



VDOT's New High Performance Concrete Specifications

Celik Ozyildirim, Ph.D., P.E.

*A partnership of the **Virginia Department of Transportation**
and the **University of Virginia** since 1948*

HPC in VDOT

- Very successful due to TEAM WORK between
 - VDOT (VTRC, CO, Districts)
 - FHWA
 - Industry
 - Academia
- HPC has led to ERS (under development, pilot projects) and to changes in current specifications

Outline

- HPC (bridges and pavements)
 - Workability: SCC
 - Durability: Low permeability, air-void parameters
 - Strength: in beams up to 10,000 psi, with UHPC up to 30,000 psi
 - Crack control
- ERS
- VDOT's new spec

Workability

Self-Consolidating Concrete SCC

- First SCC application
- Arch Bridge - 2001



- 5,000 psi
- 2500 coulombs



Rte 33 Bridge over Pamunkey River



40 SCC Beams



SCC span with gages

Drilled Shaft - SCC



Durability

- Low permeability: pozzolans, slag, w/cm
- Chemical resistance: ASR
- Freeze/thaw resistance: air void parameters rather than total air content
- Wear/abrasion resistance

Low Permeability and High Strength



- 1995
- Beams: 8,000 psi
- Beams and deck: low-permeability

- 1997
- Beams: 10,000 psi
- 0.6-in diameter strands
- Beams and deck: low-permeability



Lightweight (LW) HPC

Route 106 over Chickahominy River



- 2001
- Beams: 8,000 psi
- Beams and deck: low-permeability

Two Bridges on Route 33

LWHPC Bulb-T Beams

Long spans and poor soil conditions

Mattaponi Bridge

- 3,454 ft
- 2,195 ft LWHPC.
- Span lengths:
145, 200 and 240 ft

Pamunkey Bridge

- 5,354 ft
- 2,169 ft LWHPC.
- Span lengths:
136'-4", 200 and 240 ft



LW HPC - Route 33 Bridges

2006, over Mattaponi River

2007, over Pamunkey River



Beams: 8,000 psi, 1500
coulombs

Decks: 5,000 psi, 2,500
coulombs



Rte 624 Bridge with UHPC Beams



Fiber Reinforced Concrete (FRC)

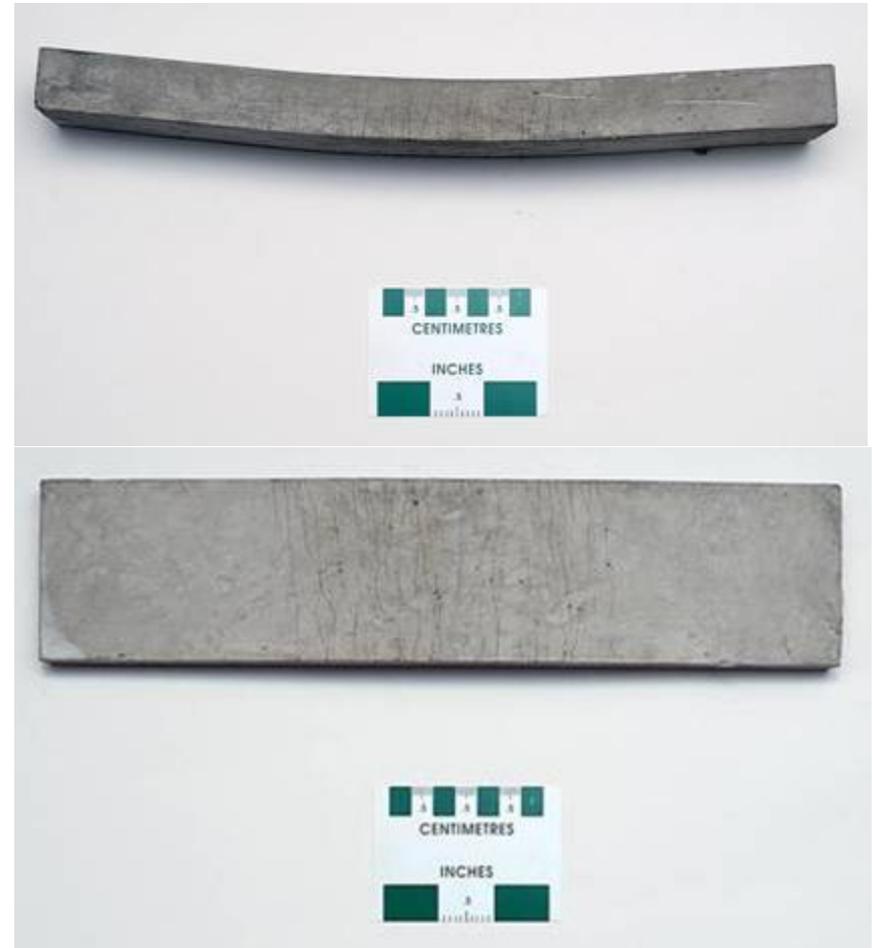
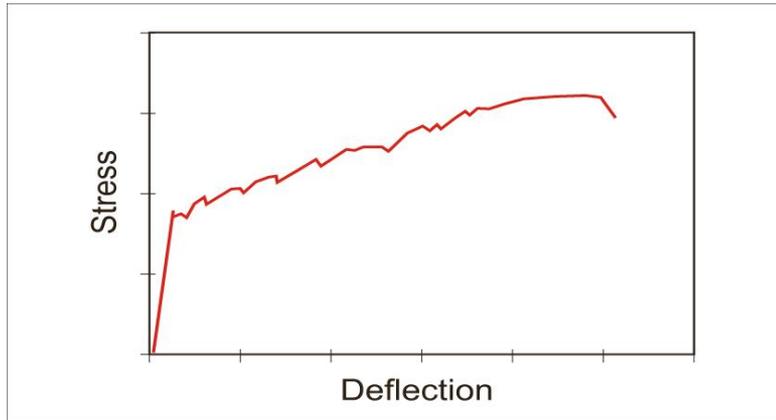


Route 11 over
Maury River

Rte 106 over
Chickahominy River



High Performance FRC



Mass Concrete I-895, Footings



75% slag



Mass Concrete - Route 33

40% Class F fly ash



HPC Pavements

- Low permeability concrete
- Large aggregates (2-in at Rte 288)
- Combined aggregate (Rte 288)
- Lower cementitious materials and lower water contents (540 lb/yd³ at Rte 288)

HPC Requirements

- Proper material selection
- Proper proportioning
- Proper consolidation
- Proper curing
- Proper testing (quality control)

- **PROPER SPECIFICATIONS**

End Result Specifications ERS

- Mix design responsibility given to the contractor/producer
- Prequalification (process control): historic data or trial batching before work starts
- Proper sampling and testing
- Screening tests (fresh concrete tests) by the contractor and acceptance tests (by VDOT)

NEW VDOT SPEC CHANGES

Section 214.02

EMPHASIS ON DURABILITY

Add Section 214.02(c):

(c) Expansive hydraulic cement shall conform to the requirements of ASTM C 845, Type K.

Expansive cement reduces cracking in concrete.

Reduced cracks help prevent intrusion of chlorides to the level of reinforcement.

LMC with Type K in overlays, A4 with Type K in closure pours

NEW VDOT SPEC CHANGES

Section 217.02

EMPHASIS ON DURABILITY

- High amounts of pozzolans can be used with the approval of the Engineer
 - Pozzolans lower permeability
 - Provide resistance to chemical attack
 - Control heat rise

Permeability Requirements

Table II-17

EMPHASIS ON DURABILITY

For all applications except in small bridges and incidental concrete as described in Sections 219, 232, 302, 415, 502, 504, 506, and 519. Small bridges are those bridges off the Federal aid system less than 200 feet in length

- Includes lower permeability limits for harsher environment (over tidal water);
A3=A4=max 2,000 coulombs

Permeability of Overlays

Table II-17

- Overlays have low permeability limits (max 1,500 coulombs)
- Binary blends (pc+FA, pc+S) pc=portland cement, FA=ClassF fly ash, S=slag permitted in overlays
- Ternary blends (pc[min 77.5%] + SF[2.5-5%] + FA[15-20%], pc[min 67.5%] + SF[2.5-5%]+S[30-35%]) permitted in overlays

Aggregate Requirements

Table II-17

EMPHASIS ON DURABILITY

- Different aggregate sizes or combination of sizes can be used upon approval by the Engineer
- Maximum size aggregate is 2.5 in.
- Optimizing aggregate is expected to minimize water, cementitious material, and paste contents.

NEW VDOT SPEC CHANGES

Section 217.02

EMPHASIS ON DURABILITY

- ASR table modified and included in the specifications. Pozzolans not covered in the table can be used after testing (maximum expansion of 0.15% according to ASTM C227 at 56 days using borosilicate glass as aggregate).

ASR Table

Material	Total Alkalies $\leq 0.75 \%$	Total Alkalies $>0.75 \leq 1 \%$
Class F Fly ash (%)	20	25
Slag (%)	40	50
Silica Fume (%)	7	10
Metakaolin (%)	7	10

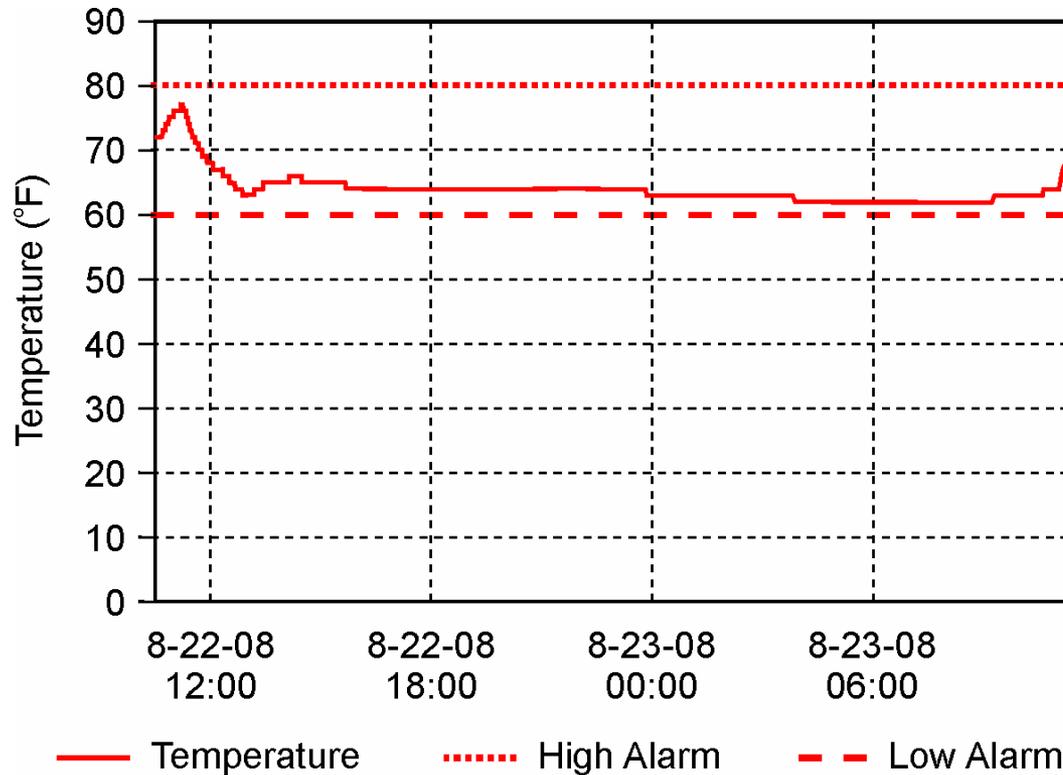
Metakaolin: a new addition

Other Changes to 217

- 217.04(a)4 Admixtures: Dispensed and used according to manufacturer's recommendation (before AEA dispensed with mix water; now allowed with aggregates).
- 217.08 for Sampling: After at least 2 ft³ has been discharged and the 2 ft³ discharged is not used as part of test sample
- 217.08 Storage chamber for specimens shall be equipped with a continuously recording thermometer.

Other Changes to 217 Storage Chamber

Curing Box with continuous recording (data printout)



Other Changes to 217 Continued

- 217.08 Concrete Temperature: shall be measured in accordance with the requirements of ASTM C1064.
- 217.09 Ready Mixed Concrete: Form TL-28 signed by the VDOT Certified Concrete Field Technician or a designated company representative working under the direction of the VDOT Certified Concrete Field Technician.
- 217.09 Ready Mixed Concrete: permits concrete discharge after 90 minutes with Engineer's approval.
- 217.09 Ready Mixed Concrete: maximum 125 revolutions of transit mixing deleted.

Concrete Pavement Section 316.04(o)

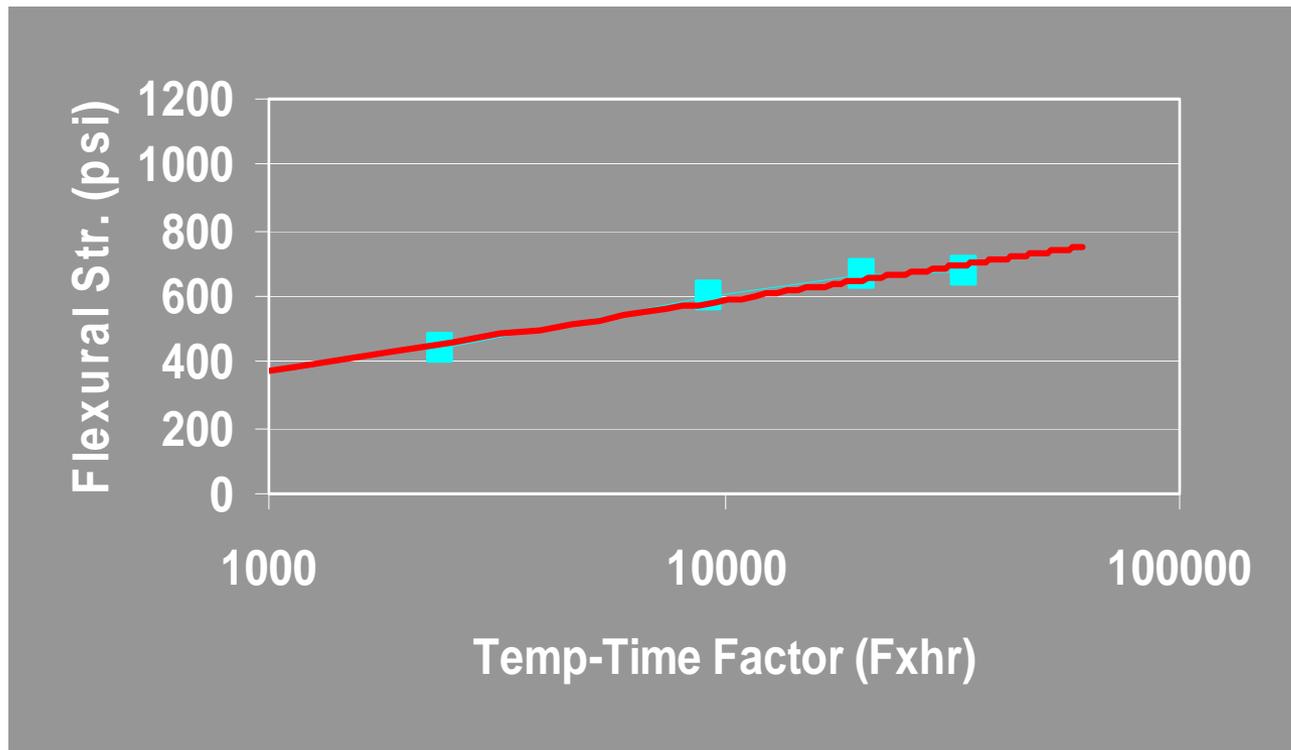
STRENGTH FOR OPENING TO TRAFFIC

Maturity test method can be used to estimate strength for opening to traffic

(A strength of 600 psi is required before opening to traffic; ASTM C78 third point loading)



Maturity – Rte 288



Prestressed Concrete 405.02(a)3

- When a high-range water-reducer is used, the upper limit for the slump may be increased to 9 inches with prior approval by the Engineer and provided no segregation is seen in the mix.

Changes on the Way

- Encourage ternary blends of pozzolans and slag
- Adopt NRMCA or similar plant and truck certification
- Allow mix design approval process from ERS as an option
- Emphasize QC testing by the contractor
- Encourage more SCC use



Thank You

*A partnership of the **Virginia Department of Transportation**
and the **University of Virginia** since 1948*