Section 6
WYDOT Specifications for Structural Concrete (SSRBC 513 & SS-500G)

WMTC Concrete Training & Certification Seminar

Classes of Structural Concrete

Table 513.4.4-1
Concrete Class

Parameter	Class		
	A	B	S
Ultimate Design Strength—f_c @ 28 d (psi [MPa])	4000 [28]	3500 [24]	4000 [28]
Min. Cement Content (lb/yd^3 [kg/m^3])	611 [362]	564 [335]	611 [362]
Max. Water : Cement Ratio	0.45	0.45	0.45
Max. Water: (Cement + Fly Ash) Ratio	0.45	0.45	0.45
Percent Entrained Air Content—Range	4.5 - 7.5	4.5 - 7.5	4.5 - 7.5
Consistency—Max. Slump (in [mm])(1)	6 [150]	6 [150]	6 [150]
Percent Fine Aggregate(2)	41 ± 3	41 ± 3	41 ± 3

(1) Ensure that concrete with slump greater than 4 in [100 mm] contains a water-reducing admixture.

(2) Percent by weight [mass] of the total aggregate.

Proportioning Concrete Mixes (SS-500G)

- New mix design required when there is a change in aggregate source, admixtures, cement type or fly ash source.
- Fine and coarse aggregates may be adjusted up to 2% by weight, based on total dry weight of aggregate without a new mix design.
- For fly ash mixes, minimum cement contents
  - Class B 451 lb/cuyd
  - Class A & S 489 lb/cuyd
  - % Fly Ash 20 to 25 (total cementitious material)
- Can resubmit old mixes if less than 3 years old but with conditions
- Not allowed: Air reducing & retarding admixtures.
- Allowed: Hydration stabilizers

Proportioning Concrete Mixes

- For Level I Concrete, contractor designs & submits Class A Concrete mix design & WYDOT may verify
- For Level 2 Concrete, WYDOT will complete 2 mix designs per class of structural concrete at no cost to contractor, each additional mix cost $1,500
- At least 30 days before concrete production, send samples of actual materials to Materials Program … (SSRBC 513.4.4)

1.	Fly Ash	50 lb
2.	Portland Cement	140 lb
3.	Fine Aggregate	400 lb
4.	Coarse Aggregate	600 lb
5.	Chemical Admixtures	1 pint (each admixture)

Also, include procedure and sequence for adding each ingredient to batch

Level of Control

513.4.4.1 Level of Control

The extent of contractor quality control and the department's quality assurance are defined by the level of control. Use a class A mix design and when specified in the contract, class S mix design. The required level of control is shown in Table 513.4.4-2, Determining Level of Control. The level of control requirements are shown in Table 513.4.4-3, Minimum Testing Requirements. Sampling frequency, including aggregate samples, is based on volume of concrete.

Table 513.4.4-2
Determining Level of Control

Level of Control	Type of Placement
Level I	Bridge Decks excluding curb and sidewalk unless placed monolithically with the deck.
Level II	All bridge items, excluding bridge decks, concrete slope paving and erosion control concrete. All structural items associated with cast-in-place box culverts and retaining walls.

From SS-500G SUPPLEMENTARY SPECIFICATION FOR STRUCTURAL CONCRETE WITH QUALITY CONTROL And QUALITY ACCEPTANCE

Quality Control- Contractor

- QC Control Plan and Control Charts (See Section 6, 6-17, 6-18)
- Contractor performs Quality Control testing
- **Quality Control Tests**
  a) Air Content
  b) Slump
  c) Yield & Unit Weight
  c) Temperature
  d) Aggregate tests
- Reject concrete based on QC testing

Quality Acceptance - WYDOT

- WYDOT performs Quality Acceptance testing
- WYDOT Materials in Cheyenne tests all acceptance cylinders
- **Quality Acceptance Tests**
  a) Air Content
  b) Strength
  c) Slump
  d) Gradation

Pay Factors

- Computed by WYDOT
- Rewards good control of parameters
- Penalizes poor control of parameters
- Based on …
  Air Content,
  Slump
  Strength
  Aggregate Gradations

Definition of Lot and Sublot

Only for Level I Control(Bridge Decks)

(SS500-G 513.4.10.3.1)

- Maximum Lot Size 150 CY
- Number of Sublots

Lot Size	Sublots per Lot
120 to 150 CY	5
90 to 120 CY	4
Less than 90 CY	3

Engineer may increase sublots/lot

by a maximum of two for better sampling

Min. Testing Requirements
(SS500G)

Contractor QC Technician

1st load test is independent of frequency testing

WYDOT QA Technician

Table 513.4.4-3
Minimum Testing Requirements

	Level of Control	
	I	**II**
Quality Control (Contractor Testing)		
Mix Production[5]		
Compressive Str.	See footnote [1]	See footnote [1]
Air Content	1st load[3] then 1per 25 CY [20 m^3]	1st load[3] then 1per 25 CY [20 m^3]
Slump	1st load[3] then 1per 25 CY [20 m^3]	1st load[3] then 1per 25 CY [20 m^3]
Yield and Unit Weight	1st load[3] then 1per 25 CY [20 m^3]	1st load[3] then 1per 25 CY [20 m^3]
Temperature	1st load[3] then 1per 25 CY [20 m^3]	1st load[3] then 1per 25 CY [20 m^3]
Moisture Content	1/day min	
Quality Acceptance (WYDOT Testing)		
Coarse Aggregate		
Gradation	1 test per 200 CY [150 m^3]	
Moisture Content	1 test per each gradation	
Fine Aggregate		
Gradation	1test per 200 CY [150 m^3]	
Moisture Content	1 test per each gradation	
Mix Production[5]		
Compressive Str. (28 Day)	1 set per sublot [4]	1 set per 50 CY [35 m^3] **per each Pay Item** [4]
Air Content[2]	1 test per sublot	1 test per 50 CY [35 m^3] **per each Pay Item**
Slump[2]	1 test per sublot	1 test per 50 CY [35 m^3] **per each Pay Item**

[1]QC cylinders are not required. The contractor is responsible for any concrete cylinder test required for early strength information.

[2]Take Slump and air content tests with each set of cylinders.

[3]The "1st load" refers to the first truck load delivered on a given day.

[4]A "set" is three cylinders, where the compressive strength is the average of the three cylinders

[5]When a truck is rejected or re-dosed, the following truck load will be tested.

Example

For a **Level I** structural concrete project with 60 CY

QC: Test 1st load plus 1 per 25 CY

QA: Number of lots: 60 CY/150 CY = 0.4 ⟶ 1 Lot

Number of sublots: 3 (from 513.4.10.3.1)

Test	Testing Frequency	
	Quality Control	**Quality Acceptance**
Temperature	**1 + 60/25 = 3.4 = 4**	3 by default
Slump	**4**	1 per sublot x 3 sublots = **3**
Unit Weight & Yield	**4**	3 by default
Air Content	**4**	**3**
Strength (cyl)	Optional	**1 strength test per sublot (3 cyl/test)** **3 cyl/sublot x 3 = 9**

Correlation of Slump, Air Content & Unit Weight Tests (SS500G)

- Minimum batch size 1 cuyd
- May take place before concrete production or on first concrete delivered if approved by Engineer
- QC & QA technicians perform slump, air content and unit weight tests
- **Allowable Differences**
  - Slump (for 0 – 2 inch concrete) ± 0.5 in.
  - Slump (for 2 – 4 inch) ± 1.0 in.
  - Slump (for greater than 4 inch) ± 1.5 in.
  - Air content ± 0.4%
  - Unit Weight ± 1.0 pcf
  - If differences exceed these values, enact dispute resolution

(See Section 6, page 6-14 thru 6-16)

Batching

- Weight cement & fly ash on approved scales. Don't use cement damaged by moisture.
- Handle & delver aggregates without segregation. Do not use contaminated aggregates (clay balls, dirt, etc.).
- Store admixtures (air entraining) in sealed containers, protect from freezing and stir before using. Add air-entraining admixture separately from calibrated dispenser.
- Maximum variation of total combined weights of portland cement & fly ash from approved mix design … 1%
- Fine and coarse aggregate tolerance … 2%

Mixing & Delivery

SSRBC 513.4.9 & SS-500G

- Mixers must not have build-up of dried concrete or broken or missing blades (worn 1 in or more)
- If quality of mixer in doubt, perform uniformity tests
- Empty any water in mixer before batching
- Batch cement so no loss occurs due to wind
- Truck mixers need drum counters
- Mixers must have meter for measuring water
- Retempering with water or admixtures not allowed

- Fresh concrete temperature, immediately before placing
  - not less than 50°F
  - no more than 90°F

When ice used to cool concrete, do not discharge until ice melts.

- Mixer revolution: not less than 70, not more than 100 plus 30 additional revolutions when adjusting slump by adding water (or admixtures, if allowed)
- Employ additional mixing revolutions in accordance with admixture manufacturer's recommendations
- Maximum turns of drum including mixing & agitation is 300
- Place concrete within 90 minutes after mixing when concrete temperature between 50F & 70F

- For each one degree increase in concrete temperature above 70F, reduce max. placing time by 2 min.

Max. Place Time = 90 min – [2 min x (T – 70F)]

Example: for 80F concrete …

Max. Place Time = 90 min – [2 min x (80F – 70F)] = 70 min

- When chemical stabilizers used, may add up to 90 minutes to allowable placing time and limit for adding water
- Can adjust admixture dosage rates within manufacturer's recommendations without new mix design

Testing for Concrete Consistency

(SSRBC 513.4.10)

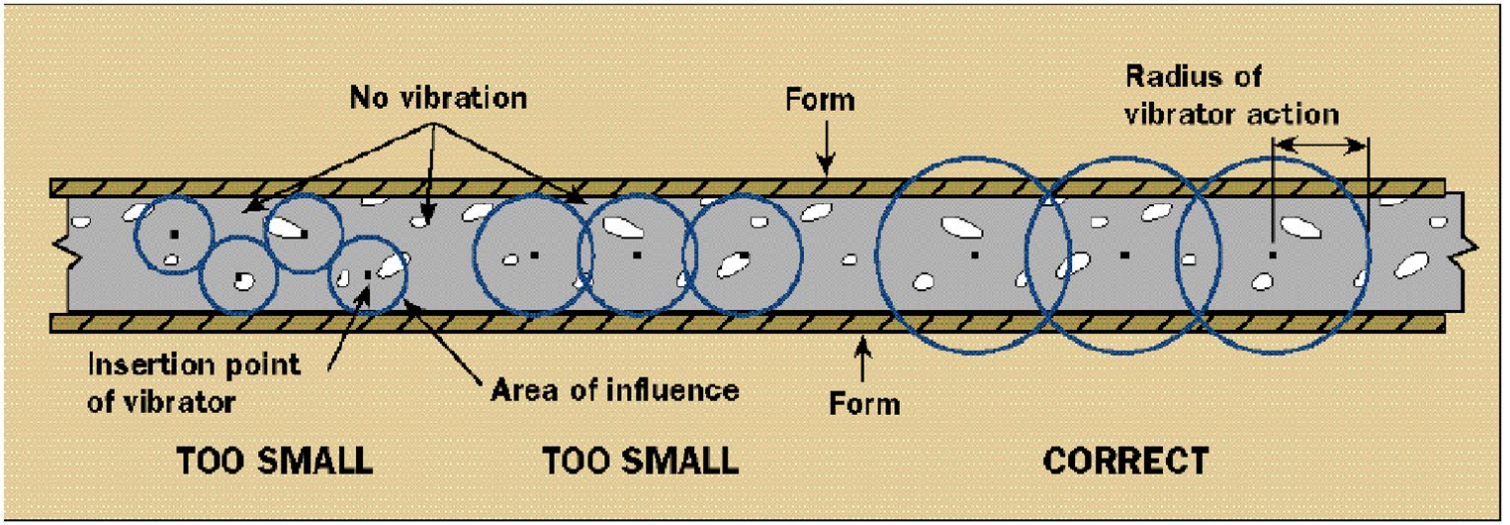
- Consistency of load - test slump at
  - Beginning
  - Middle
  - End
- 1½ inch max difference allowed
- If exceeded, don't use mixer until repaired

Placing Concrete (SSRBC 513.4.11)

- Maximum interval between trucks … 20 minutes (SSRBC 513.4.9.1)
- Place concrete near final position (don't push along form)
- Use closed chutes or pipes when dropping concrete more than 5 ft
- When air temperature is above 90°F, cool forms, rebar, steel beam flanges, other surfaces with cool water
- Maximum lift heights
  - beams & slabs 18 inches
  - footings, walls, & columns 30 inches
  - Place nearly square ends and level tops, don't taper concrete

Consolidation (SBRBC 513.4.11.2)

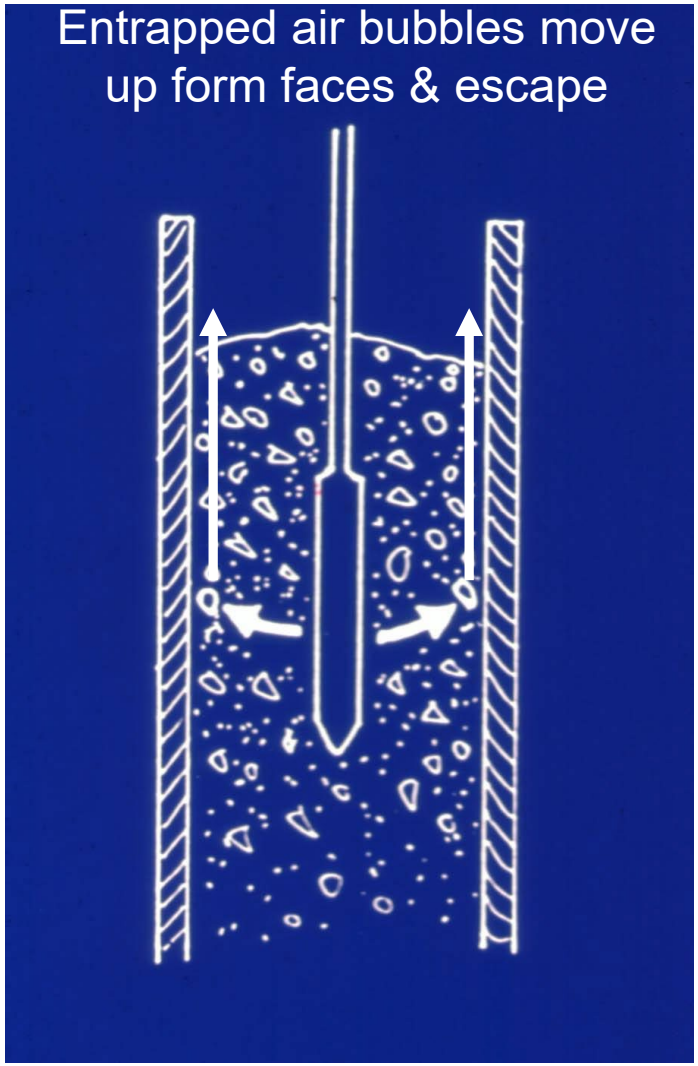
- Vibrators - minimum of 7,000 pulses per minute
- Need at least 2 onsite when more than 10 cy placed
- Insertion spacing not to exceed 1½ x radius of influence
- Radius of influence needs to overlap by at least 2 inches plunge vibrator into concrete & hold in place for 5 to 15 seconds

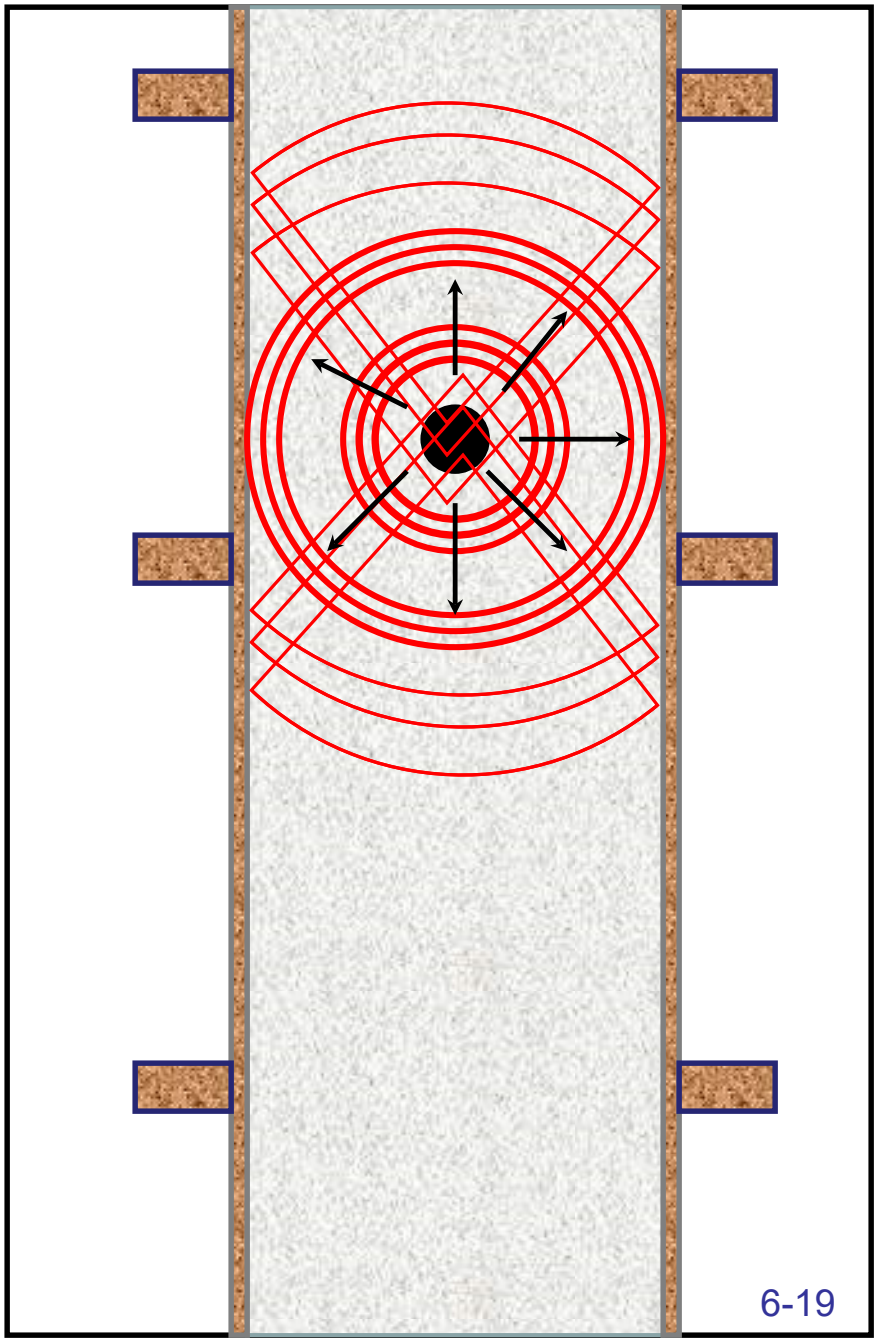


A vibrator's radius of action varies, depending on the vibrator's frequency and head size and the stiffness of the concrete mix. Make sure the vibrator head is large enough and the intervals between vibrator insertions are close enough to vibrate all the concrete.

Internal Vibrators

Spud or Poker Vibrators





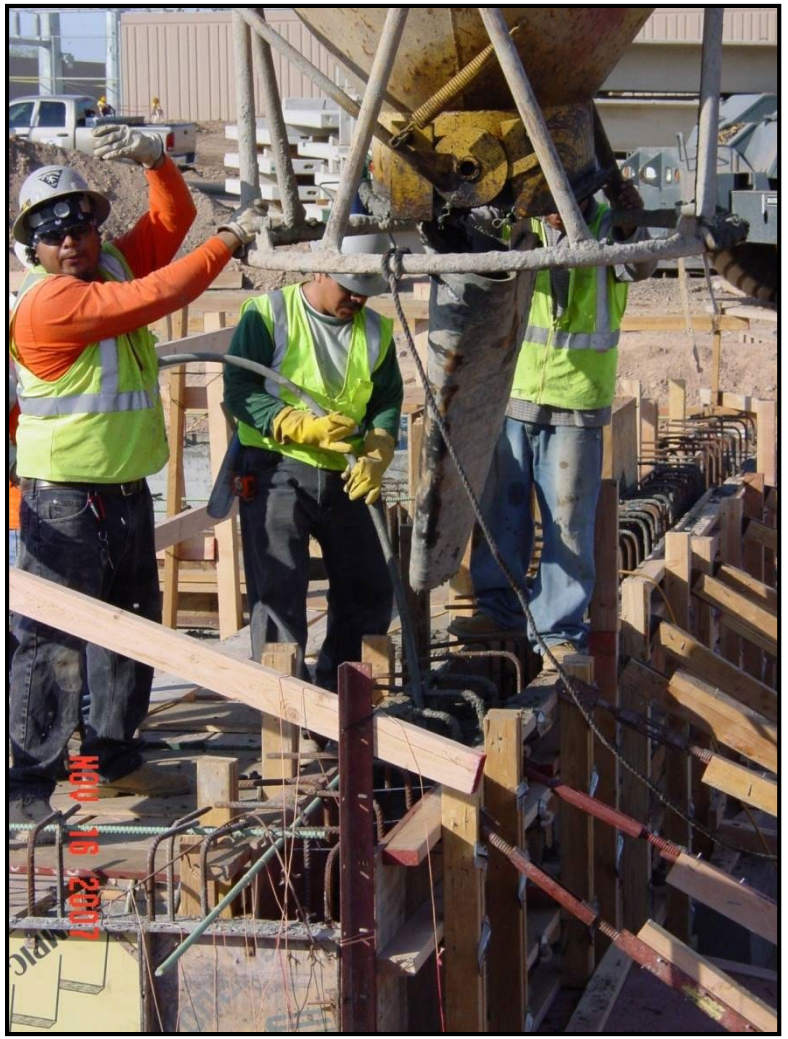
Stages of Consolidation

1. **Liquefaction**

   Levels concrete & drastically reduces internal friction between aggregate particles (honeycomb removed)

2. **De-aeration**

   Removal of Air Bubbles, before consolidation, entrapped air content between 5% to 20%, (large air bubbles move to surface)



How to Vibrate

1. Insert vibrator into concrete vertically & rapid to bottom of lift
2. Penetrate previous lift about 6 inches*
3. Don’t push vibrator down – let it sink
4. Hold at bottom for 5 to 15 sec (listen to tone)
5. Withdraw gradually with an up-and-down motion (jigging action)
6. At top, remove quickly

Adequacy of Internal Vibration

1. Leveling & embedment of large aggregates
2. Blending with previous placed concrete along perimeter of the radius of action
3. Thin film of mortar on top surface
4. Layer of cement paste along form face
5. Air bubbles stop escaping
6. Pitch or tone changes: frequency drops off & finally becomes constant when concrete is free of entrapped air bubbles

What about entrained air bubbles for freeze thaw protection?

Finishing Concrete Surfaces

(SSRBC 513.4.12.1)

- Types of Finishes
  - Ordinary Finish
  - Rubbed Finish
  - Float Finish
- Do not add water to surfaces for finishing operations.
- If approved by engineer, use commercial evaporation retarder

Finishing Bridge Decks (SSRBC 513.4.12.2)

- Use deck finishing machine, minimum hand tools
- Verify adjustments & operation of deck finishing machine
- Check specified cover over reinforcing steel
- Check depths of fresh concrete behind screed (max. ±½ in.)
- After screed floating, check deck for surface irregularities using 10-ft straight edge (max deviation ±1/4 in.)
- After finishing and evaporation of bleed water, burlap drag
- Tine surface – do not tear surface & unseat aggregate
- Tine groves: 1/8 to 3/16 in. deep at right angle to roadway
- Surface tolerance: max. deviation ±1/4 in., Grind high & repair low spots
- Apply cure as soon as surface not marred by actions

Curing Concrete (SSRBC 513.4.13)

- Cure all concrete minimum of 5 days
- Until curing begins, may need to use fine mist fogger or approved evaporation retardant to prevent surface drying
- If surface protected by metal or oiled forms for at least 5 days
  - No curing required
- Minimum five day cure period
  - Ponding or misting
  - Wet burlap (keep surface wet at all time)
  - Curing compounds
  - Polyethylene sheeting (overlap min. 18 in. & extend min 12 in.)
  - Curing (impervious) compound
  - Receive two applications
  - Minimum rate of 1 gal / 300 sqft for each application
  - Don't apply to dry concrete, re-wet or dampen if necessary
- Don't use water if air temperature below 35°F

Weather Limitations (SSRBC 513.4.2)

- **If air temperature is 35F or less …**
  - Heat water, aggregates or both
    - To at least 70F but not more than 150F
    - Aggregates shall be free of frozen lumps, ice & snow
  - Provide heated enclosures for curing
  - Maintain minimum surface temperature of
    - 60F for at least 72 hrs after placing concrete
    - 40F for remainder of 6-calender day cure period

- **If air temperature is less than 40°F ...**
  - Fresh concrete shall arrive at site between 60°F & 90°F

- Don’t place concrete on frozen ground or against materials with a temperature less than 35F (may need to heat base, rebar, forms, etc. before placing concrete)

- Handling equip. (chutes & buckets) shall have a minimum temperature of 35F

- For bridge decks, provide foggers, wind breaks, evaporation retarders if critical evaporation rate exceeds 0.2lbs/ft^2/hr (SSRBC Figure 513.4.2-2)

- Discuss hot & cold weather operations at prepour conference