region ______
Project No. ______ Contract No. ______ Date ______
Contractor Placing Concrete ______ Volume Poured this Date (m^3, yd^3) ______
Daily Report No. ______ Date of Pour ______ Requested Age of Test ______
Concrete Producer ______ Plant Location ______
QPL No. ______ Product Mfgr ______ Product Name ______
Cyl./Core Numbers ______ Volume Represented by Cyls/Cores (m^3, yd^3) ______
Design Number ______ Design Strength ______ Concrete Class ______
TDOT Supervisor ______ Unit No. ______

Item Number			
Pay Quantity/Unit			
Quantity Delivered			
Sta. of Cyl./Core			

Cylinder Curing Data	
Initial Curing Equipment	
Min Temp Recorded, °F	
Max Temp Recorded, °F	
Date Placed in Wet Curing Environment	

Description of Pour(s):	
Remarks:	

Laboratory Test Data *(ASTM C-39, C-511, and C1231)*		
Technician and Certification No.		
Cylinder No. / Core No.		
Serial No.		
Date Received		
Date Tested		
Date Reported		
Diameter (in)		
Cross-sectional Area (in^2)		
Maximum Load (lbf)		
Compressive Strength (psi)		
Ave. Compressive Strength (psi)		
Type of Fracture		

Types of Fracture

Field Test Data	
Slump, in. *(ASTM C-143)*	
Air Temp., °F	
Concrete Temp., °F *(ASTM C-1064)*	
% Air *(ASTM C-173, Volumetric)*	
% Air (ASTM C-231 Pressure)	
Unit Weight (lbs/ft^3) *(ASTM C-138)*	
Technician Cert. No.	
Contractor Observer/Cert. No.	

LAB USE (ASTM C39)
Determine the average diameter and surface resistivity for every tenth cylinder

D_1 D_2 D_{AVE} Surface Resistivity

Condition of Cylinder: Good Fair Poor
COMMENTS:

All cylinders 10,000 psi and less will be capped and conditioned using ASTM C-1231

Original to: Headquarters Materials and Tests
Copies to: Regional Materials and Tests, Project Supervisor

Approved by ______
Director of Materials and Tests

Contractor: Received by ______ Date ______
SM Sample ID: ______
SM Testing ID: ______

Form DT-0062 (Rev. 07-22)

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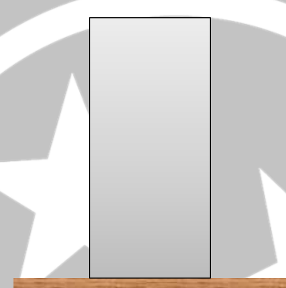
Procedure

- Dampen Equipment
- Place the mold on a level, horizontal, rigid surface that is free of vibration



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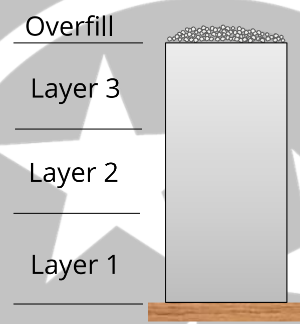
Procedure (6 in. x 12 in.)

- **Required for Class CP only**
- Fill the mold in three equal layers
- Slightly overfill the last layer
- Rod each layer with 25 strokes of the tamping rod
- Tap the sides of the mold 10 to 15 times with the mallet after rodding each layer



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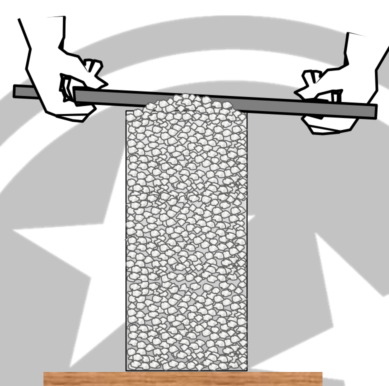
Procedure

- Strike off the concrete by rolling the tamping rod
- Produce a flat even surface that is level with the rim or edge of the mold
- Do not etch on the top surface



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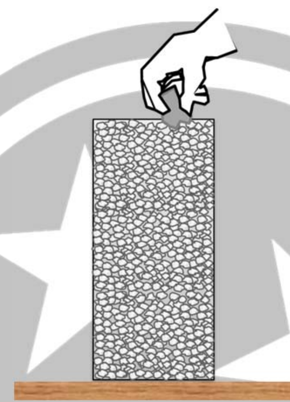
Procedure

- Produce a flat even surface that is level
  - No depressions or projections larger than ⅛ inch
  - Cylinders that are not level at the top or bottom must be saw cut to be tested
- Clean off rim



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Cylinder Video

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Procedure

Handling

- Move to initial curing within 15 minutes after molding
  - Lift and support the cylinder from the bottom of the molds
  - Improper handling of the cylinders may cause deformation

Storage

- Supporting surface on which the specimens are stored should be level to within ¼ inch per foot

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Procedure

Initial Curing

- Immediately after molding and finishing, store cylinders for a period up to 48 hours in a temperature ranging from 60 and 80ºF
- High early strength cylinders (>6000 psi) shall have initial curing temperature between 68 and 78ºF
- Continuously monitor initial curing storage with a minimum and maximum thermometer
  - Record data in the SiteManager sample remarks and the Concrete Cylinder Test Report per 722.09

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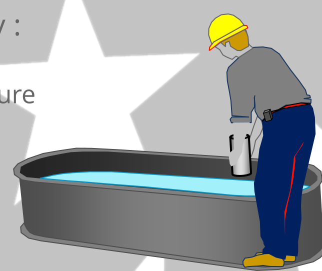
Procedure

- Maintain temperature and moisture
  - Temperature can be maintained by using:
    - Ventilation
    - Ice
    - Cooling devices
    - Heating devices
  - Moisture can be maintained by :
    - Immersing cylinders in water
    - Storing in a container or enclosure
    - Covering with plastic lids
    - Placing inside plastic bags
    - Covering with wet fabric
    - Placing in damp sand pits



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Procedure

Final Curing

- Within 30 minutes after removing molds, cure cylinders with free water maintained on surface at all times at temperature of 73.5± 3.5^{0}F

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Procedure (604.15.C)

Early Break Cylinders

- Field cure in the same manner and method as placed concrete
- Predominately used for:
  - Form Removal
  - Determination of when a structure may be put into service

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Transportation

- Cylinders shall not be transported until at least 8 hours after final set
- Transportation time shall not exceed 4 hours
- Protect cylinders from damage by using suitable cushioning material
- Prevent moisture loss

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Let's Review

- How many layers do we fill 6x12 cylinders in? 4x8s?
- What size diameter tamping rod is required for making 6x12 cylinders? 4x8s?
- How level should the supporting surface be when storing cylinders?
- What is the initial curing temperature required for high early strength cylinders?
- What is the maximum time allowed to transport cylinders?

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Questions

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Volumetric Mobile Mixers

ASTM C685

ACI 304.6R

Use of Volumetric-Measuring and Continuous-Mixing Concrete Equipment

References

Standard Specifications

ASTM C685

ACI 304.6R

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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

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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

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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

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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

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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

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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

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Volumetric Mobile Mixer Video

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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

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Questions

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Temperature of Freshly Mixed

Hydraulic Cement Concrete

AASHTO T 309

ASTM C1064

TDOT Standard Method of Test for

Temperature of Freshly Mixed Hydraulic-Cement Concrete

References

Standard Specifications
AASHTO T 309
ASTM C1064

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Significance and Use

- Measuring the temperature of freshly mixed concrete at the time of testing
  - Ensure concrete temperature meets standard specifications prior to use

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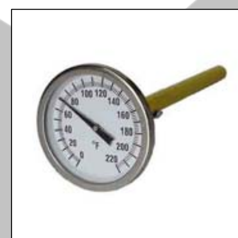
Equipment

Temperature Measuring Device

- Shall be capable of measuring the temperature of the concrete to ±1°F throughout a range of 30° to 120°F
- Calibrate at least once a year or whenever there is a question of accuracy

digital models



analog (dial) models

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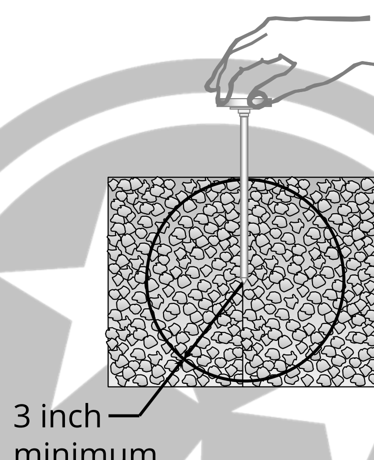
Procedure

- Place the thermometer in the concrete so that the probe is submerged a minimum of 3 inches with 3 inches of cover in all directions
- Coverage must be at least 3 times the nominal maximum coarse aggregate size



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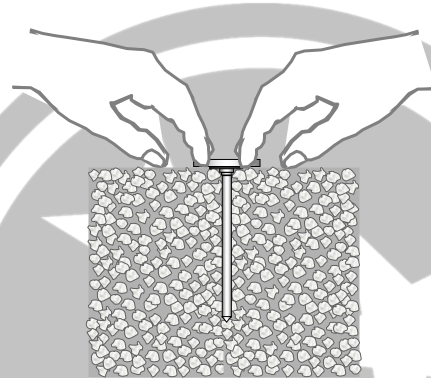
Procedure

- Gently press the concrete around the device at the surface so that ambient air temperature does not affect the reading



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Procedure

- Leave the thermometer in the concrete for a minimum of 2 minutes but not more than 5 minutes
- While the thermometer is ***<u>still in the concrete</u>***, read and record the temperature to the nearest 1ºF

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Temperature Video

https://youtu.be/YQrL4XVOJcA

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Specifications

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

604.12
- Mixing concrete shall discontinue when air temperature is 40°F and falling
- Mixing of concrete shall not start/resume until air temperature is 35°F and rising
- Concreting at air temperatures above 35°F
  - Concrete temperature at the time of placement shall be no less than 50°F nor more than 90°F
- When authorized concreting at air temperatures 35°F or less
  - The mixed, heated concrete shall not be less then 60°F nor more than 100°F at the time of placement

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Let’s Review

- What is the minimum concrete cover required? What if we are taking the temperature of Class CP?
- What is the required amount of time to leave the thermometer in the concrete?
- What do we record temperature to?
- What is the maximum allowable concrete temperature at the point of discharge?

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Questions

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Slump of Hydraulic Cement Concrete

AASHTO T 119

ASTM C143

TDOT Standard Method of Test for

Slump of Hydraulic Cement Concrete

References

Standard Specifications

AASHTO T 119

ASTM C143

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Significance

- To monitor the consistency/workability of plastic concrete
  - Consistency - ability of freshly-mixed concrete to flow
  - Workability - ease of placing, consolidating, and finishing freshly-mixed concrete
- To *estimate* the water content and strength of concrete in a *laboratory setting*
  - Slump increases proportionally with water content and inversely related to concrete strength

$$\boxed{high\,\frac{w}{cm} \Rightarrow weak\ concrete}$$

$$\boxed{low\,\frac{w}{cm} \Rightarrow strong\ concrete}$$

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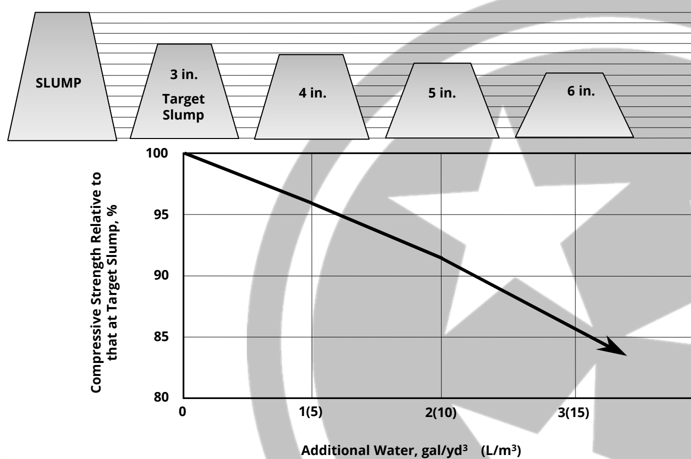
Significance

Effect of Additional Water on Slump and Strength of Concrete in Lab



94

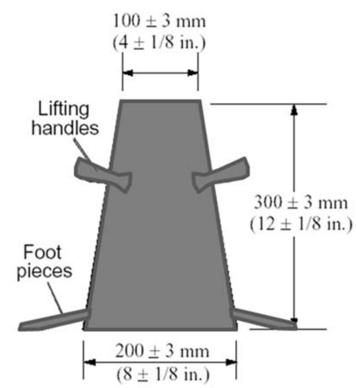
Use

- For plastic concrete with coarse aggregate up to 1½ inches in size
  - If aggregate is larger than 1½ inches, then wet sieving per AASHTO R-60 is required
    - Pour concrete over 1½ inch sieve and shake/vibrate by hand or mechanical means
    - Mix for uniformity the concrete that passes through the sieve
- *Not* applicable:
  - Non-Plastic Concrete (slump < ½ inch)
  - Non-cohesive concrete (slump > 9 inches)

95

Equipment

Mold
- Metal or plastic
- Non-absorbent
- Smooth and free of
  - Dents
  - Deformations
  - Adhered Mortar
- Always be sure to check all equipment for these types problems with every test you perform



Dimensions of slump cone

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Equipment

Tamping rod
- Round, straight steel rod
- ⅝ inch ± 1⁄16 inch in diameter
- 4 inch greater than depth of the mold, but no more than 24 inches long
- Tamping end, rounded to a hemispherical tip

Base
- Flat, nonabsorbent
- Large enough to contain all the slumped concrete in an acceptable test

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Equipment

Ruler/Measuring Tape

- At least 12 inches long
- Marked in increments of ¼ inch or smaller

Scoop

- Large enough so concrete obtained from the sampling receptacle is representative
- Small enough so concrete is not spilled during placement in the mold

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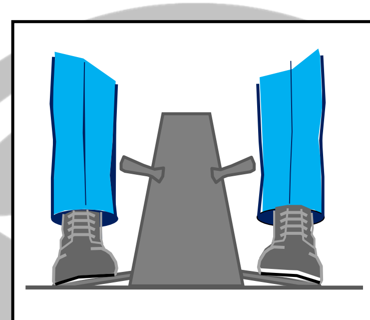
Procedure

- Dampen the inside of the mold and the surface of the base
- Place the base on a flat, level surface
- Place and lock the mold onto the base

  OR
- Stand on the two foot pieces to hold the cone firmly in place



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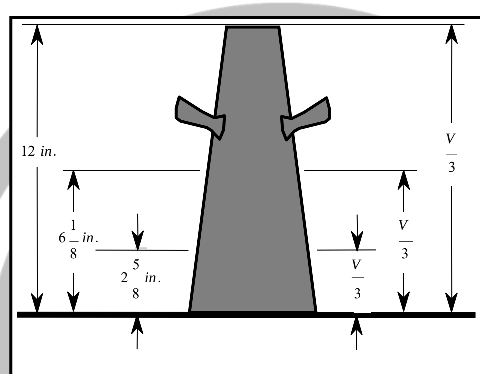
Procedure

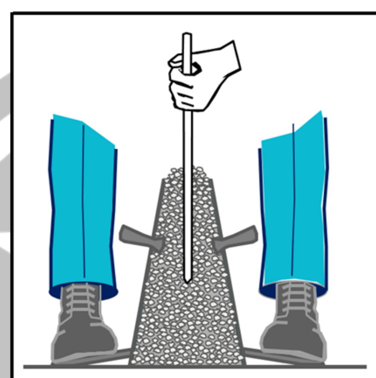
- Fill the mold in three layers
  - Approximately ⅓ of the mold volume
- Fill the cone to overflowing on the last layer



100

Procedure

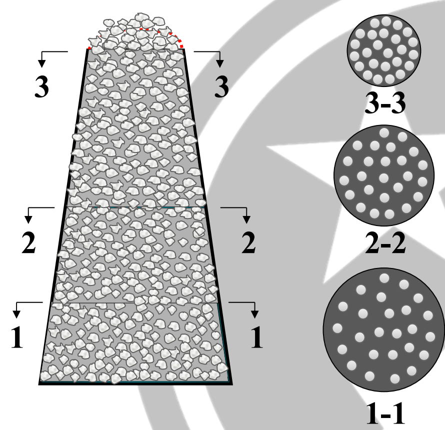
- Rod each layer with 25 strokes of the tamping rod
  - Tilt the tamping rod for the bottom (first) layer
  - When rodding the middle and last layers, penetrate about 1 inch into the previous layer



101

Procedure

- Cross-sectional views showing uniform distribution of strokes



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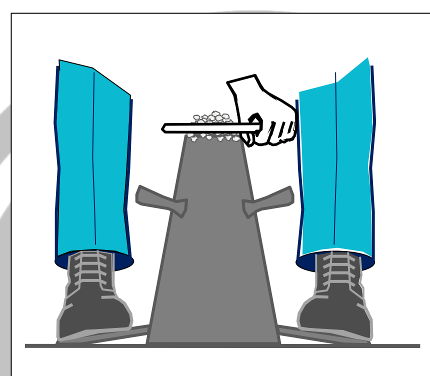
Procedure

- Strike off excess concrete from the cone by a means of screeding and rolling motion of the **tamping rod**
- Clean the concrete away from the base of the mold



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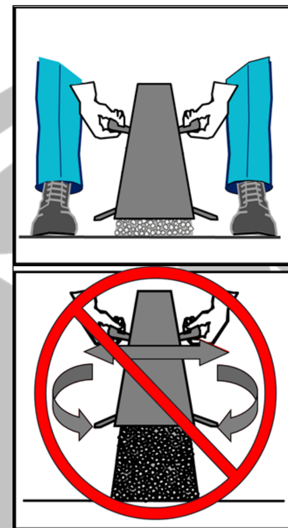
Procedure

- Raise the mold 12 inches in 5 ± 2 seconds
  - Use a steady upward lift
  - Do not use lateral or torsional motion
- Complete entire test from the start without interruption in 2 ½ minutes



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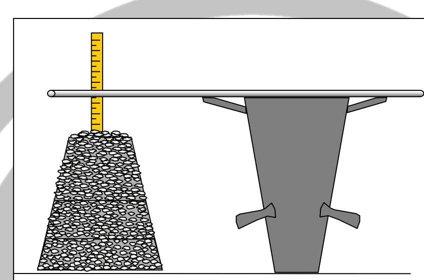
Procedure

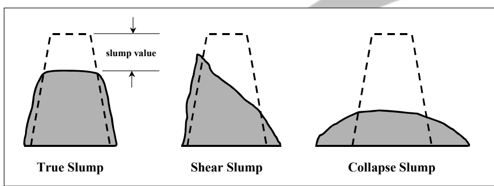
- Place the steel rod horizontally across the inverted mold so that the rod extends over the slumped concrete
- Immediately measure the distance from the bottom of the rod to the displaced center of the concrete
- Record the slump to the nearest ¼ inch



105

Procedure

- If a shearing or collapse of the concrete mass is observed, disregard the results and perform the test again on another portion of the sample



- If two consecutive tests on a sample show a shearing or collapse of the concrete mass, the concrete lacks the necessary plasticity and cohesiveness for the test to be applicable

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Slump Video

https://www.youtube.com/watch?v=jDUQO-bn8pU

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Composition of Various Classes of Concrete

Table 604.03-1: Composition of Various Class of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1 (1)
D, DS (3)	4,000	620	0.40	7	8 max (4)
L (3)	4,000	620	0.40	7	8 max (4)
S (Seal)	3,000	682	0.47	6 ± 2	6 ± 2
X (6)					

(1) For slip forming, the slump shall range from 0 to 3 inches

(4) Water reducing admixtures are acceptable; however, do not exceed the maximum water/cement ratio in order to achieve the required slump

(6) Plans specific requirements

- If using a Type A, F, or G water reducer, then allowable slump shall be a maximum of 8 inches

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Let's Review

- How many layers do we fill the slump cone in?
- How many times do we rod each layer?
- What is the maximum allowable time to complete the slump test?
- Measure slump to the nearest ______.

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Questions

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Unit Weight (Density) and Yield of Concrete

AASHTO T 121

ASTM C138

TDOT Standard Method of Test for

Unit Weight (Density) and Yield of Concrete

References

Standard Specifications

AASHTO T 121

ASTM C138

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Scope

Unit Weight

- Mass per cubic foot of concrete

Yield

- Volume of concrete produced from a mixture of known quantities of component materials

Relative Yield

- Ratio of actual volume of concrete obtained to the volume as designed

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Equipment

- Balance
- Tamping rod
- Internal vibrator (if needed)
- **Strike-off plate**
- Mallet
- Measure
- Scoop







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Capacity of Measure

Nominal Maximum Size of Coarse Aggregate (in.)	Minimum Capacity of Measure (cf)
1	0.2
1 ½	0.4
2	0.5

ASTM C138: Table 1

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Consolidation Method

Slump (in.)	Method of Consolidation
≤ 1	Vibration
1-3	Rod or Vibration
> 3	Rod

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Procedure

- Select a representative sample

- Dampen measure
- Determine the mass of the empty measure

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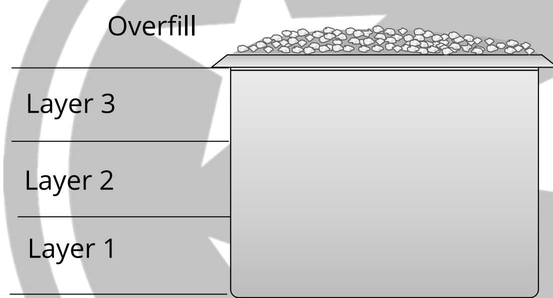
Procedure

- Place measure on flat surface
- Fill the measure in three equal layers
- Slightly overfill the last layer



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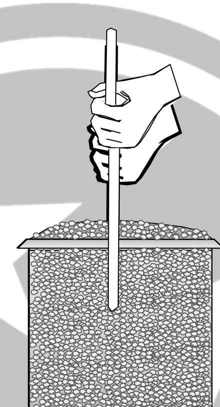
Procedure

- Rod each layer with 25 strokes of the tamping rod
  - Uniformly distribute the strokes over the cross-section of the layer
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the measure
- Rod the middle and top layers penetrating about 1 inch into the underlying layer



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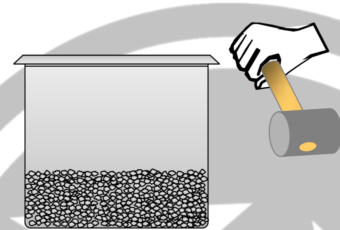
Procedure

- Tap the sides of the measure smartly 10 to 15 times with the mallet after rodding each layer



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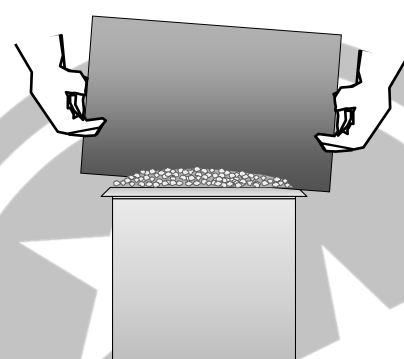
Procedure

- Strike off the concrete using a **strike-off plate**
- Place the plate to cover ⅔ of the surface and use a sawing motion to finish the covered area
- Place the plate on the same ⅔ of the surface and use a sawing motion to advance the plate until it completely slides off the measure
- Incline the plate and perform final strokes for a smooth surface



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UNIT WEIGHT, USE THE PLATE!!!

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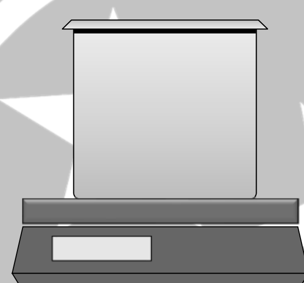
Procedure

- Clean all excess concrete from exterior of measure
- Determine the mass of the concrete and measure



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Unit Weight Video

https://www.youtube.com/watch?v=1mLgdtgRxY8

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Unit Weight Calculations

- Unit Weight (Density)

$$M_{Concrete} = M_{Measure+Concrete} - M_{Measure}$$

$$Unit\ Weight\ (D) = \frac{M_{Concrete}}{V_{Measure}}$$

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Unit Weight Example

- Determine the unit weight of concrete if:

$V_{Measure}$ = 0.50 cf

$M_{Measure}$ = 19.6 lb

$M_{Measure + Concrete}$ = 92.1 lb

$$M_{Concrete} = M_{Measure+Concrete} - M_{Measure} =$$

$$D = \frac{M_{Concrete}}{V_{Measure}} =$$

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Yield Calculations

- Yield (Y)

$$Y_{Concrete}(cy) = \frac{W_{Load}}{(D \times 27)}$$

W_{Load} = total weight of load
D = Unit Weight
27 = convert units cf to cy

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Relative Yield Calculations

- Relative Yield (Ry)

$$R_y = \frac{Y}{Y_d}$$

- If Ry > 1.00, an excess of concrete is being produced
- If Ry < 1.00, the batch is “short” of its designed volume

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Yield/Relative Yield Example

- Determine the yield and relative yield of the following mix:

Design batch (Y_d) = 7 cy

Total weight of load (W_{Load}) = 27,300 lbs

Unit weight of the concrete (D) = 145 lbs/cf

$$Y_{Concrete}(yd^3) = \frac{W_{Load}}{(D \times 27)} =$$

$$R_y = \frac{Y}{Y_d} =$$

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Let's Review

- Determine the unit weight, yield, and relative yield:
  - $V_{Measure}$ = 0.25 cf
  - $M_{Measure}$ = 7.5 lbs
  - $M_{Measure + Concrete}$ = 43.2 lbs
  - Total weight of load (W_{Load}) = 36,000 lbs
  - Design batch (Y_d) = 9 cy

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Solution

- $M_{Concrete} = M_{Measure+Concrete} - M_{Measure} =$
- $Unit\ Weight\ (D) = \frac{M_{Concrete}}{V_{Measure}} =$
- $Y_{Concrete}(yd^3) = \frac{W\ Load}{(D \times 27)} =$
- $R_y = \frac{Y}{Y_d} =$

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Let's Review

- What do we divide our mass of concrete by to get unit weight?
- How many times do we rod each layer?
- What do we use to strike off the measure?
- Relative Yield less than 1 means….

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Questions

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9

Air Content of Freshly Mixed Concrete

By the Pressure Method

AASHTO T 152

ASTM C231

TDOT Standard Method of Test for

Air Content of Freshly Mixed Concrete by the Pressure Method

References

Standard Specifications

AASHTO T 152

ASTM C231

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Significance and Use

- Obtain the air content of freshly mixed concrete
    - Entrained air improves the freeze thaw durability of concrete, but too much air can lead to strength reduction

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Scope

- Applicable to concrete made with relatively dense aggregate particles
- Not applicable to lightweight aggregate
  - exclusive of any air that may exist inside voids within the aggregate particles

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Equipment

- Air Meter
- Tamping Rod
- Strike-off Bar
- Syringe
- Scoop
- Mallet

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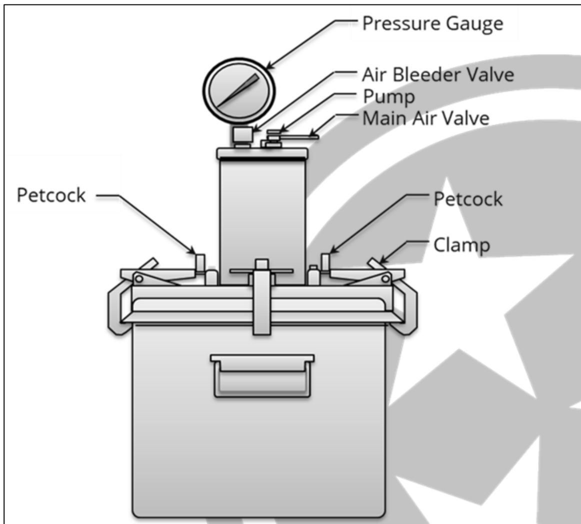
Equipment – Type B Meter



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Equipment – Super Air Meter (SAM)

- Used for PEM designs
- Can determine typical air content along with spacing factor of air voids

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Procedure

- Obtain a sample of freshly-mixed concrete

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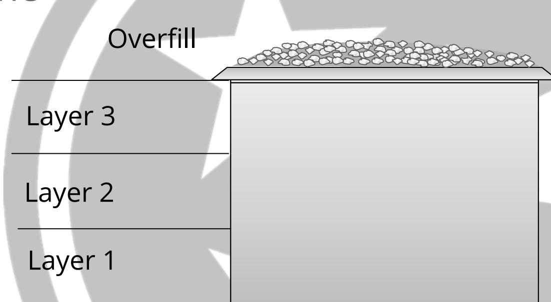
141

Procedure

- Place measure on flat surface
- Fill the measure in three equal layers
- Slightly overfill the last layer



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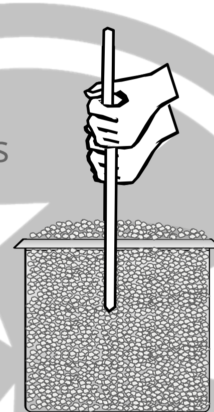
Procedure

- Rod each layer with 25 strokes of the tamping rod
  - Uniformly distribute the strokes over the cross-section of the layer
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the measure
- Rod the middle and top layers penetrating about 1 inch into the underlying layer



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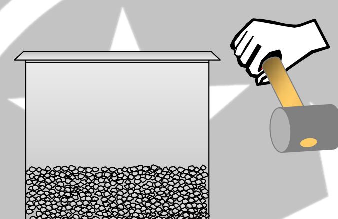
143

Procedure

- Tap the sides of the measure smartly 10 to 15 times with the mallet after rodding each layer



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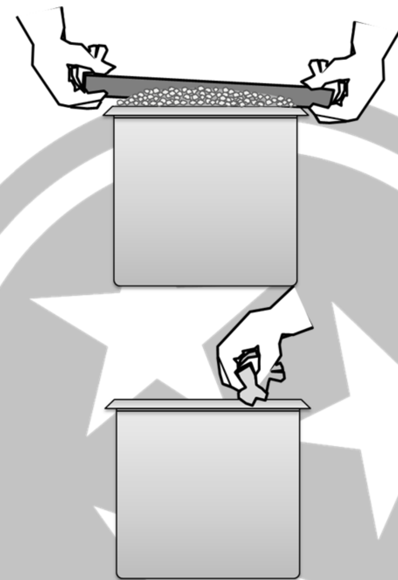
Procedure

- Strike off the concrete level with the top of the measure using the strike-off bar
- Clean off the rim



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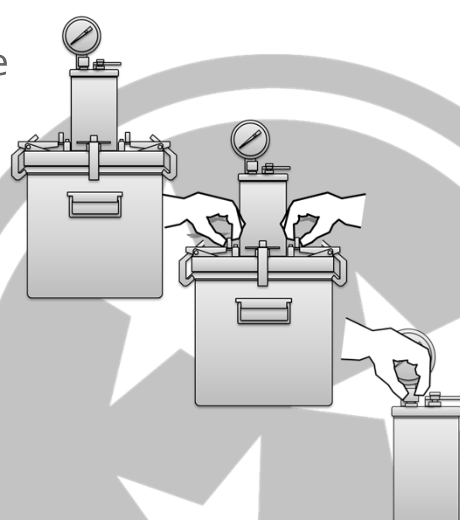
Procedure

- Attach the top of the meter to the measure
- Open both petcocks
- Close the air bleeder valve



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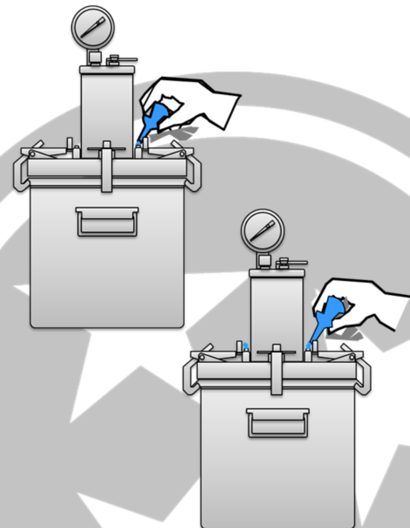
146

Procedure

- Inject water through the petcock until it flows out of the other petcock
  - Continue injecting water into the petcock while tapping the measure to ensure that all of the air is expelled



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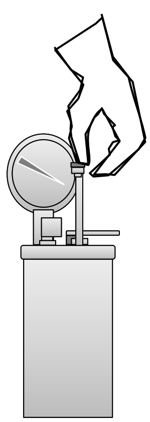
147

Procedure

- Pump air up to the initial pressure line



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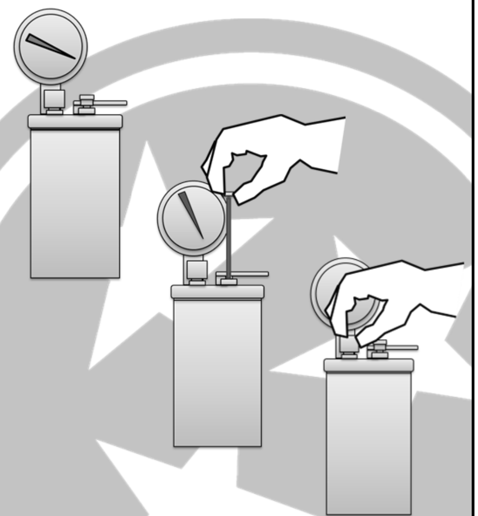
Procedure

- Allow a few seconds for the compressed air to stabilize
- Adjust the gauge to the initial pressure by pumping and bleeding as necessary



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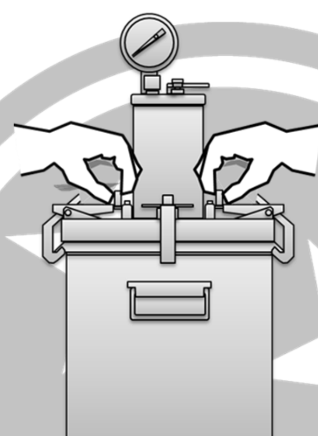
Procedure

- Close both petcocks!



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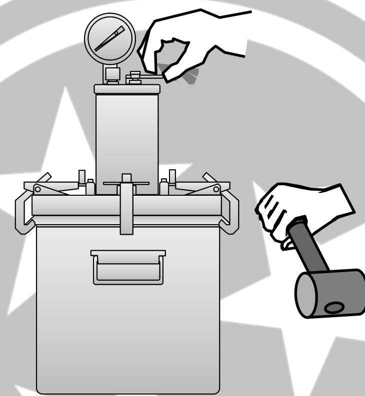
150

Procedure

- Open the main air valve between the chamber and the measure

Simultaneously

- Tap the sides of the measure with the rubber mallet



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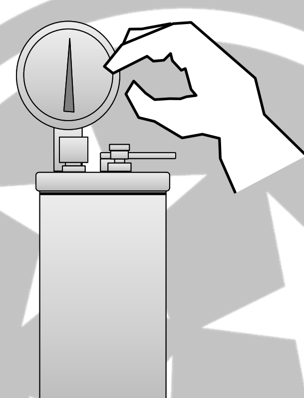
151

Procedure

- Lightly tap the gauge to stabilize the needle
- Read the percentage of air to the nearest 0.1%



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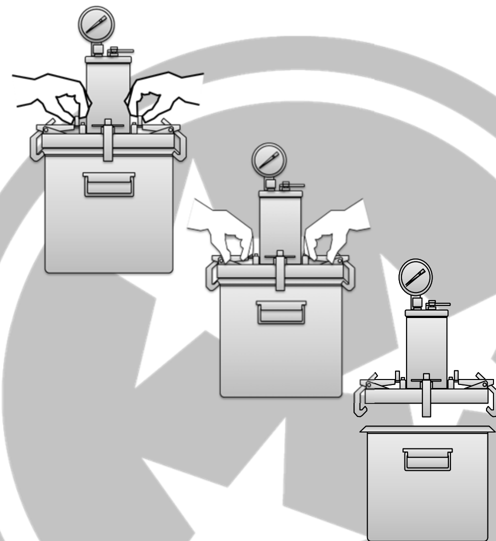
Procedure

- Open petcocks to release pressure
- Unlatch clamps
- Remove the cover



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Air Content (Pressure Method) Video

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Composition of Various Classes of Concrete

Table 604.03-1: Composition of Various Class of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1
D, DS (3)	4,000	620	0.40	7 (3)	8 max
L (3)	4,000	620	0.40	7 (3)	8 max
S (Seal)	3,000	682	0.47	6 ± 2	6 ± 2
X (6)					

(3) Design Class D, Class DS, and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.

(6) Plans specific requirements

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Let's Review

- Which type of concrete can this test NOT be used for?
- How many layers do we fill the measure in?
- How many times do we rod? Tap with the mallet?
- What tool do we use for strike-off?
- Record air to the nearest ______.

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Questions

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10

Air Content of Freshly Mixed Concrete

By the Volumetric Method

AASHTO T 196

ASTM C173

TDOT Standard Method of Test for

Air Content of Freshly Mixed Concrete by the Volumetric Method

References

Standard Specifications

AASHTO T 196

ASTM C173

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Significance and Use

- Air content of freshly mixed concrete having dense or lightweight aggregate
- Results are not affected by air that may be present within porous aggregate particles
- Air content in the mortar (paste) fraction of the concrete

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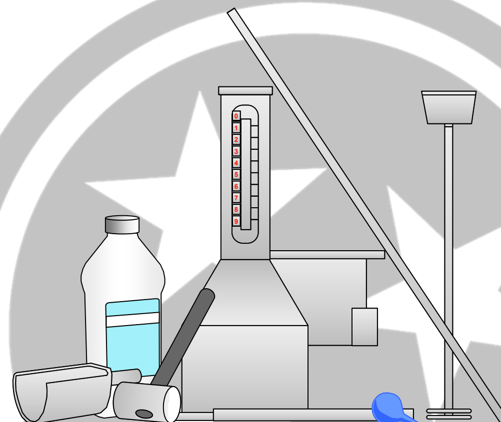
Equipment

- Tamping Rod
- Air Meter
- Funnel
- Strike-Off Bar
- Calibrated Cup
- Syringe
- Pouring Vessel
- Scoop
- Isopropyl Alcohol
- Mallet



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Procedure

- Obtain a sample of freshly-mixed concrete

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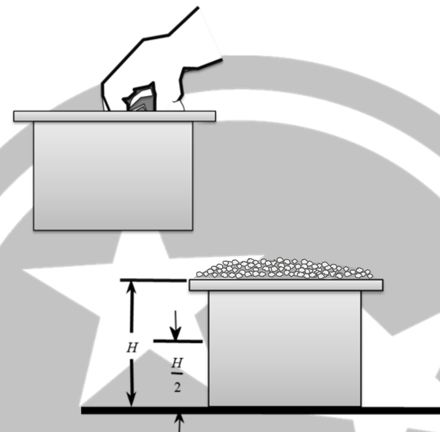
Procedure

- Dampen the inside of the measure
- Fill the measure with a sample of fresh concrete in 2 equal layers
- Slightly overfill the second layer



163

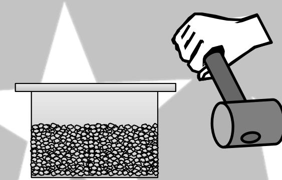
Procedure

- Rod each layer 25 times
  - Uniformly distribute the strokes over the cross-section of each layer
- Rod the bottom layer throughout its depth without forcibly striking the bottom of the measure
- Rod the top layer throughout its depth and penetrate about 1 inch into the first layer

164

Procedure

- Tap the sides of the measure 10 to15 times with the mallet after rodding the each layer



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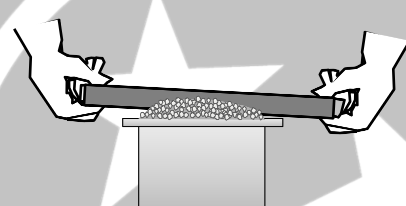
165

Procedure

- Strike off excess concrete from the top with a strike-off bar to level the top of the sample



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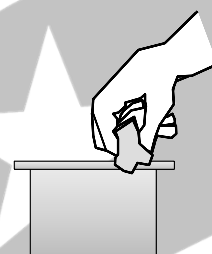
Procedure

- Carefully clean the top edge of the flange and the gasket to allow a tight seal



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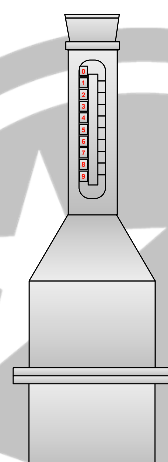
Procedure

- Clamp the top section to the measure
- Insert the baffle bottom funnel
- Add at least 1 pint of water and the selected amount of alcohol
  - Record the number of full pints of alcohol added



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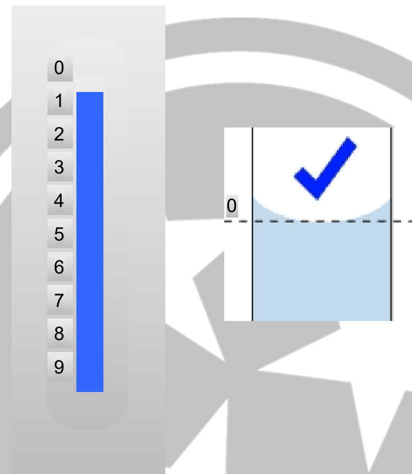
Procedure

- Add more water until it appears in the top section
- When the water line begins approaching zero, remove funnel and add water using the syringe until the bottom of the meniscus is level with the zero line



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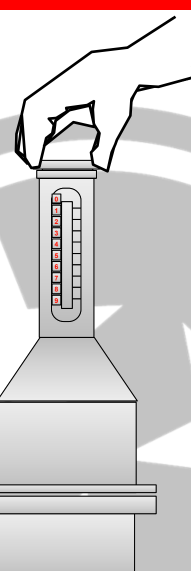
Procedure

- Attach and tighten the watertight cap
  - Note that the seal works by expanding (compression), not twisting (threading)



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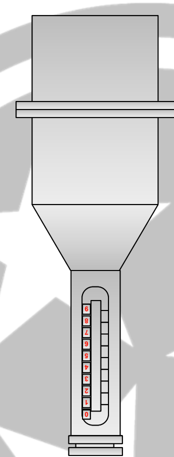
Procedure

- Quickly invert the meter, shake the base horizontally, and return the meter to the upright position
  - Do not keep the meter inverted for more than 5 seconds at a time
- Repeat the inversion and shaking process a minimum of 45 seconds to free the concrete from the base



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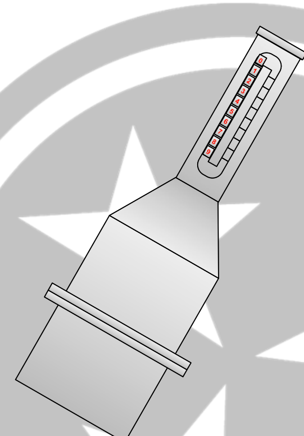
Procedure

- With one hand on the neck and the other on the flange, roll the meter along the testing surface for approximately 1 minute
  - Roll the meter ¼ to ½ turn back and forth
  - Turn the bowl ⅓ turn and repeat the rolling process
  - Continue the turning and rolling procedures for the remaining time



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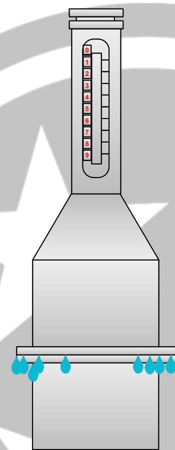
Procedure

- If at any time the air meter leaks while inverting or rolling, the test is invalid
- Start a new test on a new sample



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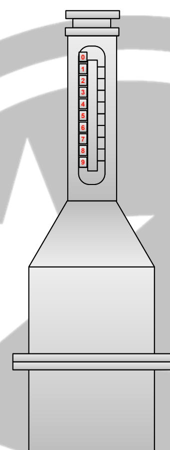
Procedure

- Set the unit upright
- Loosen the cap to allow any pressure to stabilize
- Allow the meter to stand until while air rises to the top and the liquid level stabilizes
  - The liquid level considered stable when it does not change more than **0.25%** air within a 2 minute period



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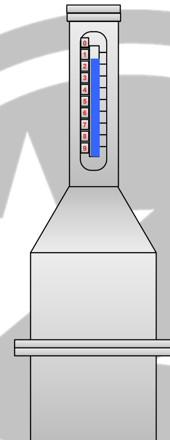
Procedure

- Discard the sample and start a new test if:
  - takes more than 6 minutes for the liquid level to stabilize

    OR
  - more foam than that equivalent to 2% air above the water level
- Use a larger addition of alcohol than was used with the initial trial



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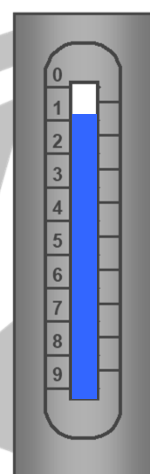
Procedure

- Once the sample has stabilized:
  - Read the liquid level to the nearest 0.25%
  - Record the initial meter reading
- Retighten the cap and repeat the rolling procedure



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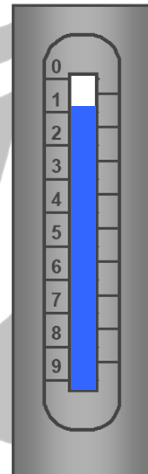
Procedure

- Once the sample has stabilized again:
  - Read the liquid level to the nearest 0.25%
  - If the second reading changed from the initial reading by more than 0.25% use the second reading as the new initial meter reading
  - If not, use the second reading as the final meter reading



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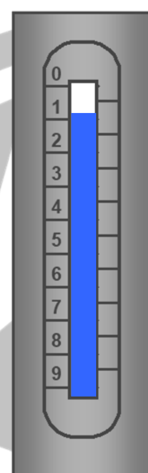
Procedure

- If a third reading is required, repeat the rolling process, and once stable:
  - Read the liquid level to the nearest 0.25%
  - If the third reading changed from the initial reading by more than 0.25%, discard the sample and start a new test with a greater amount of alcohol
  - Otherwise, use the third reading as the final meter reading



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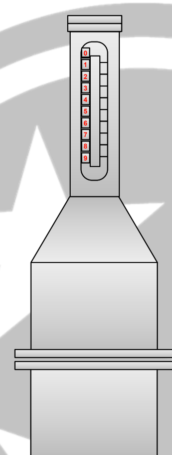
Procedure

- Disassemble the air meter
- Examine the contents for undisturbed concrete
  - If portions of undisturbed concrete are found, the test is invalid
  - If no undisturbed portions are found, the test is valid



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Procedure

- If the air content is greater than the 9% range of the meter, add a sufficient number of calibrated cups of water to bring the liquid level within the graduate range
  - Read the bottom of the meniscus to the nearest 0.25%
  - Record the number of cups of water added
  - The number of calibrated cups will to be added to the final meter reading when testing is complete

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Air Content (Volumetric Method) Video

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Calculations

- A = AR – C + W

A = Air Content, %

AR = Final meter reading, %

C = Correction, %

W = Number of calibrated Cup added to the meter

Correction for Effect of 70% Isopropyl Alcohol on Air Meter Reading

Pints Used	Correction (%)
≤ 2	0.0
3	0.25
4	0.50
5	0.75

*Corrections are applied only when 2.5 pt. or more of isopropyl alcohol are used

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Composition of Various Classes of Concrete

Table 604.03-1: Composition of Various Class of Concrete

Class of Concrete	Min 28-Day Compressive Strength (psi)	Min Cement Content (pound per cubic yard)	Maximum Water/Cement Ratio (pound/pound)	Air Content % (Design ± production tolerance)	Slump (inches)
A	3,000	564	0.45	6 ± 2	3 ± 1
D, DS (3)	4,000	620	0.40	7 (3)	8 max
L (3, 5)	4,000	620	0.40	7 (3)	8 max
S (Seal)	3,000	682	0.47	6 ± 2	6 ± 2
X (6)					

(3) Design Class D, Class DS, and Class L concrete at 7% air content. Acceptance range for pumping and other methods of placement is 4.5-7.5%. Sampling will be at the truck chute.

(5) The unit weight of air dried Class L concrete (lightweight concrete) shall not exceed 115 pounds per cubic foot as determined according to ASTM C567.

(6) Plans specific requirements.

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Lets Review

- Which type of concrete can this test be used for?
- Invert and shake the air meter for a minimum of ____.
- How long do we roll the air meter?
- Record air to the nearest _____.
- What would constitute repeating the test?

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Questions

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Appendix

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Contacts

- Field Services
  - Knoxville: Brad Baskette - 865-594-4552
  - Chattanooga: Tony Renfro - 423-510-1190
  - Nashville: Kevin Isenberg - 615-350-4312
  - Jackson: Lindsey Skaggs - 731-935-0216
- HQMT Training Coordinator
  - Kim Whitby – 615-350-4158; Kimberly.Whitby@tn.gov

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AASHTO/ASTM Resources

- Sampling Freshly Mixed Concrete: R 60 / C172
- Temperature of Freshly Mixed Hydraulic-Cement Concrete: T 309 / C1064
- Slump of Hydraulic Cement Concrete: T 119 / C143
- Unit Weight & Yield of Concrete: T 121 / C138
- Air Content of Freshly Mixed Concrete By the Pressure Method: T 152 / C231
- Air Content of Freshly Mixed Concrete By the Volumetric Method: T 196 / C173
- Making & Curing Concrete Test Specimens in the Field: R 100 / C31

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SOP 1-1

- Acceptance Testing Frequencies
  - Part Two: Acceptance Samples and Tests
  - Part Three: Verification/Check Samples and Tests
- Class PEM added to both parts
  - Super Air Meter, Surface Resistivity, Resistance of Concrete to Rapid Freezing and Thawing, Resistivity of Concrete
- Maturity test added for Part Three
- Changes are highlighted in red

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Acceptance Testing Frequencies (SOP 1-1)

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
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

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Acceptance Testing Frequencies (SOP 1-1)

Part Three: Verification/Check Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
CONCRETE						
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Cement, Fly Ash, Slag Cement	Laboratory Analysis	M&T	Every six months	Concrete plant	One-pint sample shall be sent to HQ M&T Lab.
	Aggregate: Coarse & Fine	Quality		Annually	Aggregate plant	Also, as appearance changes or locations in quarry are changed. Additional samples to be obtained when production exceeds normal output.
		Gradation and Wash (Not required for minor structures)		Per month	Concrete plant	Perform wash test on fine aggregate only when percent passing the No. 200 sieve dry exceeds 2.0%
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Precast Products, Reinforced Concrete Pipe	Fitment	Project Inspector	Per Product	Project Site	Verification is based on the final acceptance of the product(s) meeting the requirements of the contract plans.
		Verification in accordance with SOP 5-3				
	Class PEM	Super Air Meter number, Surface Resistivity, Resistance of Concrete to Rapid Freezing and Thawing, Resistivity of Concrete	M&T	With every PEM design submission	Project Site	Refer to Standard Specification 604.03 A.1.d. All information for data collection only
	All Classes	Maturity	M&T	During Trial Batch	Producer Facility	Refer to ASTM C1074 for guidance Must be witnessed be M&T Intended for data collection for designs on select projects
Polymer Modified (PMC)	Aggregate: Coarse & Fine	Gradation	Project Inspector or M&T	At beginning of project and every 500 tons	Project stockpile	Refer to Standard Specification 619.04.A
		Moisture		Per day		

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SOP 4-1

- Quality Control and Acceptance of Portland Cement concrete for Bridge Decks
  - Establishes the minimum TDOT requirements for the quality control and acceptance testing of Portland cement concrete for bridge decks
    - Pre-pour conference is required
    - Bridge deck concrete placed by pumping or other placement methods shall have an air content of 4.5% - 7.5% at the discharge end of the truck chute immediately prior to pumping or placement, no exceptions
    - Each truck shall be tested for air content, slump, and temperature at the beginning of each day until three consecutive trucks meet specification. Once that specific truck meets specifications, it shall be allowed to pour
    - One set of cylinders shall randomly be cast from one of the first three passing loads

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Upcoming Spec Changes

- Performance Engineered Mixture (604.03)
  - Super Air Meter (SAM) number
  - Resistance to Rapid Freezing and Thawing
  - Surface Resistivity
  - Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction
  - Optimized Aggregate Gradations
- Maturity Method
- Blended Hydraulic Cement (901.01)

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Operations Memos

- Concrete Cylinder Acceptance
  - Date: November 16, 2016
  - Subject: Number of Cylinders
    - (2) 4x8” Cylinders
    - Except Class CP (2) 6x12” Cylinders
- Concrete Cylinder Acceptance
  - Date: November 14, 2017
  - Subject: Making, curing, handling of cylinders
    - Contractor to provide proper storage on site for curing
    - Initial Curing Temperature Conditions
    - Transportation Guidance
    - Key References at end of memo
- Circular Letters
  - C.L. 604.03-01
    - Date: April 1, 2009
    - Subject: Concrete Delivery Tickets
  - C.L. 50.09-01
    - Date: July 1, 1992
    - Subject: Concrete Batch Tickets

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Concrete Ready-Mix Truck Memo (Volume)

- Producers must identify the maximum allowable volume of concrete (cubic yards) that can be hauled
  - Tare weight assumptions includes full tank of fuel, full water tank, and operator being seated in cab.
- Effective at start of 2023

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
CONSTRUCTION DIVISION
SUITE 700, JAMES K. POLK BUILDING
505 DEADERICK STREET
NASHVILLE, TENNESSEE 37243-1402
(615) 741-2414

BUTCH ELEY
DEPUTY GOVERNOR &
COMMISSIONER OF TRANSPORTATION

BILL LEE
GOVERNOR

MEMORANDUM

TO: Regional Operations
Regional Materials and Test
Tennessee Ready Mix Suppliers
Tennessee Contractors

FROM: Brian Egan, PE, Construction Division Director
Heather Hall, PE, Materials and Tests Division Director

DATE: September 26, 2022

SUBJECT: Bridge Weight Formula—Concrete Ready-Mix trucks

During the past year there have been some instances with concrete ready-mix trucks exceeding the maximum allowable gross weights and therefore violating the bridge weight formula when hauling on the Interstate System. It is recognized that ready mix trucks are not weighed before (tare) and after (gross) being loaded with the concrete materials. Due to the weight of water (100-200 gallon tanks), fuel (50-100 gallon tanks), and other items on the truck, the actual tare weight may be different than what is posted on the side of the vehicle (required per §107.02A).

The purpose of this memorandum is to establish new guidelines to avoid the need to check each ready-mix truck for weight compliance on state routes and the interstate. This will require ready mix producers to check and verify the current tare weights and allowable weights on their trucks. This is necessary due to the numerous variations in the number of axles, spacing of axles, tare weights, etc.. in the trucking fleet.

Effective calendar year 2023, all “Concrete Truck Checklists”, submitted with the annual plant renewal, shall also identify the *maximum allowable volume of concrete (Cubic Yard/YD^3) that can be hauled (state routes and interstates) without exceeding the allowable gross weights (example attached).* This must include the assumption that the tare weight includes a full tank of fuel, a full water tank, and the operator is seated in the cab (§109.01 E.) However, the ready-mix producer could elect to make tare and gross weights for every truck delivered to the project. Concrete mixture properties (i.e. unit weight) and allowable batching tolerances should also be considered when determining the maximum volume of concrete allowed.

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Best Management Practices

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Best Management Practices

- Hot weather concreting
  - Causes/Effects
  - Best pre-pour practices
  - Best practices during pour
  - Best post-pour practices
- Cold weather concreting
  - Causes/Effects
  - Best pre-pour practices
  - Best practices during pour
  - Best post-pour practices

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HOT
WEATHER
TIPS

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7 Day Planner
JustWeather.com
SAT SUN MON TUE WED THU FRI
20% 20% 20%
103 102 102 101 100 100 100
80 78 78 79 80 80
SEVERE
WEATHER TEAM

200

Hot Weather Concreting

Causes

- High Temperatures
  - Average daily temperature greater than 77°F (ACI)
- High Winds
- Low Relative Humidity
- Solar Radiation

Effects

- Plastic shrinkage cracking
- Accelerated slump loss
- Loss of entrained air
- Quicker set time
- Thermal cracking

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Best Pre-Pour Practices

- Plan and be prepared!
- Look at the upcoming weather forecast
- Hold a pre-pour conference
  - TDOT, the contractor, and the concrete producer should all be present.
  - Discuss actions that should be taken by all parties to ensure quality concrete

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Best Pre-Pour Practices

- Concrete Producer:
  - Shade aggregate stockpiles
  - Sprinkle water on coarse aggregate stockpile
    - Adjust mix proportions due to the moisture content
  - Use chilled water or ice in place of mix water
    - Must not exceed water/cement ratio for the design
  - Use liquid nitrogen to cool the concrete
  - Submit a hot weather mix design for approval
    - Use water reducing and set retarding admixtures
    - Use of Class F fly ash or slag can lower heat generation

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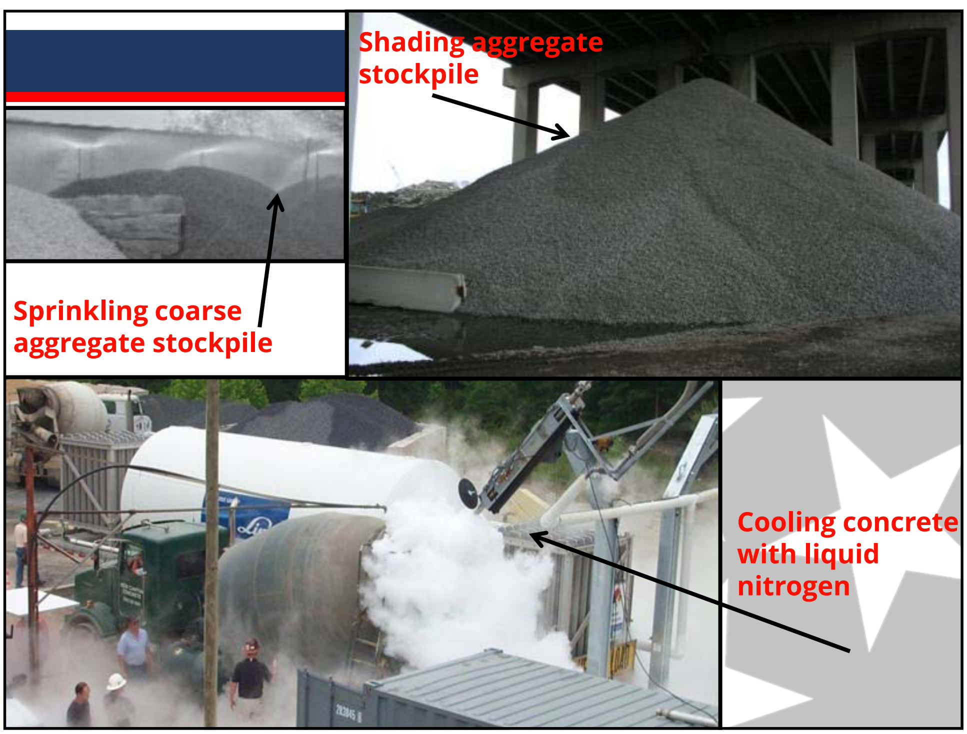

204

Best Pre-Pour Practices

- Contractor:
  - Schedule pours for the night or early morning
  - Avoid delays in delivery, placement, and finishing of concrete
    - Have ample laborers to be able to handle the amount of concrete
    - Schedule trucks to maintain a consistent moving operation to avoid any stop/start delays
  - Have evaporation control measures on-site

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Best Practices During the Pour

- Inspector:
  - Ensure design water/cement ratio has not been exceeded by the addition of ice or chilled water (added at the plant or on-site)
  - Ensure measures are in place when evaporation rate exceeds 0.2 Lbs/S.F./Hr (Use nomograph)
  - Check discharge time of the concrete (501.10, 604.13)
  - For example, if pouring structural concrete:
    - 90 minutes if air temperature is less than 90°F
    - 60 minutes if air temperature is 90°F or above (bridge decks)
  - Test concrete temperature
    - Maximum allowable concrete temperature is 90°F (604.11)

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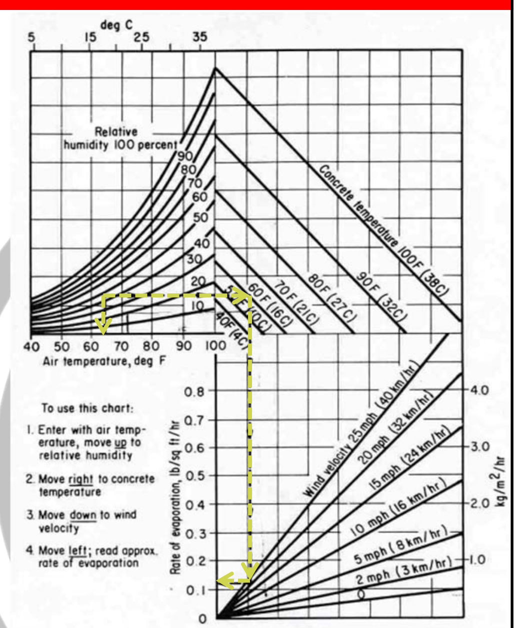
ACI Nomograph

- Estimates rate of evaporation of surface moisture from concrete
  - Figure 604.16-1 on Page 546 in TDOT Standard Specifications for Road and Bridge Construction 2015
- Shown example:
  - 65°F Air Temperature
  - 45% Relative Humidity
  - 60°F Concrete Temperature
  - 20 mph Wind Velocity



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Best Practices During the Pour

- Inspector:
  - Initial curing for concrete test cylinders:
    - Immediately after molding and finishing, store specimens in a cure box for a period up to 48 hours.
    - Temperature in cure box shall range between (AASHTO T-23):
      - 60°F-80°F for mixes with design strength below 6000 psi
      - 68°F-78°F for high early strength cylinders (≥6000 psi)
    - Storage temperature shall be controlled by use of heating and cooling devices, as necessary.
  - Within 30 min. after removing molds, cure specimens with free water maintained on surface at all times at a temperature of 73.5°±3.5°F

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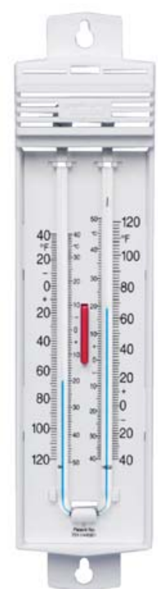
Initial Curing

Final Curing

Max/Min Thermometer



210

Best Practices During the Pour

- Contractor:
  - Dampen forms and reinforcement (604.16)
  - Use evaporation measures when required
    - Plastic sheeting
    - Fog spray
    - Windbreaks
    - Sunshades
  - Place and finish concrete ASAP!
  - Begin curing procedure immediately after the water sheen disappears from the surface (604.23)

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Best Post-Pour Practices

- Keep surfaces damp and protected from the sun for (604.23):
  - 120 hours for bridge decks and other slabs
  - (Use a continuously fed soaker hose system)
  - 72 hours for all other surfaces
- Protect concrete from a rapid temperature drop (40°F drop in first 24 hours-ACI 305.1-06)
  - Use insulation blankets or other approved method for regulating concrete temperature

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Continuously Fed Soaker Hose System

Applying insulation blankets

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Cold Weather Best Practices

- 3 consecutive days in which the average daily temperature drops below 40°F is considered cold weather (ACI)
- Any 24-hour duration in which the temperature is above 50°F for 12 hours is no longer considered cold weather (ACI)
- When cold weather is expected while concreting, preparations must be made to ensure quality concrete

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Effects of Cold Weather Concreting

- 50% reduction of ultimate strength of the concrete if it freezes within the first 24 hours (Can't be repaired)
- Thermal cracking caused by a rapid change in concrete temperature (Thermal shock)
- Delayed set time
- Temperature curling of concrete pavement

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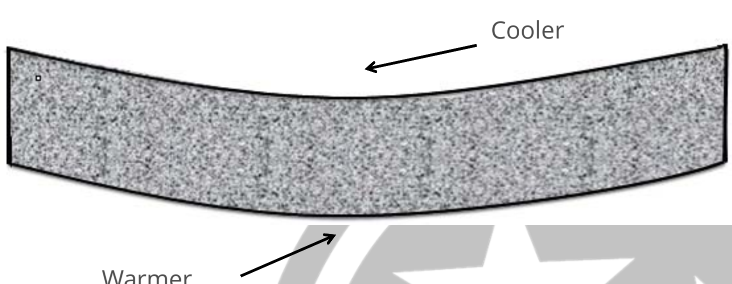
Temperature Curling



Large temperature difference in the top and bottom of the slab can cause concrete to curl.

Watch out for this in concrete pavement!

220

Best Pre-Pour Practices

- Concrete Producer:
  - Submit a cold weather mix design for approval
    - Use Type III cement or use an extra 100-200 lb/C.Y. of Type I cement (high-early strength concrete)
    - Avoid use of fly-ash and slag
    - Use a Type C (Accelerator) chemical admixture
    - Use a Type E (Water reducer & Accelerator) chemical admixture
  - Heat materials
    - Uniformly heat aggregates and water before mixing.

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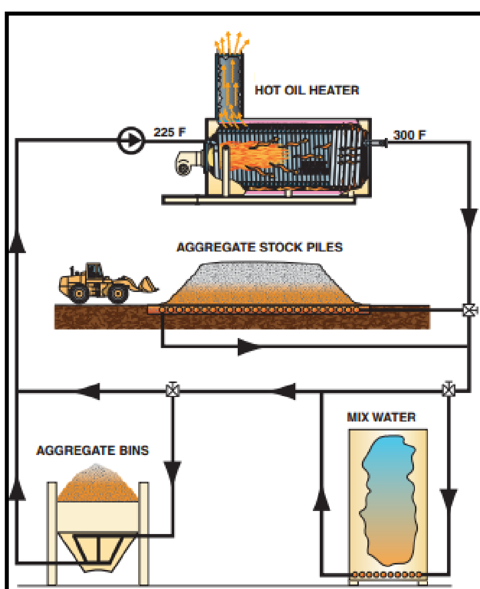
Heating Concrete Materials



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Best Pre-Pour Practices

- Contractor:
  - Schedule pour for the warmest part of the day
  - Surfaces to be cast against should be free from ice and snow
  - Insulate the subgrade prior to pouring
  - Have materials available on-site to protect the concrete from cold weather

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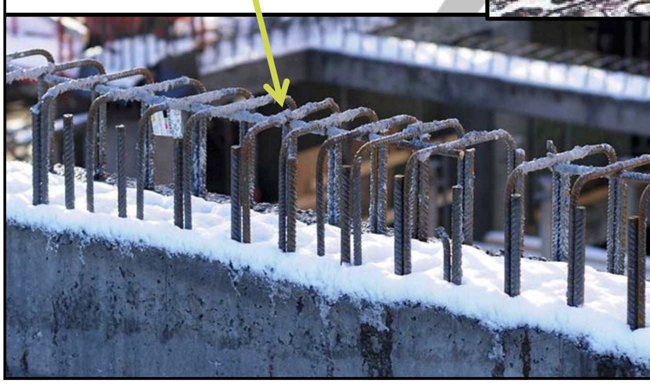
Clean off snow/ice from reinforcement bars



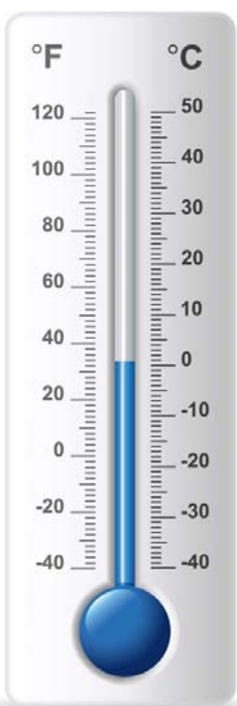
Heating the ground with hydronic heat pipes

224

Best Pre-Pour Practices

- Inspector:
  - Check the air temperature (501.11 & 604.12)
    - Temperature must be 35°F and rising to begin mixing and concreting operations
    - Mixing and concreting operations shall discontinue when temperatures reach 40°F and falling.
  - Concrete may be poured at temperatures below 35°F, if authorized by the engineer in writing.
    - Water and aggregates at time of mixing must be between 70°F and 150°F. (Plant inspector can check)

225



Ensure thermometer is calibrated and working properly!

35°F and rising

10 AM Tue, Dec 22	32°	23°
11 AM Tue, Dec 22	33°	24°
12 PM Tue, Dec 22	34°	25°
1 PM Tue, Dec 22	35°	26°
2 PM Tue, Dec 22	36°	27°

40°F and falling

1 PM Tue, Dec 22	41°	35°
2 PM Tue, Dec 22	40°	35°
3 PM Tue, Dec 22	40°	34°
4 PM Tue, Dec 22	39°	33°
5 PM Tue, Dec 22	39°	33°

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Best Practices During the Pour

- Contractor:
  - Provide a cure box for initial curing of concrete cylinders for up to 48 hours.
  - Temperature in the cure box shall be maintained by heating and cooling as necessary and shall range between:
    - 60°F-80°F for mixes with design strength below 6000 psi
    - 68°F-78°F for high early strength mixes (≥6000 psi)

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Heat or cool as necessary

Storage for initial curing of concrete cylinders

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Best Practices During the Pour

- Contractor:
  - Curing
    - Avoid using conventional water curing methods within 24 hours of freezing temperatures
    - Use liquid membrane curing compound
    - Use live steam
- Inspector:
  - Monitor concrete temperature (501.11 & 604.12)
    - 50°F-90°F at time of placement
    - 60°F-100°F if authorized to pour below 35°F

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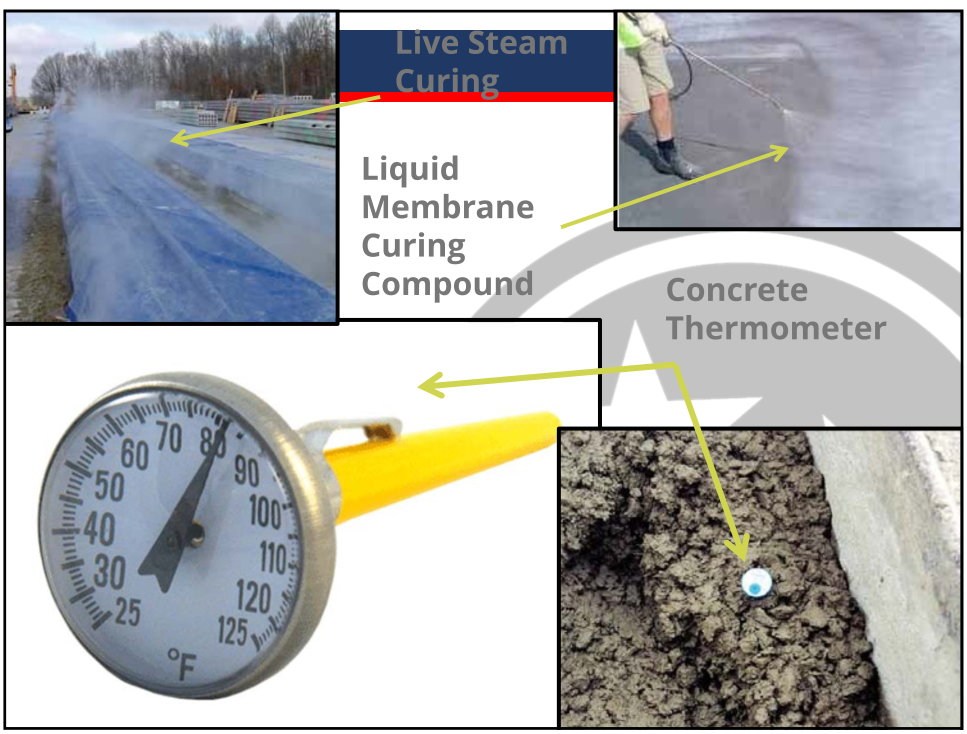

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Best Post-Pour Practices

- Inspector:
  - Record the maximum and minimum temperature surrounding the fresh concrete daily
- Contractor:
  - Provide cold weather protection of fresh concrete if ambient temperature is expected to drop below 35°F (604.24)
    - Air surrounding the fresh concrete must be maintained at a temperature between 45°F-80°F for 120 hours (5 days)
    - Furnish a maximum-minimum thermometer for temperature documentation

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Insulation Blanket Protection

Max/Min Thermometer

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Best Post-Pour Practices

- Contractor:
  - Acceptable cold weather protection:
    - Insulation blankets
    - Heated enclosures
  - Caution with heated enclosures
    - When using combustion heaters, there must be sufficient ventilation for safety as well as to protect concrete from carbonation
    - Place heaters in a manner to prevent overheating or over drying select areas of the fresh concrete

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Carbonation led to the deterioration

Heated Enclosures

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Cracks Resulting from Thermal Shock

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Best Post-Pour Practices

- Contractor:
  - Removal of forms and falsework (501.19 & 604.19)
    - In cold weather, vertical forms shall remain in place until concrete has set sufficiently to withstand damage when forms are removed.
    - Falsework may be removed from concrete structures after 21 calendar days or 7 days in which the temperature has not fell below 40°F.
  - Avoid thermal shock! (rapid temperature change)

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Review Slide Answers

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Sampling Review

- What part of the batch do we sample from?
  - Between the first 10% and last 10% of a concrete batch
- How many portions make up a sample when sampling from the truck? When sampling from a paver?
  - Truck – at least 2 portions; paver – at least 5 portions
- What is the maximum allowable time to obtain a complete sample?
  - 15 minutes
- When do we start slump, temperature, and air?
  - Within 5 min of obtaining final portion of sample
- When do we begin making cylinders? What is the minimum sample size we need to cast cylinders?
  - Within 15 min of gathering final portion of sample
  - 1 cubic foot

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Cylinders Review

- How many layers do we fill 6x12 cylinders in? 4x8s?
  6x12 - 3 Layers, 4x8 - 2 Layers
- What size diameter tamping rod is required for making 6x12 cylinders? 4x8s?
  6x12 - 5/8"±1/16, 4x8 - 3/8"±1/16
- How level should the supporting surface be when storing cylinders?
  1/4" per foot
- What is the initial curing temperature required for high early strength cylinders?
  68°F - 78°F
- What is the maximum time allowed to transport cylinders? 4 hours

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Volumetric Mobile Mixer 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

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Temperature Review

- What is the minimum concrete cover required? What if we are taking the temperature of Class CP? 3 inches in all directions

For Class CP (nominal max aggregate size of 1 ½ inches) it's 4 ½ inches

- What is the required amount of time to leave the thermometer in the concrete?

  Between 2 minutes and 5 minutes

- What do we record temperature to?

  Record temperature to the nearest 1°F

- What is the maximum allowable concrete temperature at the point of discharge?

  90°F

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Slump Review

- How many layers do we fill the slump cone in?

  3 equal volume layers

- How many times do we rod each layer?

  25 times per layer

- What is the maximum allowable time to complete the slump test?

  2:30 from scoop to measurement

- Measure slump to the nearest ______.

  ¼ inch

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Unit Weight Review

- What do we divide our mass of concrete by to get unit weight?
  Volume of our measure
- How many times do we rod each layer?
  25 times per layer
- What do we use to strike off the measure?
  Unit weight use the plate
- Relative Yield less than 1 means….
  The batch is short of the designed volume

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Air Content (Pressure) Review

- Which type of concrete can this test NOT be used for?
  Lightweight Concrete
- How many layers do we fill the measure in?
  3
- How many times do we rod? Tap with the mallet?
  25 10-15
- What tool do we use for strike-off?
  Strike-off Bar
- Record air to the nearest 0.1%.

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Air Content (Volumetric) Review

- Which type of concrete can this test be used for?
  All concrete, lightweight included
- Invert and shake the air meter for a minimum of 45 seconds, inverting for no more than 5 seconds at a time.
- How long do we roll the air meter?
  1 minute
- Record air to the nearest 0.25%.
- What would constitute repeating the test?
  1. Leak 2. too much foam (>2%) 3. slow to stabilize (>6min)
  4. level drops on third read (>0.25%) 5. concrete left in pot

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Questions

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Materials & Tests Website

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

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THANK YOU!

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