

NJDOT's use of High Early Strength Concrete on Route I-76



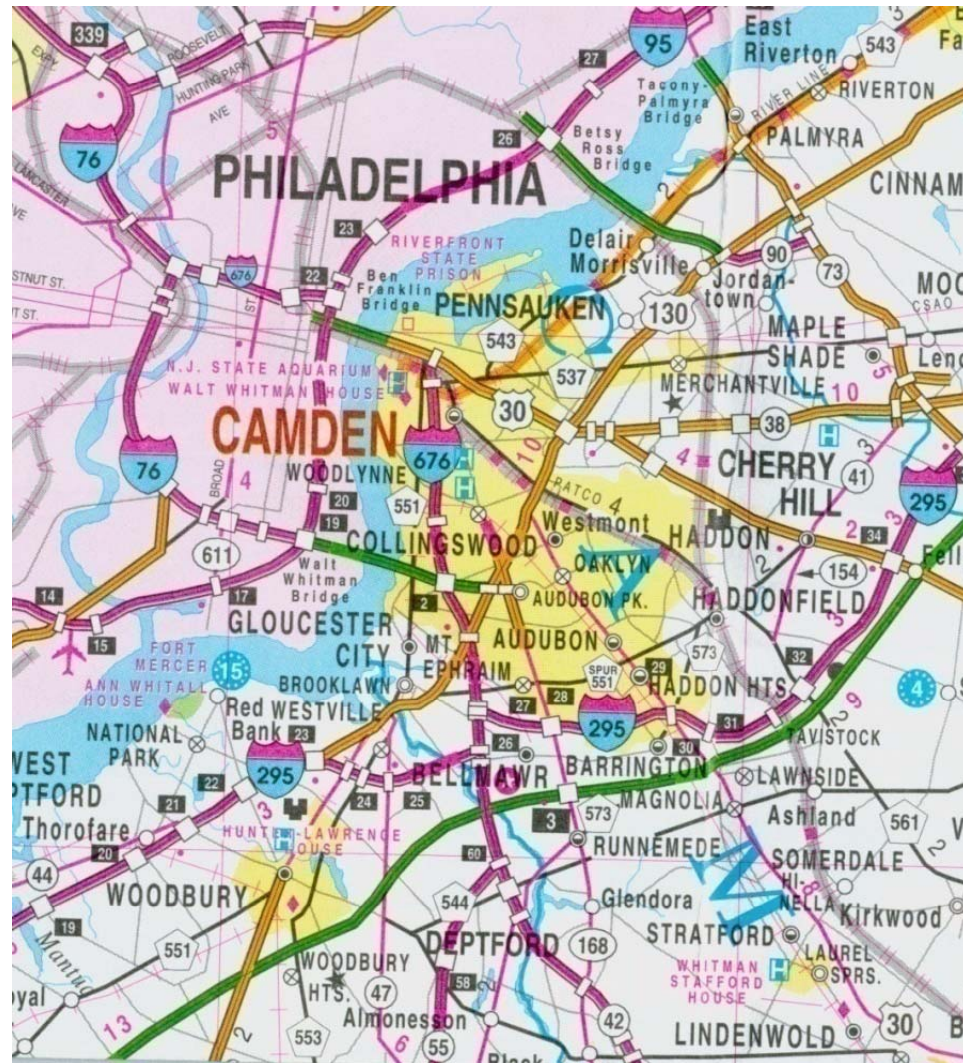
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About Interstate 76

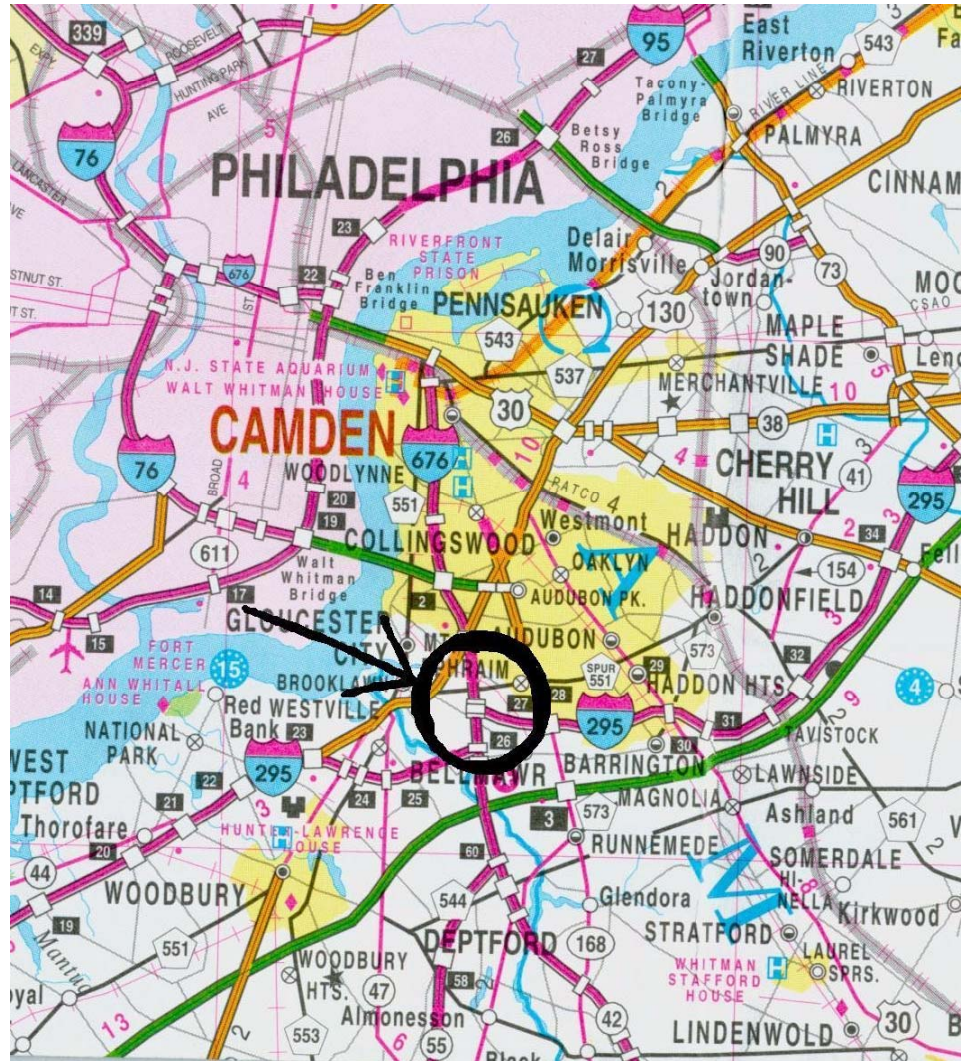
- I-76 Runs from Akron OH to Bellmawr NJ
- Comprises most of the PA Turnpike, Schuylkill Expressway and Walt Whitman Bridge.
- I-76 in NJ carries high volumes of the traffic Between South Jersey & Philadelphia.

Interstate 76 in NJ

- Feeds I-295 and 42 (To A.C. Expressway)
- Consists of 5-6 lanes in both directions.
- 174,400 ADT
- Peak volume 13,950 Vehicles/Hr (**4/sec.**)
- 8% trucks



Project location



Project location





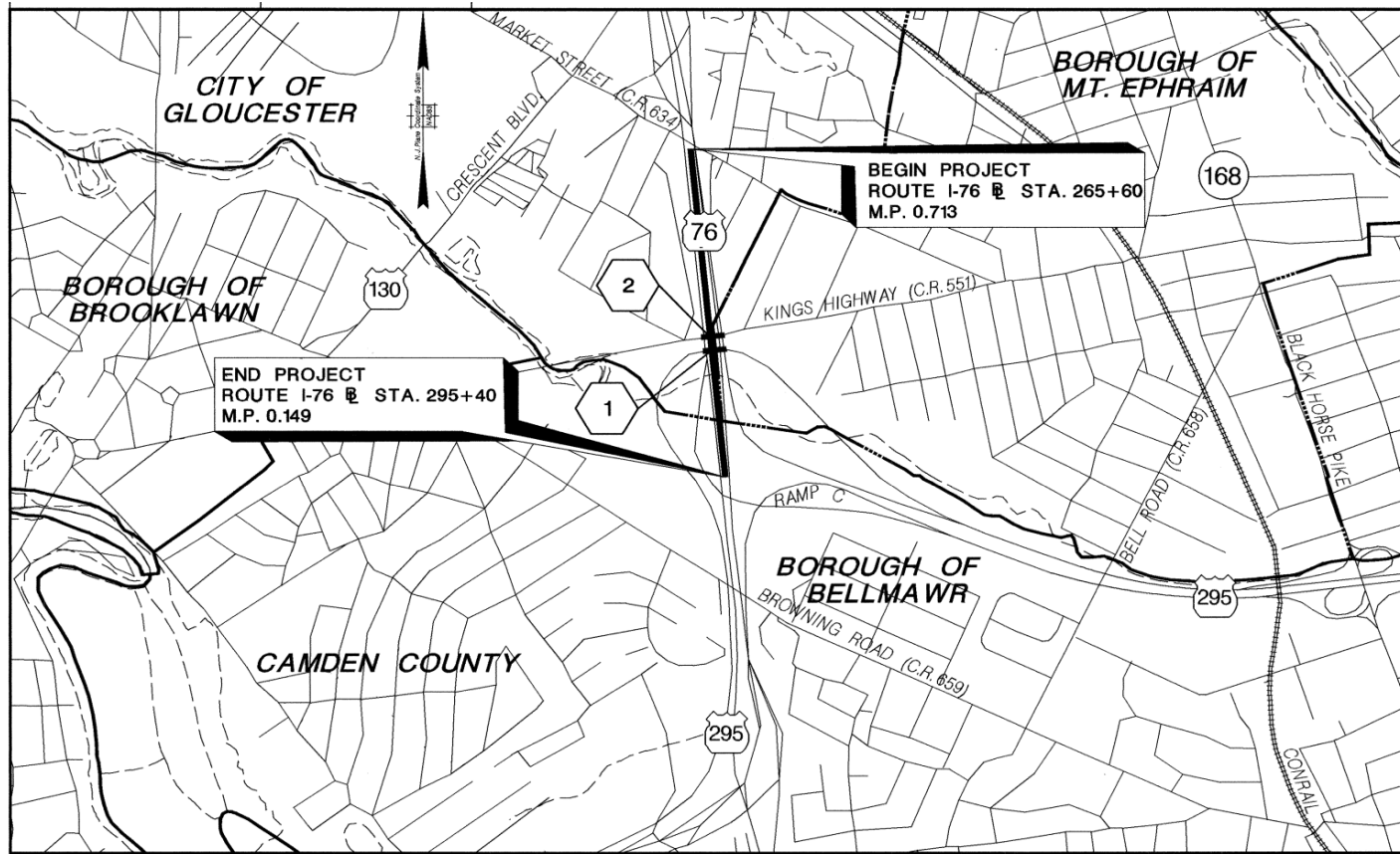
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HOLD

I-76
RT 42

09-26-08
07:41:27



I-76 over Kings Highway and I-295 SB



- 2 Bridges in close proximity. Each about 210' Wide and 72' Long.

I-76 over Kings Highway and I-295 SB



- 2 Bridges in close proximity. Each about 210' Wide and 72' Long.

The Problem

These 2 Bridge Decks over Kings Highway and I-295 SB (Al-Joe's Curve) were badly deteriorated



I-76 over Al-Joe's Curve @ S Abutment



- I-76 over Al-Joe's Curve @ N Abutment



76 over Kings Highway



- Project was already in the pipeline.
- Urgency of the project increased in the Spring of 2007 when chunks of concrete began to fall onto roadways beneath.
- Advertisement was moved up to 7/26/2007





Project Scope

- Remove and replace both concrete bridge decks
- Reconstruct Approaches
- Maintain at least 4 active lanes of traffic in both directions throughout construction

The Challenge

- **Do it FAST!!!**
- Complete 2 NB Stages between Start Date 9/22/2007 and 12/31/2007. (Bid opening 8/23/07)
- Substantial Completion 6/27/2008 (9 months total for work, including Winter)
- **But do it RIGHT!!!**

The Solution (?)

Build both 8½ inch thick bridge decks, headers and parapets full-depth with **Very Early Strength Latex Modified Concrete (VESLMC)**



Concerns With VESLMC

- VESLMC is a good material for some applications (Fast-Track pavement patches & joint replacements, extending service life of pavements, deck overlays with short duration lane closures)

Concerns With VESLMC

- VESLMC is a good material for some applications (Fast-Track pavement patches & joint replacements, deck overlays with short duration lane closures)
- **However...**

Concerns With VESLMC on 76

- Durability (Cracking)
- Constructability
- Never used full depth *
- Little used in this region
- Spec was poorly written

Next Move?

- Construction & Materials called meeting with Designer, Structural Engineering and Project Management to get the VESLMC changed.
- What did we really need from our Concrete ?

Next Move?

- Project schedule was aggressive, but hard lane closures lasting for 2 +/- weeks do not require concrete to gain design strength overnight. (Approaches need to be constructed concurrently with concrete cure time)
- Project Schedule could be maintained if bridges could be open to traffic in 3 days.

Next Move?

- We needed our concrete to achieve 4000 psi in 3 days in addition to the 28 day design strength.
- NJDOT Materials believed that this could be achieved with a **ready mix concrete** and volunteered to write a spec to replace VESLMC.
- NJDOT did not have a “High Early” class of concrete (Other than for fast track pavement repairs and VESLMC)

Mix Design Requirements

- 4000 psi in 3 days.
- 28 Design Strength equal to Class A. (4600 psi)

HPC???

- HPC is NJDOT's design standard for bridge decks.
- Performance Specification based on 56 day strength and Rapid Chloride Permeability, Scaling, and Freeze-Thaw tests.

HPC???

- HPC was not a good choice for 3-day concrete since pozzolans are required, 56 day acceptance, and prohibitive time required for performance tests.

VES???

- VES (Very Early Strength) Concrete is NJDOT's fast-track concrete pavement repairs.
- Designed for opening to traffic in 6.5 – 8 hours.
- Flexural testing is the basis for opening to traffic.

VES???

- VES was not a good choice because the requirements apply to pavements, not structures.

Class “A” Concrete

- Class A was our “old” standard concrete for decks.
- Acceptance based mainly on 28 day compressive strength. (4600 psi on job)

The Solution

Concrete in Structures,
“High Early Strength”

“High Early Strength”

- **Materials recommended specifying Class A, with the additional requirement of 4000 psi in 72 hours.**
- **No prescription for how to achieve 72 hour strength.**
- **Allow supplier to be innovative.**
 - Standard Specs allow Type III Cement,
 - Standard Specs allow Non-Chloride Accelerators.
 - Class A has no pozzolan requirement.

ASR Considerations

We knew that allowing contractors to eliminate slag and fly ash could result in suppliers being unable to use many of our “potentially reactive” aggregates.

We decided not to waive reactivity of aggregates requirements. Sources not classified as reactive did exist (though about 1/3 of tested fine aggregate sources).

The Spec. (by addendum)

524.02 Materials.

Materials shall conform to Subsections 501.02 and Sections 405 and 914. The concrete mix design shall conform to the design, control, and acceptance requirements of Class A, with the following additional requirements:

72-hour Design Strength (field cure) 4200 psi

72-hour Verification Strength (standard cure) 4500 psi

72-hour Retest Limit (field cure) 4000 psi

The Engineer will make additional compressive strength tests during production to verify the design strength is met in 72 hours. The initial sampling rate for 72 hour tests will be the same as the initial sampling rate for 28 day compressive strength acceptance.

The Spec. (by addendum)

524.04 Construction.

Construction shall meet the requirements of Section 501 except as follows:

- Deck slabs shall be finished with a **stiff broom finish and Saw Cut Grooved Surface** in accordance with subsection 501.15.
- Deck slabs shall be wet cured in accordance with subsection 501.17, except that the minimum **wet cure period shall be 72 hours.**

524.05 Opening to Traffic.

Opening to traffic for deck slabs will be in accordance with 501.24, except that the minimum curing time shall be 72 hours. **If any one of the initial 72 hour compressive strength tests fail to meet the 72 hour retest limit, the deck slab shall not be loaded with construction equipment or traffic until authorized by the Engineer.** The engineer may make additional strength tests for the purpose of determining the time at which the deck may be opened to traffic.

Advertised 7/26/07; Bids Opened 8/23/07

- Engineers Estimate \$8.4M
- 6 Bids received:
 - **\$8.72M (Richard E. Pierson Const. Co. Inc.)**
 - \$8.95M
 - \$9.29M
 - \$9.31M
 - \$10.66M
 - \$16.19M
- Contract Awarded 9/07/07

Mix Design

Mix Design (Pierson Materials)

- Cement Hercules Type 1/2 752#
- Sand Dunrite (ASR 0.09) 1170#
- Stone Hansen (Argillite) 1700#
- Superplasticizer Axim Allegra 122 (Polycarboxylate)
- Accelerator Axim Catexol 2000RHE 241 oz/CY
- Air Entraining Axim Catexol AE 260

- Water/Cement at verification was 0.360

Mix Design



Mix Design Strength Results

- 3 Days: 4700 psi
- 7 Days: 5900 psi
- Mix Approved on the basis of 3-day and 7 day results

Construction

Stage Construction

- Project was constructed in 5 stages
- 2 stages NB
- 3 stages SB

Stage Construction



(Stage 2 NB cattle chutes)

Stage Construction



24 Hour Work Operation. Most of the work performed at night

Demolition



SIP Forms



SIP Forms & Shear Connectors



Placement by Pumping



Machine Finish



Field Sampling / Testing

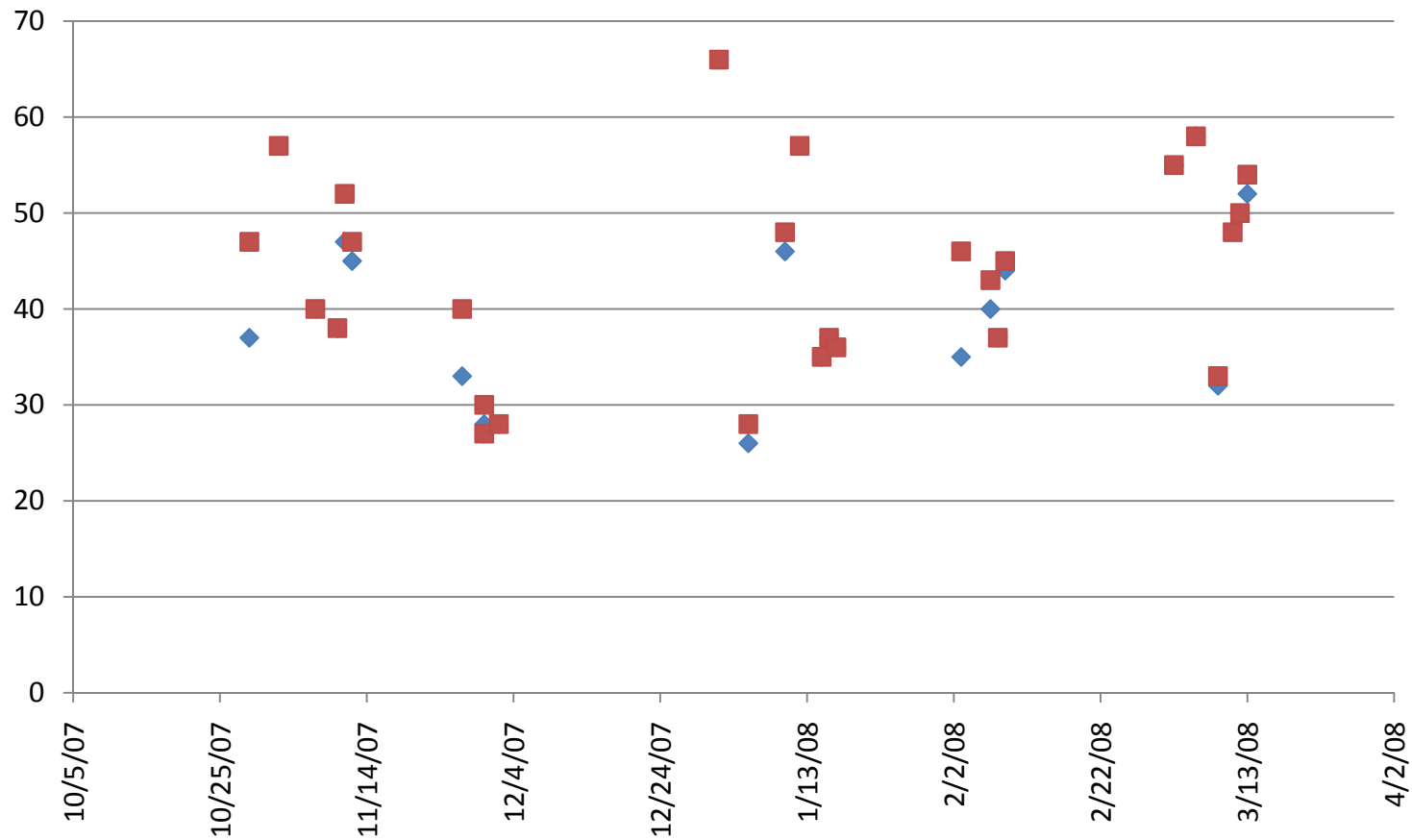


Air & Concrete Temperatures

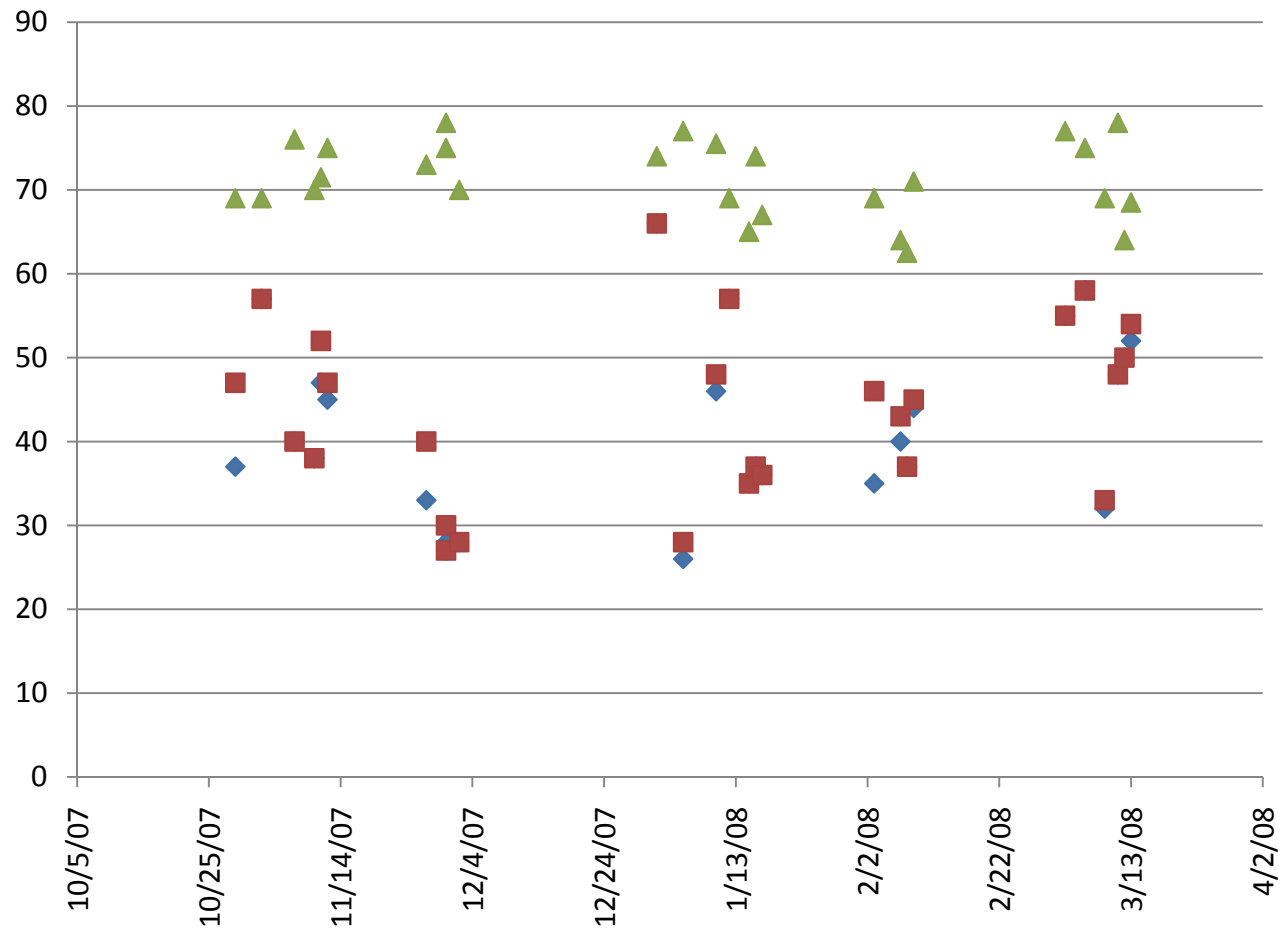
- Concrete poured from Oct 29 thru March 13.
- Air Temperatures at time of placement ranged from 27 F, to 66 F
- Concrete Temperatures ranged from 62 F to 82 F.

(Very mild winter weather!)

Air Temperatures



Air & Concrete Mix Temperatures



Curing

- Pre-placement heating of pans, re-steel.
- Electric Heaters beneath pans post-placement.
- Wet cure with burlene and/or burlap.
- Insulated Blankets.

Curing

- Temperatures monitored during cure.
- First day temperatures mostly 100 – 110 F
- Highest recorded was 115 F

Curing

- After 72 hours, heat, blankets, and curing removed in controlled fashion to gradually reduce temperature to ambient.

3 Day Compressive Strength Results

- 23 Lots Tested (Decks, Headers, Parapets)
- Field cured with deck
- Mean = 4680 psi
- Standard Dev = 456 psi
- Coefficient of Variation = 10%
- Low = 3930 psi (Retest at 5 day = 5760)
- High = 5550 psi

28 Day Compressive Strength Results

- 27 Lots Tested
- Standard cured per AASHTO T-23
- Mean = 6450 psi
- Standard Dev = 539 psi
- Coefficient of Variation = 8%
- Low = 5680
- High = 7720

Cracking?

- Only minimal cracking was observed upon removal of curing.

Project Completion

- Interim Completion was 9 days ahead of schedule (\$7000 / day incentive)
- Substantial Completion 6/09/07

Project Completion



Lessons learned

1. Sometimes the simplest solution to the problem is the best.

Lessons learned

2. Don't use quick-fix materials for long term applications.

Lessons learned

3. Use Cooperation, Teamwork and Flexibility.

Lessons learned

4. Always, always, always...

Lessons learned

4. Always, always, always...

**Listen to your Materials
People!!!**

Thanks For Your Attention



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