VDOT
Virginia Department of Transportation

Concrete Pocket Guide

Updated: March 2022

INTRODUCTION

Concrete is critical in the infrastructure of the Commonwealth of Virginia. Achieving high quality hydraulic cement concrete and successful installation require cooperation and a high level of communication between Contractors, Consultants, HCC Producers and VDOT personnel.

As Inspectors, you play a critical role in ensuring concrete is placed in conformance with all requirements. Field control begins long before concrete arrives at the project site and continues long after the concrete has been placed. There are many factors in the field that may adversely affect concrete, resulting in reduced strength and durability. For these reasons, it is necessary that field conditions be controlled to achieve the desired product.

This Guide is NOT an official governance document, *but rather a best practices guide intended for use by VDOT and Consultant Inspectors. This Guide cannot be used to reject work that was done in conformance with the contract documents. This Guide should be used as a quick reference to use on site and to help quickly identify problems and to supplement the Specifications and the reader's knowledge.*

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REFERENCE DOCUMENTS

ASTM – American Society of Testing and Materials

- ASTM C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm] Cube Specimens)
- ASTM C31 – Standard Practice for Marking and Curing Concrete Test Specimens in the Field
- ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C173 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete
- ASTM C143 – Standard Test Method for Slump of Hydraulic-Cement Concrete
- ASTM C1064 – Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- ASTM C138 – Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- ASTM C1611 – Standard Test Method for Slump Flow of Self-Consolidating Concrete
- ASTM C1621 – Standard Test Method for Passing Ability of Self-Consolidating Concrete by J-Ring
- ASTM C1758 – Standard Practice for Fabricating Test Specimens with Self-Consolidating Concrete

VRBS – Virginia Road and Bridge Specifications

MOI – Manual of Instructions

- Chapter II – Methods and Frequencies of Sampling

- Chapter IV – Sampling and Control of Hydraulic Cement Concrete
- Chapter VIII – Reports and Forms

VTM – Virginia Test Method

- VTM 92 – Testing Epoxy Overlays for Surface Preparation and Adhesion (Bond Strength)

1. COMPONENTS OF CONCRETE


Cement


Water


Aggregates


Supplementary cementitious materials


Chemical Admixture

Types of Portland Cement and Blended Cement	
Type I	General-purpose cement.
Type II	Used when sulfate concentrations in ground water are higher than normal. May be used in structures of considerable mass, such as large piers, heavy abutments, and heavy retaining walls.
Type III	High-early-strength cement which will develop higher strength at an earlier age. It is used when early form removal is desired
Type IV	Used in massive structures, such as dams. Used where the heat generated during hardening is critical.
Type V	Used mainly in western part of US
Type IL	Combination of Portland Cement with a higher limestone content to help with carbon footprint reduction
Type I-P	Blended cement is a combination of Portland Cement and a pozzolan.
Type I-S	Blended cement is a combination of Portland Cement and blast-furnace slag.

Mixing water – almost any natural water that is drinkable is satisfactory as mixing water for making or curing concrete.

Wash water can be reused in the concrete mixture provided:

- it is metered
- is 25 percent or less of the total water.

A uniform amount of wash water must be used in consecutive batches, with subsequent admixture rates adjusted accordingly to produce a workable concrete that conforms to the specifications.

Aggregates for concrete –should consist of clean, hard, strong, and durable particles free of chemicals, coatings of clay, or other fine materials that may affect the hydration and bond of the cement paste.

Harmful substances and their effect on concrete	
Organic Impurities	affect setting time and hardening, and may cause deterioration
Too much material finer than the #200 sieve	affect bond and increases water demand
Lightweight Materials	affect durability, and may cause pop outs and stains
Soft Particles	affect durability and wear resistance
Friable Particles	affect workability and durability, break up in mixing, and increase water demand
Clay Lumps	absorb mixing water or cause pop outs

Mineral Additives Supplementary Cementitious Material, SCM	
Fly Ash	
Definition	Benefits
Finely divided residue that results from the process of combustion of ground or powdered coal and that is transported by flue gasses	- Reduces heat of hydration - Improves sulfate resistance - Reduces Alkali-Silica Reactivity (ASR) - Improves workability - Reduces permeability
Slag	
Definition	Benefits
Formed when granulated blast furnace slag is ground to suitable fineness. It is a recovered industrial by-product of an iron blast furnace. Predominately glassy structure with a composition very similar to Portland Cement.	- Reduces heat of hydration - Improves sulfate resistance - Reduces ASR - Gives higher strength at later ages - Reduces permeability
Silica Fume	
Definition	Benefits
Very fine byproduct of producing silicon metal or ferrosilicon alloys	- Increases early strength - Reduces permeability - Reduces ASR

Metakaolin	
Definition	Benefits
anhydrous calcined form of the clay mineral kaolinite	- Increases early strength - Improves sulfate resistance - Reduces permeability - Reduces ASR

Admixtures – includes all materials which are added to concrete, other than the base components of cement, SCM, water, and aggregates. Admixtures can be broadly classified as follows:

Admixtures	
Air Entrainment	
Purpose	Notes
Improves workability, freeze-thaw, sulfate resistance and reduces scaling.	- Avoid prolonged vibration (> 15 sec) - Less air is entrained as the temperature of the concrete increases - The air content increases as the slump increases up to about 7 in, and decreases with further increases in slump

Retarding Admixture	
Purpose	Notes
Delay setting time of concrete, offset the accelerating effect of hot weather on the setting of concrete, and provide time for difficult placing or finishing in such items as bridge decks or large piers.	- Most retarders also function as water reducers, but not all - A retarded concrete may lose slump faster than a non-retarded concrete
Water Reducing Admixture	
Purpose	Notes
Many may also retard the setting time of concrete, some also entrain air in concrete.	- An increase in strength can be obtained if the water content is reduced and slump and cement content is kept the same - A rapid loss in slump and a significant increase in drying shrinkage can result from the use of some of these admixtures
Accelerating Admixture [(1), (2)]	
Purpose	Notes
Used to accelerate the setting and the strength development of concrete.	- Can cause an increase in the drying shrinkage of concrete - Not an antifreeze agent

	- VRBS does not allow the use of an accelerator except in special circumstances approved by the Engineer
High-Range Water Reducer (Superplasticizer)	
Purpose	Notes
Permit large reductions in the water cement ratio, or provide large increases in the consistency.	- Beware of a very limited time duration before the benefits of increased consistency have been lost, which can create finishing problems

(1) The development of strength of concrete can also be accelerated by:

1. *Using Type III Cement (high-early-strength cement)*
2. *Lowering the water cement ratio by:*
    a) *Decreasing the water content*
    b) *Increasing the cement content*
3. *Curing at higher temperatures*

(2) Calcium chloride is the most commonly used accelerating admixture. It should be added in a solution form as part of the mixing water in amounts not to exceed 2% by weight of cement. A greater amount can result in placement problems and can be detrimental to concrete:

- may cause rapid stiffening,
- increase drying shrinkage,
- corrode reinforcement steel.

The addition of no more than 2% of calcium chloride has no significant corrosive effect on ordinary steel reinforcement provided the concrete is of high quality.

2. TYPES OF CONCRETES

Examples of concrete types and their use:

- Bridge Deck – typically low shrinkage A4 modified HCC – VRBS Section 217.12
    - Shrinkage Reducing Admixture (SRA) is used to limit shrinkage and maximum cementitious materials is 600 lbs./CY
    - Lightweight Coarse Aggregate is used to limit cracking and maximum cementitious materials is 650 lbs./CY
- Precast HCC – Nominal Maximum Aggregate size (NMS) often is smaller than specified in Table II-17, Yield test can vary from 27 CF and minimum pozzolan requirements are waived for items installed below the frost line
- Pavement HCC – VRBS Section 316 and Special Provision in the contract
    - Flexural strength used for determination when the pavement can be opened to traffic
- Overlay HCC – may use one or more mineral admixtures (silica fume, latex, class F fly ash, ground-granulated blast furnace slag or a combination of these) in the mix design. Coarse aggregate is determined by the depth of the overlay in conjunction with the presence of reinforcing steel.
- Self-Consolidating Concrete (SCC) – often made by using a higher cementitious content, decreasing the coarse aggregate content, increasing the fine aggregate content, using viscosity modifying admixtures and additional high-range water

reducers. SCC characterizes with decreased labor due to speed of placement, but the forms have to be stronger due to greater hydrostatic pressure.
    - Slump Flow and J-Ring instead of the standard Slump Test
    - Cylinders for strength and permeability are cast in accordance with ASTM C1758

If you have any of the following refer to the contract Special Provision

- Drilled Shaft SCC (DSC)
- Mass Concrete (MC)
- Roller-Compacted Concrete (RCC)
- Shotcrete
- Hydraulic Cement Mortar and Grout
- HCC Repair and Coating Materials
- ECC, VHPC, UHPC

3. BUY AMERICA

To comply with Buy America Act all federally funded VDOT contracts have Special Provision for Use of Domestic Material incorporated into them.

- all iron and steel (including miscellaneous items such as fasteners, nuts, bolts and washers) to be permanently incorporated for use on federal aid projects shall be produced with all manufacturing processes taking place in the United States of America
- Tie wire, steel chairs, and any other objects embedded in concrete (impossible to place without) are subject to Buy America

- Any incidental items that are not required to be left in place, but are permanently incorporated into the work because they are left in place for the Contractor's convenience, may be exempt from Buy America (e.g. sheet piling in most cases)
- Form C-76 Contractor's Certificate of Compliance for Steel and Iron Items (For Compliance with "Buy America" 23 CFR 635.41)

The contractor submits C-76 form whenever iron or steel products are delivered to the project site. The signed form must be received by VDOT prior to placement of the items; the supporting documentation is not required at the same time as the C-76 form (the Contractor must have and retain the back-up documentation; VDOT may require proof at a later date).

4. MATERIAL ACCEPTANCE

VDOT forms: http://vdotforms.vdot.virginia.gov/

a) **C-25 – Source of Materials Form**

The Project Inspector should not approve the use of material until verification is received that the Source of Material form has been processed or otherwise receives a processed copy. Include Job Mix Formula number of approved mix design.

b) TL-27 – Statement of Hydraulic Cement Concrete Mix Design

- Producers of Hydraulic Cement Concrete submit to the District Materials Engineer a proposed concrete mix design, Form TL-27, before the

start of concrete operations and thereafter in time to be re-approved per each District guideline.

- Each approved design must be assigned by the District Materials Engineer, a design number which should be referenced on the Contractor's source of materials letter, Form C-25.
- The form can be used for quick reference for field acceptance testing such as slump and air content, as well as to ensure maximum water-cement content is not exceeded if water is added in the field.

Form TL-27 (Revised 12/07)

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

STATEMENT OF HYDRAULIC CEMENT CONCRETE MIX DESIGN

Submit one copy to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This mix design is approved for all projects of the Department for the class of concrete shown: Calendar Year 2022 Mix Design No. 4000-1-22

Producer Concrete Ready Mix Plant Location Richmond Phone 804-123-4567
Type of Mix: Ready Mix Job Mix X Date 1/11/2022

Mix Design - One Cubic Yard (Meter) Based on SSD Condition

Class of Concrete A3 General (E) Slump 1 - 7 in. mm Air Content 4 - 9 %
(M) Flow

Material		Quantities				Code	Source Name	Plant/Quarry Location
Cement	Type I/II	470	lbs.		kg.	11	Richmond Cement	Richmond, VA
Min.Admix.1	Fly Ash	118	lbs.		kg.	123	DC Ash Supplier	Washington, DC
Min.Admix.2			lbs.		kg.			
Sand (1)		1142	lbs.		kg.	4123	Richmond Sand Pit	Richmond, VA
No. 57	Stone (1)	1827	lbs.		kg.	4234	Richmond Quarry	Richmond, VA
Gr./No.	Aggr. (1)		lbs.		kg.			
Water (2)	260 lbs.	31.2	gal.		L.			
Admixture (AE) (3)		Varies	oz.		ml.	44	Richmond Admix	Richmond, VA
Admixture (Retarder) (3)		Varies	oz.		ml.	45	Richmond Admix	Richmond, VA
Admixture (Other) (3)		Varies	oz.		ml.	46	Richmond Admix	Richmond, VA

NOTES:

(1) The quantities of fine and coarse aggregates necessary to conform to specifications in regard to consistency and workability shall be determined by the method described in "Recommended Practice for Selecting Proportions for Normal Weight Concrete" (ACI-211.1) and the actual quantities used shall not deviate more than plus or minus 5 percent from such quantities.

(2) To provide minimum slump permissible in Table II-17 while satisfying placement and finishing requirements. A separate design shall be submitted for each slump desired.

(3) The quantity of admixture will not be approved or disapproved since it varies considerably and must be initially established by trial and error by the producer or contractor with subsequent adjustment during batching to maintain the desired results within the range specified.

Mineral Admixture #1 - sp.gr.	2.1
Mineral Admixture # 2 - sp.gr.	
Sand - Abs.	0.8
Sand - F.M.	2.92
Sand - sp.gr.	2.6
C.A. #1 - Abs.	0.6
C.A. #1 - sp.gr.	2.69
C.A. #1 Unit mass	102.5 / (Lbs./C.F. / kg/C.M.)
Aggr. #2 - Abs.	
Aggr. #2 - sp.gr.	
2nd F.A./C.A.-F.M./U.Wt.	/ (E / M)
Design W/C Ratio	0.44

Contractor _____ (Name of Company) By Certified Technician Signature (Certified Technician Preparing Form)

Producer Technician's Expiration Date 3/3/2025 (Do Not Use Social Security Number)

FOR DEPARTMENT USE ONLY

Remarks: _____

Copies: District Materials Engineer
Project Inspector
Plant Inspector
Sub- Contractor and / or R.M. Producer

Checked by District Technician Signature

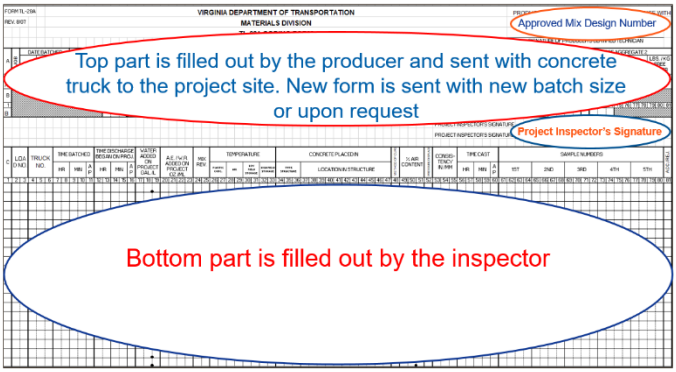
Approved by DME Signature (District Materials Engineer)

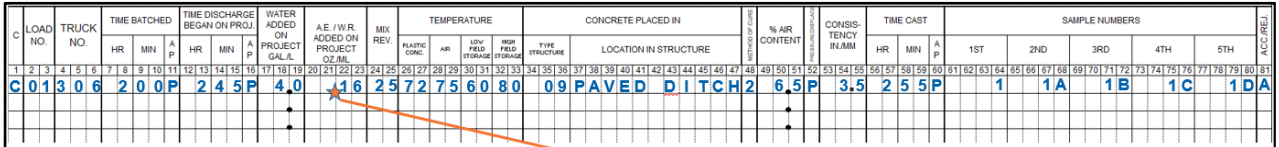
Approved tentatively subject to the production of material meeting the requirements of the Specifications and Special Provisions.

c) TL-28A – Coding Form (Concrete Batch Report)

The Hydraulic Cement Concrete Coding Form contains three (3) records - A, B, and C. The plant record (A & B – top part) is completed by the Producer's Technician, and the site record (C – bottom part) is completed by the Project Inspector.

This form is used to document times, test results and quantities for all shipped loads to the project. New form is sent with new batch size or upon request.





C	LOAD NO.	TRUCK NO.	TIME BATCHED HR	TIME BATCHED MIN	TIME BATCHED A/P	TIME DISCHARGE BEGAN ON PROJ. HR	TIME DISCHARGE BEGAN ON PROJ. MIN	TIME DISCHARGE BEGAN ON PROJ. A/P	WATER ADDED ON PROJECT GAL./L	A.E. / W.R. ADDED ON PROJECT OZ./ML	MIX REV.	TEMPERATURE PLASTIC CONC.	TEMPERATURE AIR	TEMPERATURE LOW FIELD STORAGE	TEMPERATURE HIGH FIELD STORAGE	CONCRETE PLACED IN TYPE STRUCTURE	CONCRETE PLACED IN LOCATION IN STRUCTURE	METHOD OF CURE	% AIR CONTENT	PRE-DISCHARGE ADD	CONSISTENCY IN./MM	TIME CAST HR	TIME CAST MIN	TIME CAST A/P	SAMPLE NUMBERS 1ST	SAMPLE NUMBERS 2ND	SAMPLE NUMBERS 3RD	SAMPLE NUMBERS 4TH	SAMPLE NUMBERS 5TH	ACC./REJ.
1	2 3	4 5 6	7 8	9 10	11	12 13	14 15	16	17 18 19	20 21 22 23	24 25	26 27	28 29	30 31	32 33	34 35 36	37 38 39 40 41 42 43 44 45 46 47	48	49 50	51	52	53 54 55	56 57	58 59	60	61 62 63 64	65 66 67 68	69 70 71 72	73 74 75 76	77 78 79 80	81
C	0 1	3 0 6	2 0	0	P	2 4	5	P	4 0	1 1 6	2 5	7 2	7 5	6 0	8 0	0 9	P A V E D	D I T C H	2	6 5	P		3 5	2 5	5	P	1	1 A	1 B	1 C	1 D	A

Box 2-3 Load No. from delivery ticket
Box 4-6 Truck No. from delivery ticket
Box 7-11 Time batched
Box 12-16 Time discharge began on project
Box 17-19 Water added on project- may add up to 1 gal per CY provided water was withheld at the plant
Box 20-23 Air Entraining or Water Reducing Admixture added on project
Box 24-25 Minimum of 25 additional mixing revolutions required each time water is added or 70 revolutions for air-entraining admix.
Box 26-27 Temperature of plastic concrete
Box 28-29 Air temperature
Box 30-31 Low field storage temperature
Box 32-33 High field storage temperature
Box 34-36 Type of structure
Box 37-47 For inspector's use to further identify where concrete was placed
Box 48 Method of cure
Box 49-51 Air content (Ty A or B meter)
Box 52 Pressure or Displace
Box 53-55 Slump test results
Box 56-60 Time cylinders were cast
Box 61-80 Sample numbers:
3 x Strength (i.e.1,1A,1B)
2 x Permeability- if required (i.e.1C,1D)
Box 81 Accept or Reject

Admixtures to be added only by VDOT-Certified Concrete Plant Technician

Code List for Curing Methods

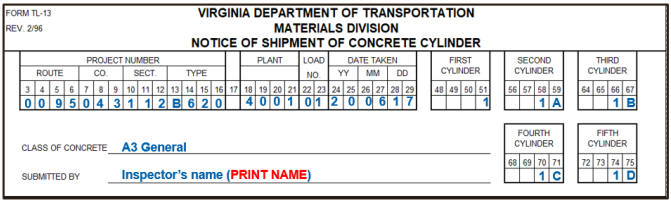
Code No.	Method
1	Liquid Membrane Seal
2	Polyethylene Sheeting
3	Burlap
4	Burlene
5	Wet Sand
6	Water Ponding
7	Steam
8	Heater Blanket

Code List for Type of Structure

Code No.	Type Structure
1	Box Culvert and/or Appurtenances
2	Bridge (except deck)
3	Bridge Deck
4	Parapet Wall
5	Approach Slab
6	Retaining Wall
7	Curb and Gutter
8	Slope Paving
9	Ditch Paving
10	Sidewalk
11	Precast Piling
12	Precast Beams
13	Precast Miscellaneous
14	Sidewalk or Driveway
15	Miscellaneous
16	Pier Stem
17	Paving
18	Tunnel

d) TL-13 – Notice of Shipment of Concrete Cylinder

Test specimens are submitted for testing to the lab with the TL-13 form. The information on the card shall include: project number, date casted, load number, cylinder numbers, class of concrete, printed name of person submitting the specimens and any other pertinent remarks.



FORM TL-13
REV. 2/96

VIRGINIA DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
NOTICE OF SHIPMENT OF CONCRETE CYLINDER

PROJECT NUMBER				PLANT	LOAD	DATE TAKEN			FIRST CYLINDER	SECOND CYLINDER	THIRD CYLINDER
ROUTE	CO.	SECT.	TYPE		NO.	YY	MM	DD			
3 4 5 6	7 8 9	10 11 12	13 14 15 16	17 18 19 20 21	22 23	24 25	26 27	28 29	48 49 50 51	55 56 57 58 59	64 65 66 67
0 0 9 5	0 4	3 1 1	2 B 6 2 0	4 0 0 1	0 1	2 0	0 6	1 7	1	1 A	1 B

FOURTH CYLINDER	FIFTH CYLINDER
68 69 70 71	72 73 74 75
1 C	1 D

CLASS OF CONCRETE: **A3 General**

SUBMITTED BY: **Inspector's name (PRINT NAME)**

Box 3-16	Project Number
Box 17	Leave blank
Box 18-21	Code for VDOT approved batch plant
Box 22-23	Load number from delivery ticket
Box 24-29	Date samples taken
Box 48-75	Sample numbers placed on cylinders
Class of concrete:	Spec. designation not code number (i.e. A3 Gen)
Submitted by:	Must show full last name . Initials for first and middle may be used.

e) TL-10 – Notice of Shipment of Sample for Test

Sample notification card, Form TL-10, is used in the field when submitting samples of plant processed and shipped material to the laboratory for test. Materials requiring TL-10 include: epoxy, rebar, dowels, etc.

FORM TL-10 (5/20)

Date: 06/17/2022 Destination Lab: Elko – Physical Lab

Project: (NFO) 0064-043-744, C501, B618 UPC: 97565

FHWA No.: STP-0643(513)

District/County: Richmond District / Henrico Co. Route: I-64

Producer, Plant or Property: Steel Mill Inc. / Salem, VA

Description of Material: Plain Reinforcing Steel

Sample Drawn From: Field Stock Representing (units): 13040 lbs.

Job Mix No: NA Lot/Sample: Heat Number / Sample #

Type of Test: ASTM A615

Type of Specification: VRBS 223.02(a)(2)

Sample By: Inspector's name (PRINT NAME) District Location: Richmond

f) VDOT Materials Division Approved Lists

This document contains a table of contents of various materials/Suppliers/Manufacturers that have been evaluated and shown to meet VDOT specifications/requirements.

This list is updated monthly as dictated by changes in products/Manufacturers/Suppliers. Not all products, Manufacturers or Suppliers are on these lists.

5. TEST METHODS

Required by VDOT number of cylinders per specified test for acceptance testing (cylinders are cured in a curing box with requirements described below)

- Three 4 x 8 in cylinders for compressive strength
- Two 4 x 8 in cylinders for permeability (if specified)

Cylinder molds for acceptance testing are supplied by VDOT, specimens are prepared by VDOT, and tested by VDOT.

Cylinder molds for control cylinders (field cured) shall be supplied by the Contractor, specimens shall be prepared by the Contractor, and the specimens shall be cured in the same way as the structure they represent. (VRBS 404.03(j)3)

Curing box requirements (VRBS 217.08(b))

- Provided by the Contractor before concrete placement
- Designed to keep specimens in continuously moist condition and within temp. 60˚- 80˚ F
- Equipped with a continuously recording thermometer accurate to ± 2°F
- Located near concrete placement site, free of vibrations and level
- Of sufficient size to store the required number of test cylinders

Key points to remember while conducting tests:

ASTM C172 – Sampling HCC

- The Contractor is responsible to provide receptacle for the Department to obtain concrete sample (VRBS 217.08(a))
- The sample secured for the tests shall be taken after at least 2 CF of concrete has been discharged from the delivery vehicle (VRBS 217.08)
- The two cubic feet discharged shall not be used as part of the test sample
- All water and admixtures shall be added prior to obtaining a sample

  - If any extra water or field-added admixtures are added to the truck after original sample has been taken then re-sample
- The sample shall be combined by mixing into one composite sample for test purposes

ASTM C31 – Cylinders (4 x 8 in)

- Mark the molds for identification
- Molding shall be performed on a flat and a level surface

ASTM C1064 – Temperature of HCC

- Minimum of 3 inches submersion of temperature sensing end
- Time in concrete 2-5 minutes
- Do not remove the device from the concrete when reading the temperature

ASTM C143 – Slump

- DO NOT tap the cone
- Rod each of 3 layers 25 times extending the rod approximately 1 inch into the previous layer for the 2nd and 3rd lift
- Measure the distance between top of the mold and **displaced original center** of the top surface of the specimen
- Complete the entire test from the start of the filling through removal of the mold without interruption within an elapsed time of 2½ min

ASTM C138 – Unit Weight

- Report the Density (Unit Weight) to the nearest 0.1 lb./ft³

$$\text{Density} = \frac{\text{Mass of the measure filled with concrete} - \text{Mass of the empty measure}}{\text{Volume of the measure } [\sim 0.25\ \text{ft}^2]}$$

** Density (Unit weight) test is a requirement for all Light Weight Concrete and shall be below 120 lb. /ft³ (VRBS Section 217.12(b))*

ASTM C231 – Air Content (Pressure Meter)

- Tap the gauge lightly by hand to stabilize the gage at initial pressure.
- Open and hold the main valve and smartly tap the sides of the measuring bowl with mallet
- Lightly tap the pressure gauge by hand to stabilize it
- Read and report the air content to the nearest 0.1%
- Release the main air valve – failure to do it will result in water being drawn into the air chamber, thus introducing error in subsequent measurements
- Release the pressure by opening both petcocks before removing the cover

ASTM C173 – Air Content (Roller Meter)

- Invert and shake the meter no more than 5 sec at a time for minimum of 45 sec
- Place the meter at 45 degree angle and roll it ¼ to ½ turn for 1 minute (quick start-stop) while turning the meter 1/3 turn while rolling
    - If meter leaks – start over from the beginning
- Set the meter in upright position, loosen the cap and allow the air to stabilize
    - Considered stabilized if doesn't change by more than 0.25% within 2 minutes
    - If it takes more than 6 min to stabilize or more than 2 full percent of foam present – start over from the beginning
- Once stabilized record it as initial reading to the nearest 0.25%

    - If the reading is greater than 9% add and record the number of calibrated cups of water
- Repeat 1-min rolling
- If after the 2nd rolling, reading doesn't change by more than 0.25% - record it as a final reading
    - If it changed record it as new initial reading and repeat 1-min rolling
- If after the 3rd rolling, reading doesn't change by more than 0.25% when compared to the new initial reading – record as a final reading
    - If it changed discard the sample and start over from the beginning using more alcohol
- Disassemble the meter and examine the bottom of the bowl to ensure that there are no portions of undisturbed, tightly packed concrete. If found the test is invalid.

ASTM C1758 – SCC Cylinders (4 x 8 in)

- Mark the molds for identification
- Fill the pouring vessel with the SCC either by passing it through the concrete or scooping concrete into the vessel

- Fill the specimen mold with SCC – the lowest part of the rim of pouring vessel shall be no further than 5 inches from the top of the mold
    - No rodding or tapping required
- Store and cure the specimens in the same way as regular concrete cylinders

ASTM C109 – Cubes (Field cast 2 x 2 in)

- Apply release agent (e.g. baby oil) to interior surfaces and wipe any excess with a cloth
- Store and cure the specimens in the same way as regular concrete cylinders

ASTM C1611 – Slump Flow* and Visual Stability Index test (VSI)

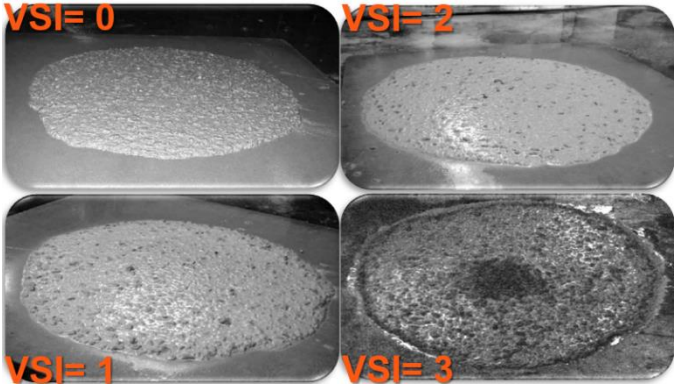
- Dampen and place the mold in inverted position (small opening facing down)
- Fill the pouring vessel with the SCC either by passing it through the concrete or scooping concrete into the vessel
- Fill the mold with SCC – the lowest part of the rim of pouring vessel shall be no further than 5 inches from the top of the mold
    - No rodding or tapping required
- Complete the entire test from the start of the filling through removal of the mold without interruption and complete it within an elapsed time of 2½ min
- Wait until concrete stops flowing and measure the largest diameter (d_1) and second diameter at 90 degree angle to the first one (d_2)
    - If a halo present – include in measurements

- If the measurement of two diameters differs by more than 2 inches – test is invalid and shall be repeated
- Measure and report to nearest ¼ inch

$$\text{Slump Flow} = (d_1 + d_2) / 2$$

VSI Test – visual test performed right after slump flow on the same sample.

- VSI=0 (Highly Stable) - No evidence of segregation or bleeding
- VSI=1 (Stable) - No evidence of segregation and slight bleeding observed
- VSI=2 (Unstable) - A slight mortar halo ≤0.5in and/or aggregate pile in the center
- VSI=3 (Highly Unstable) - Clearly segregating by evidence of a large mortar halo > 0.5 in and/or a large aggregate pile in the center



ASTM C1621 – J-Ring*

- Dampen and place the mold in inverted position (small opening facing down) centered inside the j-ring apparatus

- Fill the pouring vessel with the SCC either by passing it through the concrete or scooping concrete into the vessel
- Fill the mold with SCC – the lowest part of the rim of pouring vessel shall be no further than 5 inches from the top of the mold
    - No rodding or tapping required
- Complete the entire test from the start of the filling through removal of the mold without interruption and complete it within an elapsed time of 2½ min
- Wait until concrete stops flowing and measure the largest diameter (j_1) and second diameter at 90 degree angle to the first one (j_2)
    - If a halo present – include in measurements
    - If the measurement of two diameters differs by more than 2 inches – test is invalid and shall be repeated
- Measure and report to nearest ¼ inch

$$\text{Slump Flow} = (j_1 + j_2) / 2$$

** Slump flow and J-Ring tests shall be completed within 6 minutes.*

6. TESTING FREQUENCIES

Testing Frequencies for Structural HCC		
Test	**Test Reference**	**Acceptance Testing**
Temperature	ASTM C1064	Every Load
Slump (Consistency)	ASTM C143	Every Load
Unit Weight (Density) *	ASTM C138	Every Load
Air Content	ASTM C231 or	Every Load

	ASTM C173	
Strength (One set of three 4" x 8" cylinders or one set of two 6" x 12" cylinders)	ASTM C31 and ASTM C39	One set per 100 CY (minimum one set per day)
Permeability * (One set of two 4" x 8" cylinders)	ASTM C31 and VTM-112	One set per 100 CY (minimum one set per day)
Testing Frequencies for Miscellaneous HCC		
Test	**Test Reference**	**Acceptance Testing ******
Temperature	ASTM C1064	One per day
Slump (Consistency)	ASTM C143	Two per day
Unit Weight (Density) *	ASTM C138	One per day
Air Content	ASTM C231 or ASTM C173	One per day
Strength (One set of three 4" x 8" cylinders or one set of two 6" x 12" cylinders)	ASTM C31 and ASTM C39	One per 250 CY
Permeability * (One set of two 4" x 8" cylinders)	ASTM C31 and VTM-112	One per 250 CY (minimum one set per project)
Testing Frequencies for Pavement HCC		
Test	**Test Reference**	**Acceptance Testing ******
Temperature	ASTM C1064	One per hour
Slump (Consistency)	ASTM C143	One per hour
Unit Weight (Density) *	ASTM C138	One per hour
Air Content	ASTM C231 or	One per hour

	ASTM C173	
Strength (One set of three 4" x 8" cylinders or one set of two 6" x 12" cylinders)	ASTM C31 and ASTM C39	One per day of production, or every 0.1 mile of paving, whichever is greater
Permeability * (One set of two 4" x 8" cylinders)	VTM-112	One per day of production, or every 0.1 mile of paving, whichever is greater
Pavement Thickness	VTM-26	One per 0.1 mile
Flexural Strength (used for opening to traffic and not an acceptance test)	ASTM C78	As deemed necessary to determine opening to traffic

**** If specified*** ***** If project total is less, then minimum one test/set per project***

7. ACCEPTANCE REQUIREMENTS FOR TESTING

Concrete Temperature – VRBS 217.10		
Type of Concrete	**Min Temp., °F**	**Max Temp., °F**
Class A3 general use concrete used in the construction of incidental items specified in Division V, except retaining walls	40	95
Class A3 paving concrete placed by the slipform method and containing an approved water reducer	40	95
Concrete used in the construction of bridge decks	40	85
Retaining walls and other concrete not specified in 217.10(a), (b), or (c)	40	90

Air Content *, ** – VRBS Table II-17 (see table below) and/or approved form TL-27

Slump *, ** – VRBS Table II-17 (see table below) and/or approved form TL-27

** Per Note #1 under table II-17 – When a high-range water reducer is used, the upper limit for entrained air may be increased by 1% and the slump shall not exceed 7 inches. The lower limit for entrained air remains unchanged. (Check the top of the approved TL-27 form (HCC Mix Design)).*

*** Approved Mix Design (form TL-27) contains approved Air Content, Slump or Flow, and Water/Cement values for the specific mixture.*

Class of Concrete	Max. Water /Cementitious Mat. (lb. Water / lb. Cement)	Consistency (in of slump)	Air Content (%)
A5 Pre-stressed and other special designs	0.40	0 – 4	4 ½ ± 1 ½
A4 General	0.45	2 – 4	6 ½ ± 1 ½
Low Shrinkage A4 Mod.	0.45	2 – 4	6 ½ ± 1 ½
A4 Post & Rails	0.45	2 - 5	7 ± 2
A3 General	0.49	1 - 5	6 ± 2
A3a Paving	0.49	0 - 3	6 ± 2
A3b Paving	0.49	0 - 3	6 ± 2
B2 Massive or Lightly Reinforced	0.58	0 - 4	4 ± 2
C1 Massive Unreinforced	0.71	0 - 3	4 ± 2
T3 Tremie Seal	0.49	3 - 6	4 ± 2
Latex Hydraulic Cement Concrete Overlay	0.40	4 - 6	5 ± 2
Silica Fume, Silica Fume/ Class F Fly Ash or Silica Fume/Slag Concrete Overlay	0.40	4 - 7	6 ± 2
Class F Fly Ash or Slag Overlay	*0.40*	*4 - 7*	*6 ± 2*

SCC Acceptance Criteria (VRBS 217.11)
Slump flow

- The slump flow shall be 26 ±3 inches, and there shall be no visible segregation of the mix in the spread.

Visual Stability Index (VSI)

- Shall not exceed 1.

J-Ring Flow:

- The difference between slump flow and J-Ring flow as measured by ASTM C 1621 shall not be more than 2 inches.

8. PROTECTION OF CONCRETE

VRBS 404.03(l)1 – Protection of concrete shall begin immediately following concrete placement in the formwork and shall continue without interruption throughout the curing period.

- Weather:
    - Concrete shall be protected from rain.
    - Concrete shall not be placed against surfaces whose temperature is below 40 ˚F.
    - Concrete shall be protected from freezing by approved coverings and, when necessary, heating the surrounding air in such a manner that the concrete will not dry.
    - Protection shall be provided to prevent rapid drying of concrete as a result of low humidity, high wind, higher concrete

temperatures than atmospheric temperatures, or combinations thereof.

- The Contractor shall perform evaporation rate testing for bridge deck placements and concrete overlays.

9. CURING REQUIREMENTS

HCC Pavement (including incidental concrete, sidewalks, steps and handrails) - VRBS 316.04 (j), 502.03, 504.03

1) Membrane-forming compounds:
    - Surface of the pavement shall be sprayed uniformly with a white-pigmented membrane-forming compound immediately following the texturing operation.
    - The compound shall be applied under constant pressure at the rate of 100 to 150 square feet per gallon by mechanical sprayers mounted on movable bridges.
        - On textured surfaces, the rate shall be as close to 100 square feet as possible.
        - Application shall be such that an even, continuous membrane is produced on the concrete surface.
    - At the time of use, the compound shall be in a thoroughly mixed condition, with the pigment uniformly dispersed throughout the vehicle.
        - During application, the compound shall be continuously and effectively agitated.

- Hand spraying of odd widths or shapes and concrete surfaces exposed by removing forms and sawing joints will be permitted.
- The membrane shall harden 30 minutes after application. Personnel and equipment shall be kept off the freshly applied material to prevent damage to the seal.
- If the membrane becomes damaged within the initial 72 hours, damaged portions shall be repaired immediately with additional compound.
- Upon removal of side forms, sides of exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.
    - Form removal shall be completed after the concrete set for at least 12 hours VRBS 316.04(l)
- If the slipform method of paving is used, edges of pavement shall be cured in the same manner and at the same time as the surface.

2) PE film:
    - When PE film is used for curing, it shall be white. However, from November 1 to April 1, clear or opaque PE film will be permitted.
3) Protection in cold weather:
    - The Contractor shall prevent the temperature at the surface of the concrete from falling below 40 ˚F during the first 72 hours immediately following concrete placement.
    - Protective material shall be left in place for an additional 48 hours if freezing air temperatures

are expected to continue. Such protection shall be furnished in addition to the curing material required elsewhere in the specifications.

- The Contractor shall be responsible for the quality of the concrete placed during cold weather. Concrete damaged by the action of frost or by freezing shall be removed and replaced at the Contractor's expense.

4) Curing in hot, low-humidity, or windy weather:
   - Care shall be taken in hot, dry, or windy weather to protect the concrete from shrinkage cracking by applying the curing medium at the earliest possible time after finishing operations and after the sheen has disappeared from the surface of the pavement.

HCC Operations - Bridge Work - VRBS 404.03 (k)

- The method of curing concrete shall be subject to the approval of the Engineer prior to mixing or placing concrete.
- When the atmospheric temperature is above 40 ˚F in the shade, concrete surfaces that are not protected by formwork and surfaces from which forms have been removed shall be cured using approved materials applied before the sheen disappears from fresh concrete or immediately upon removal of formwork.
    - Forms removal shall be completed once concrete obtained sufficient strength as per VRBS 404.03(j)
- **Concrete shall be cured for 7 days, regardless of the strength obtained with control**

cylinders. During this 7-day curing period, a curing agent or medium shall be used.

- PE film used for curing shall be white except that opaque or transparent PE film may be used between November 1 and April 1.
- When liquid membrane seal is used for curing grooved horizontal surfaces, the application rate shall be 100 to 150 square feet per gallon.
    - The application rate for all other surfaces shall be 150 to 200 square feet per gallon.
    - Application shall be such that an even, white, continuous membrane is produced on the concrete surface.
- If the atmospheric temperature falls below 40˚F in the shade, water curing shall be discontinued except when it is accomplished by flooding as specified herein.
- Curing shall be immediately resumed using insulated blankets or other approved methods that will retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 ˚F for at least 72 hours immediately following concrete placement and above 40 ˚F for at least 48 additional hours.
- If the Contractor begins masonry concrete operations when the atmospheric temperature is below 40 ˚F in the shade, the method of cure and protection shall retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 ˚F for at least 72 hours immediately following concrete

placement and above 40 ˚F for at least 48 additional hours.

Bridge Deck Curing:

- Bridge deck concrete shall be moist cured with white PE sheeting with or without the use of wet burlap.
- The concrete shall be maintained in a moist condition by fogging after screeding and until covered with the sheeting.
- The concrete surface shall stay wet under the sheeting until the end of the moist-curing period.
- **The moist-curing period shall be for at least 7 days and until 70 percent concrete strength (f ’c) is achieved.** The initial temperature of the outermost surfaces of the concrete mass shall be above 50 ˚F for at least 72 hours and above 40 ˚F until the completion of the moist-curing period.
- When the burlap and sheeting are removed, white pigmented curing compound shall be applied at the rate of 100 to 150 square feet per gallon while the surface of the concrete deck is damp and free of standing water.
- Bridge deck overlay concrete shall be cured in accordance with Section 425.

Widening, Repairing, and Reconstructing Existing Structures - Shotcrete - VRBS 412.03 (g)

- After gunning, the surfaces of shotcrete shall be protected from drying or cracking.

- When necessary, fogging shall be used prior to the application of moist curing or a curing compound.
- **Shotcrete shall be moist cured for a period of at least 7 days or cured using a curing compound** containing silane or siloxane conforming to Section 220.
- The rate of application shall be not less than 1 gallon of curing compound per 100 square feet of surface.
- The color of the curing compound shall be approximately that of the existing concrete.

Rigid Concrete Bridge Deck Overlays - VRBS 425.03 (b)

- The surface shall be protected from prematurely drying or cracking by prompt application of wet burlap. Care shall be taken to ensure that the burlap is well drained and that it is placed as soon as possible, but no later than 15 minutes after screeding to ensure that the surface is wet at all times during curing.
- The burlap and surface of the concrete shall be maintained in a continuously moist condition during the initial curing period. Unless otherwise specified in the Contract or directed by the Engineer the curing periods shall be as follows:
- The initial moist curing periods for latex modified concrete and high early strength latex modified concrete overlays shall be 48 hours followed by an additional 48 hours of air curing before opening to traffic.

- Overlays of very-early strength latex-modified concrete shall be moist cured from the time they are placed until they can be opened to traffic.
- The initial moist curing period for silica fume concrete shall be 72 hours, unless otherwise specified or directed by the Engineer, followed by the immediate application of a liquid membrane-forming curing compound conforming to Section 220.
- The curing compound shall be completely dry before opening the overlay to traffic.

10. REPAIR & PREVENTATIVE MAINTENANCE OF CONCRETE STRUCTURES

Preparing Concrete Surfaces

Surface preparation methods include a combination of the following methods:

- Air blasting
- Power washing
- Grit blasting
- Shot blasting
- Hydro blasting

Repair Methods:

- Patching:
    - Partial Depth
        - Jointed Concrete Pavement Patch, Type III
    - Full Depth

        - Jointed Concrete Pavement Patch, Type I
        - Jointed Concrete Pavement Patch, Type II
        - Continuously Reinforced Concrete Pavement, Type IV-A
        - Continuously Reinforced Concrete Pavement, Type IV-B
- Crack Repairs (cracks ≥ 0.2 mm (0.007 inch) in width provide an opening for water and chlorides to easily penetrate the concrete and reach the reinforcement causing premature corrosion):
    - Gravity Fill Polymer (cracks wider than $^{1}/_{25}$ inch shall be filled with dry No. 50 sieve size silica sand prior to placement of the polymer)
    - Route and Seal
    - Pressure Injection of Epoxy

Overlays

- Hydraulic Cement Concrete Overlays: Placed to reduce infiltration of water and chloride irons and improve skid resistance, ride quality and surface appearance
    - Latex Modified Overlay
    - Silica Fume Overlay
- Epoxy Concrete Overlays: Placed on bridge decks to reduce infiltration of water and chloride ions and improve skid resistance and surface appearance.

Membranes

- Asphalt Overlay with Membrane: can be used as a deck protection system

Concrete Sealers

- Can be used to provide protection for concrete but are not recommended for surfaces subjected to traffic.
- Can be applied to parapets and pier caps
- Applied roughly every 5 years.

11. FIELD OPERATIONS – DOS AND DON'TS

General

- Materials or testing related questions: reach out to Materials
- Make a personal relationship with your District Concrete Technician and Materials Section
- Inform the Contractor and senior VDOT Inspector if concrete wash water is discharging to the ground, drainage system or surface waters (VDOT Pollution Prevention Field Guide For Construction Activities - GUIDE 3.9)

Pre-placement

- Familiarize yourself with the concrete type to be used
- Prior to larger or more complex pours it is a good idea to conduct pre-pour meeting
    - Identify testing location, washout area
    - Discuss overall best practices
- Ensure the mix design is approved, accessible, submitted on C-25 form and on file
- Request all testing equipment well in advance of first concrete pour and maintain testing equipment in good working condition
- Have TL-13 form on hand or know where to obtain online
- Ensure air meters are calibrated up to date. Calibrations for air meters shall be in accordance to corresponding ASTM and shall be as follow:
    - ASTM C231 Pressure – Every 3 months

    - ASTM C173 Volumetric (Roller Meter) – Every 12 months
- Cylinders storage chamber shall be provided by the Contractor and set on flat, vibration free storage. Cylinders inside shall be kept in a continuously moist condition and within temperature range of 60˚ to 80˚F. The Contractor shall use and provide data from Continuous Measuring Device – VRBS 217.08(b)
- Reinforcement shall be kept above the ground and protected against deformation – VRBS 406.03(b)
- Notify Materials Section about concrete pour before the pour to schedule cylinder pickup/drop off - Cylinders shall be picked up by materials or dropped to the lab after 24 hrs. and before 48 hrs. to properly cure them
- Moisten the subgrade and forms prior to placement to prevent drawing of water from concrete
- Reinforcement shall be tied at every intersection where the spacing is more than 12 inches in any direction, except in vertical mats shall be tied at every intersection or at alternate intersections provided such alternate ties will accurately maintain the position of steel reinforcement during the placing and setting of concrete – VRBS 406.03(d)
- Ensure clearance between reinforcement and forms is per plans
    - Check the plans and applicable standards to ensure correct number of bars, correct size and diameter are used, and spacing between forms and bars is provided

- Placing reinforcing steel in concrete after concrete has been freshly placed is not permitted

Placement

- Concrete shall be at least 40˚F when placed and concrete shall not be placed against surfaces that are less than 40˚F as the sudden cooling of the concrete surface while the interior is still warm can cause cracking – VRBS 217.10 & 404.03(l)1
- Aluminum forms, chutes, buckets, pump lines, and other conveying devices shall not be used if the aluminum comes in contact with concrete – VRBS 217.03(e)
- One gallon per cubic yard of water may normally be withheld at the plant and added after the concrete arrives at the job site – see note on the ticket if 1 gal has been withheld and verify water/cement ratio is not exceeded. This is especially critical with SCC mixes where extra water can create problems with the stability of the mixture. Generally, for each gallon of water added to a cubic yard of concrete, the HCC strength will be reduced by 2.5 to 3%. (e.g. for 3000 PSI concrete it means ~100 PSI strength loss)
- All adjustments, other than water, made to the concrete at the job site shall be made by the Producer's certified concrete plant technician – VRBS 217.07
- Concrete shall be delivered to the site of work and discharged within 90 minutes of the time the cement is introduced into the mixture – VRBS 217.09(b)

- The sample secured for the tests shall be taken after at least 2 ft^3 of concrete has been discharged from the delivery vehicle and the discharged 2 ft^3 is not to be used as part of the test sample – VRBS 217.08(a) and (b)
- Re-sample the concrete after any extra water or field-added admixtures are added to the truck
- Re-test before rejecting the concrete
- Cast 3 cylinders for compressive strength and 2 cylinders for permeability testing
- Latex Mod. Concrete air, slump, strength and permeability testing are required unless Rapid Set Concrete used
- Unit Weight (Density) testing is required for lightweight concrete
- The Contractor shall perform evaporation rate testing for bridge deck placements and concrete overlays using the Evaporation Rate Nomograph (can be found in Manual of Instructions: Chapter IV, Appendix C or http://www.virginiadot.org/business/resources/Materials/bu-mat-MOI-IV.pdf)
- The protective measures shall be taken when evaporation rate exceeds:
    - 0.10 pound per square foot per hour for normal concrete bridge deck placements– VRBS 404.03(l)1
    - 0.05 pound per square foot per hour for concrete overlays over the exposed surface of the concrete – VRBS 404.03(l)1

    - 0.05 pound per square foot per hour during placement of latex-modified or silica fume overlays – VRBS 425.03(b)
- Bond Strength test (VTM- 92) is required to be performed by the Contractor
    - after concrete overlays – VRBS 217.08(c)
    - prior to epoxy overlays – VRBS 431.03
- Concrete shall not be dropped a distance of more than 5 feet or deposited in a large quantity at any point and run or worked along forms
- Burlap shall be moist
- Vibrators are for consolidation and shall not be pulled horizontally through the concrete, used to transport concrete in the forms, or operated for more than 15 seconds in any one location as this will cause segregation
- Curing compound application rate:
    - grooved horizontal surfaces- application rate shall be 100 to 150 ft^2/gal
    - all other surfaces shall be 150 to 200 ft^2/gal
- Do not allow "blessing" concrete with water - water lowers strength, may cause surface cracking
- Check for correct bar splices lengths
- Be careful with form release agents; don't let the spray get on the reinforcement – will act as a bond breaker
- Ensure proper alignments of the dowels – misaligned dowels will cause the joint to fail

Post-placement

- Curing protection of exposed surfaces: 7 days required; if forms removed prior to 7 days, then

surfaces where forms were removed must be cured until the 7 days is over

- Ensure proper joint depths after saw cutting is performed
- Verify that proper time or strength requirement has been met.