Silica-Fume HPC use in I-10 Twin-Span Bridges, Louisiana

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Elkem Materials Inc / Silica Fume Assn.
Sept, 26, 2011

Western Bridge Engineers' Seminar

think harder. concrete™


Expedia
bing
I-10 Twin Spans
LOUISIANA
MISSISSIPPI
PEARL RIVER
Picayune
Hammond
Abita Springs
Covington
Ponchatoula
Madisonville
TANGIPAHOA
ST. TAMMANY
Mandeville
Pearl River
Lacombe
Slidell
Kiln
Diamondhead
HANCOCK
HARRISON
Waveland
Pass Christian
Bay St. Louis
Pearlington
Lake Maurepas
Lake Pontchartrain
Lake Pontchartrain Causeway
Lake St. Catherine
Blind Lagoon
Lake Borgne
ST. JOHN THE BAPTIST
LaPlace
Norco
Kenner
River Ridge
Metairie
ORLEANS
New Orleans
Chalmette
Hahnville
Boutte
Luling
Bridge City
Marrero
Violet
ST. CHARLES
JEFFERSON
Estelle
Belle Chasse
Big Mar
Lake Lery
ST. BERNARD
Des Allemands
Raceland
Mathews
LAFOURCHE
Lake Salvador
PLAQUEMINES
Gulf of Mexico
Mississippi
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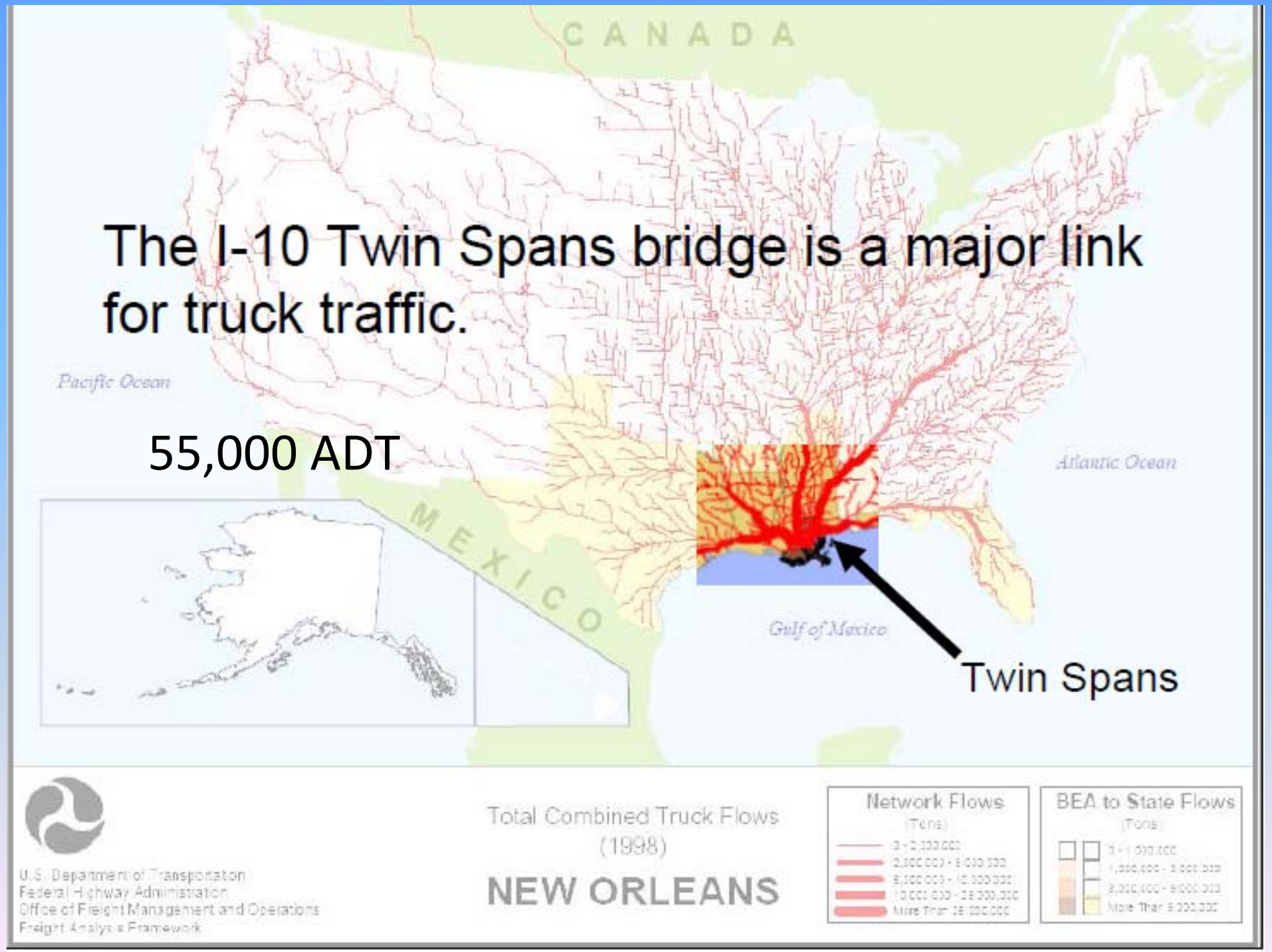
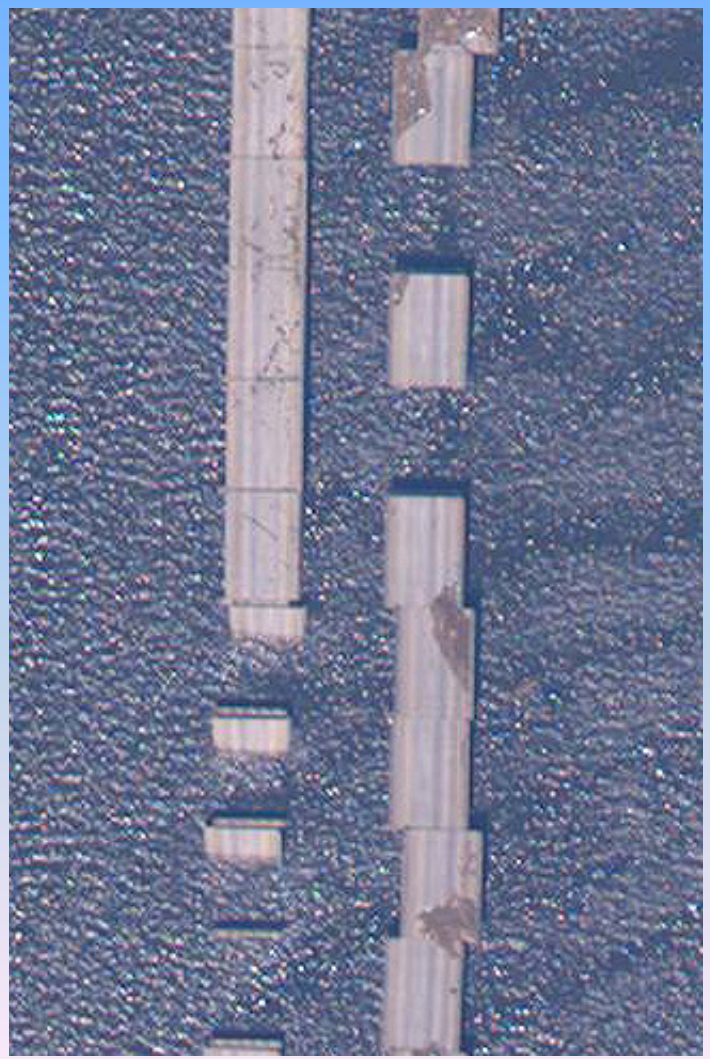
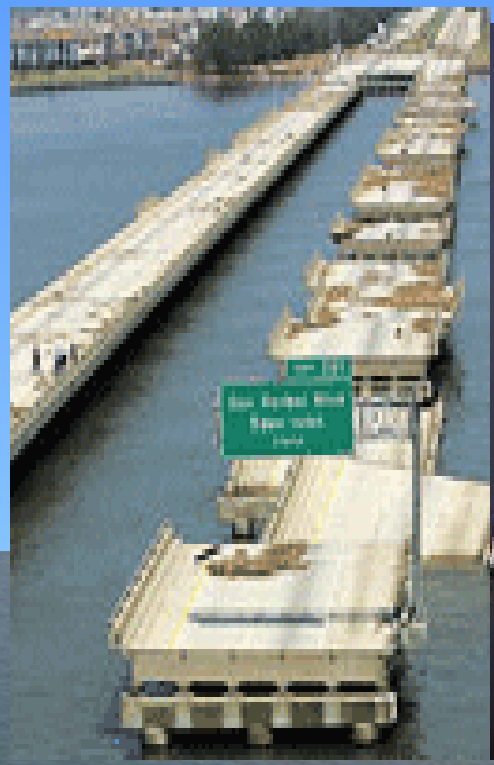
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
Gulf of Mexico
U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework
Total Combined Truck Flows
(1998)
NEW ORLEANS
Network Flows
(Tons)
0 - 2,000,000
2,000,000 - 5,000,000
5,000,000 - 10,000,000
10,000,000 - 25,000,000
More Than 25,000,000
BEA to State Flows
(Tons)
0 - 1,000,000
1,000,000 - 3,000,000
3,000,000 - 9,000,000
More Than 9,000,000


The I-10 Twin Spans bridge is a major link for truck traffic.
55,000 ADT
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
Gulf of Mexico
Twin Spans
U.S. Department of Transportation
Federal Highway Administration
Office of Freight Management and Operations
Freight Analysis Framework
Total Combined Truck Flows
(1998)
NEW ORLEANS
Network Flows
(Tons)
BEA to State Flows
(Tons)

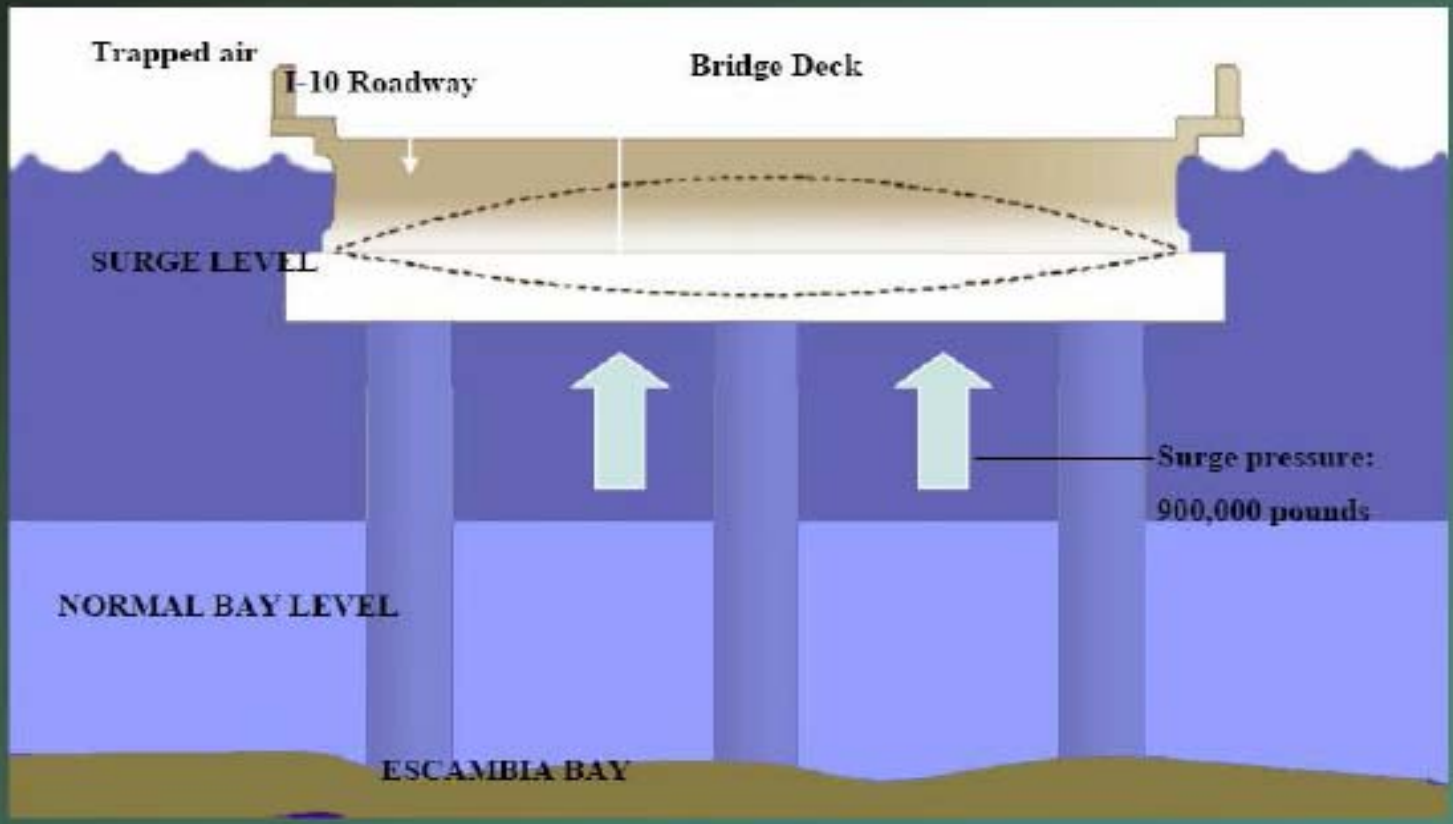
Katrina damage.

Aug 29, 2005





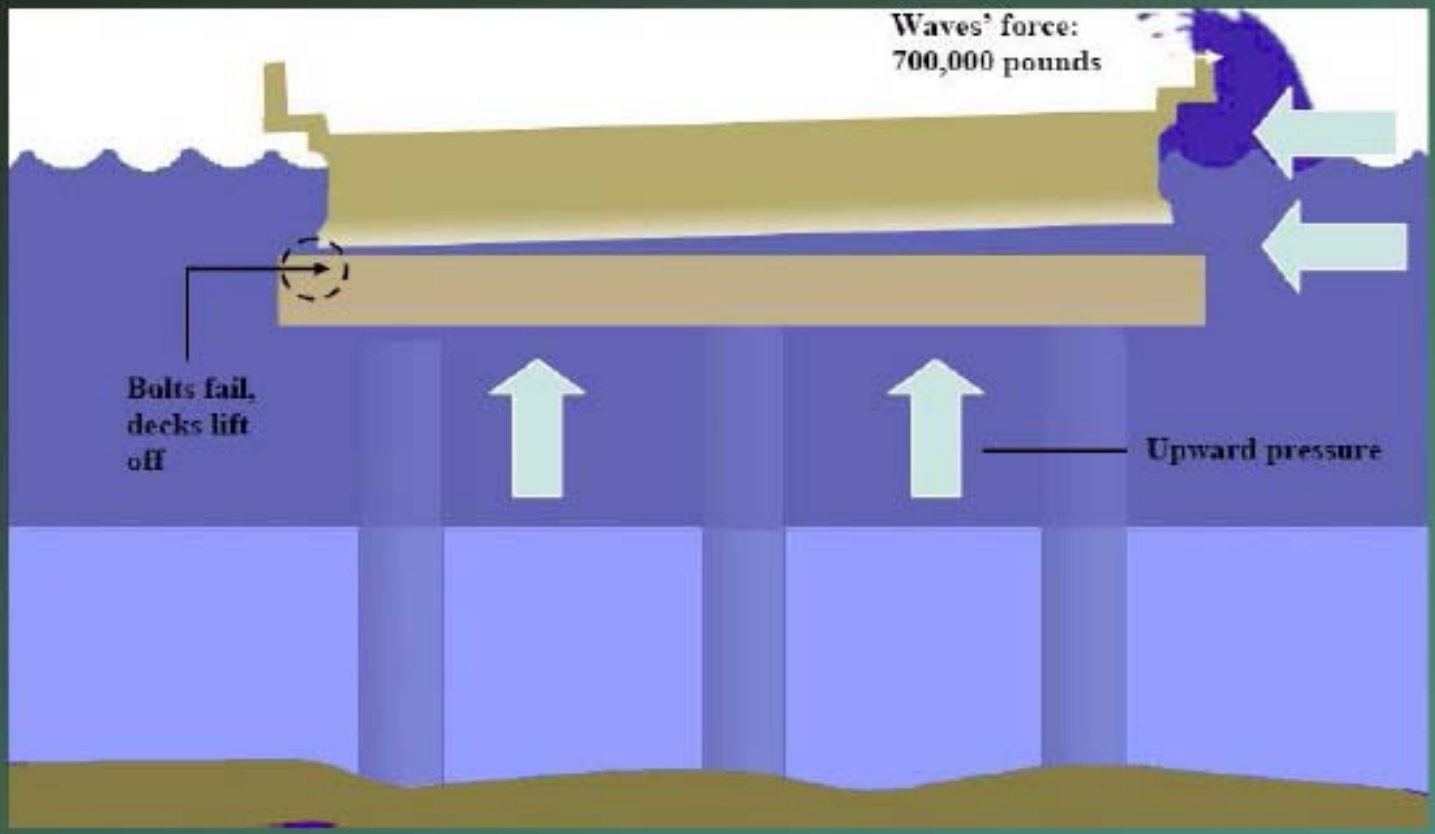
Water Hammer



1. The Lifting

   Storm surge rose to 14 to 16 feet above sea level beneath the bridge decks, where beams captured air beneath them, increasing the upward force to 900,000 pounds.

Water Hammer



2. The Pounding

At the same time, waves of 13 feet atop the surge hit the sides of the bridge decks with 700,000 pounds of force every 6.5 seconds at the height of the storm.

Reopened Oct. 14, 2006

OPENING CEREMONY
JANUARY 5,2006
BRAND NEW ACROW BRIDGE

Aug. 2006 (one yr. to the day), Phase II begins.

- $803M replacement bridge project.
- Twin bridges, 3-traffic lanes, 5.4mi (8.7km) each, w/ 2-12ft shoulders on each bridge. *(Largest in NA!)*
- Vert. clearance; 30ft and 80ft at the bascule bridge section.
- Designed to be a major evacuation route out of New Orleans, and *hurricane-proof*.
- Entire structure is HPC designed for a *100-yr service life.*

The players.

- Louisiana Department of Transportation and Development. (LADOTD)
- Boh Brothers and Traylor, Kiewit and Massman (TKM)
- Gulf Coast Pre-stressed, Prestress Services Industries, and Boykin Brothers.
- Lafarge Concrete.

How big?

433,500-ft. (+82mi, 136km) of 36-in. sq. precast displacement piles. 496 pile caps, and 32 concrete piers.

Precast girders

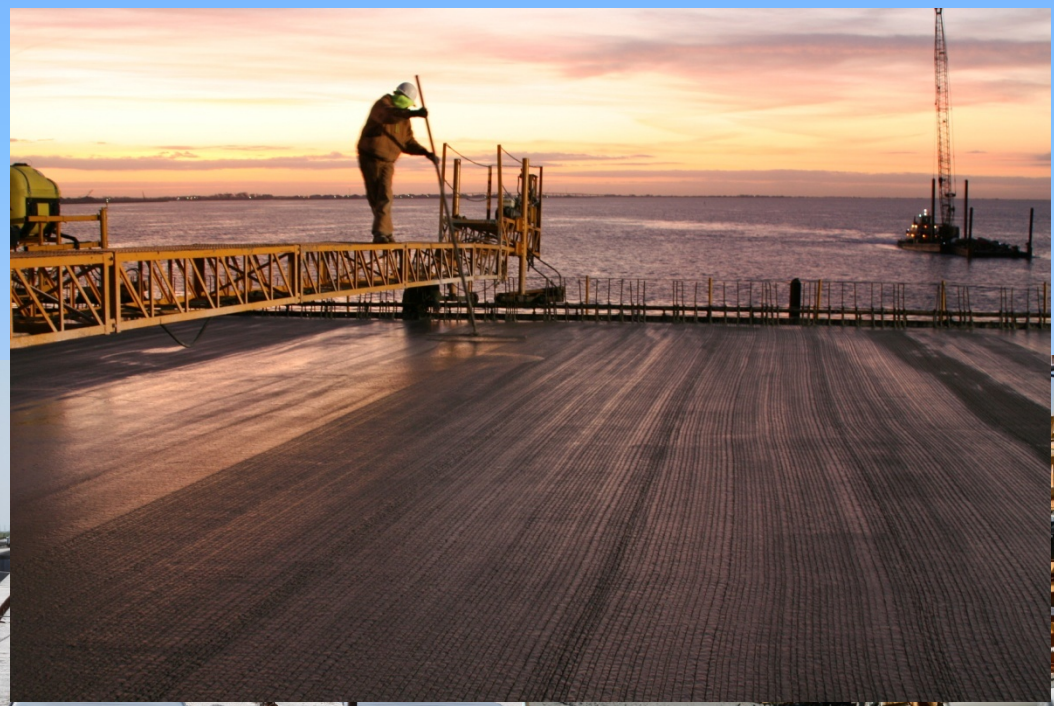
29,500-ft (5.5mi, 9.1km) AASHTO Type III

317,500-ft (60mi, 100km) BT-78 (FL Bulb-tee), 135’ long, 78-in deep.

Cast-in-place HPC deck

3,770,000-sqft, (+180,000cy) HPC deck on SIP forms.

Central mixed, trucked to site and pumped to placement.



HPC Specifications

Bridge Component	Compressive Strength at 28 days,[1] psi	Minimum Cementitious Materials, lb/yd^3	Maximum Water-Cementitious Materials Ratio	Slump, in.
Deck	4400	600	0.40	2 to 4[2]
Girders	8500	700	0.35	2 to 10
Substructure	4400	550	0.40	2 to 4[2]
Piles	6000	700	0.35	3 to 5[2]

All concrete was required to have a total air content of 5±1% and a maximum permeability of 1000 coulombs at 28 days.

1. Or at 56 days, per the project specification.
2. For mixes containing a water-reducing admixture, the slump could not exceed 8.5 in.

	Precast HPC	Deck HPC
Cement, pcy	600	310
Fly ash F	170	---
GGBFS	---	310
Silica Fume	80	30
Water	258	234
w/cm	0.30	0.36
Air,%	5	5
Slump, in	8	6
Avg. 28d	10k	7100
Coulombs	<1000	<1000

Bridge Component	Average Compressive Strength, psi	Average Permeability, coulombs
Deck	7100	350
Girders	9000-10,000[1]	240
Substructure	6900	230
Piles	8000-9000[1]	260

1. At 14 days.

Life-365 v2.0

Navigator
- Open new project
- Open existing project...

Settings
- Help for this window...
- Set default values...
- About Life-365...

Tips

Free!

www.life-365.org

Life-365™

Life-365 Service Life Prediction Model™

for Reinforced Concrete Exposed to Chlorides

Version 2.0

CONCRETE CORROSION INHIBITORS ASSOCIATION

NRMCA NATIONAL READY MIXED CONCRETE ASSOCIATION

SCA SLAG CEMENT ASSOCIATION

SFA SILICA FUME ASSOCIATION

Current Analysis | Default Settings and Parameters | Online Help

Start

Life-365 v2.0.1_RC4 I-10.life (changed) - I-10 Twin Span

Project Settings

Current Project
Save project
Save project as...
Export project data...
Close project

Steps
Define project...
Define alternatives...
Define exposure...
Define mix designs...
Compute service life...
Define project costs...
Compute life-cycle cost...

Settings
Help for this window...
Set default values...
About Life-365...

Tips

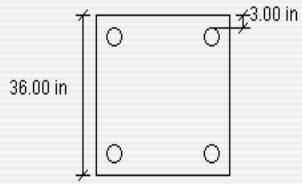
Project | Exposure | Concrete Mixtures | Individual Costs | Life-Cycle Cost | SL Report | LCC Report

Identify Project

Title: I-10 Twin Span
Analyst: tk
Description: Piles
Date: 01/11/2010

Select Structure Type and Dimensions

Type of structure: square column/beams (2-D)
Width (in): 36.0
Reinf. depth (in): 3.0
Total length (ft): 180
--> Volume of concrete: 60.0 cub. yd
Chloride concentration units: % wt. conc.



Define Economic Parameters

Base year: 2005
Analysis period (yrs): 100
Inflation rate (%): 1.60%
Real discount rate (%): 3.00%

Define Alternatives (up to 6)

Add a new alt | Delete currently selected alt

Name (double-click to edit)	Description (double-click to edit)
HPC	Fly ash and silica fume
Conventional	w/cm 0.42

Current Analysis | Default Settings and Parameters | Online Help

Life-365 v2.0.1_RC4 I-10.life - I-10 Twin Span

Project Settings

Current Project
Save project
Save project as...
Export project data...
Close project

Steps
Define project...
Define alternatives...
Define exposure...
Define mix designs...
Compute service life...
Define project costs...
Compute life-cycle cost...

Settings
Help for this window...
Set default values...
About Life-365...

Tips
In the Initation panel, the left graph shows the concentration of chlorides (on the vertical axis) at each depth of the structure, at the time of initiation.

The right graph shows the level of chlorides at the reinforcing steel (on the vertical axis) at each point in time up to the time of initiation. Each line will stop at the point in time of initiation, and reach a concentration level equal to the 'Ct' shown in the table above.

Project | Exposure | Concrete Mixtures | Individual Costs | Life-Cycle Cost | SL Report | LCC Report

Calculate service life | Compute uncertainty | Settings... | Help

Define Concrete Mixtures (select a mix to edit its properties)

Name	User Defined	D28 (in*in/sec)	m	Ct (% wt. conc.)	Init. (yrs)	Prop. (yrs)	Service Life (yrs) = Init + Prop
HPC	no	2.4950E-9	0.40	0.050	94.8	6.0	100.8
Conventional	no	1.3751E-8	0.20	0.050	7.8	6.0	13.8

Selected mix: HPC (Fly ash and silica fume)

Mix
w/cm: 0.35
Slag (%): 0.00%
Class F fly ash (%): 25.00%
Silica fume (%): 8.00%

Rebar
Rebar steel type: Black Steel
Rebar % vol. concrete: 1.20%

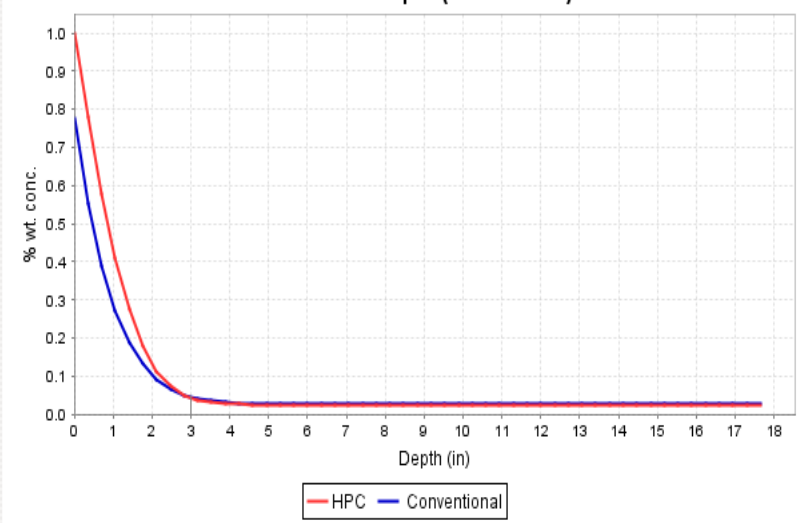
Inhibitor
<none>

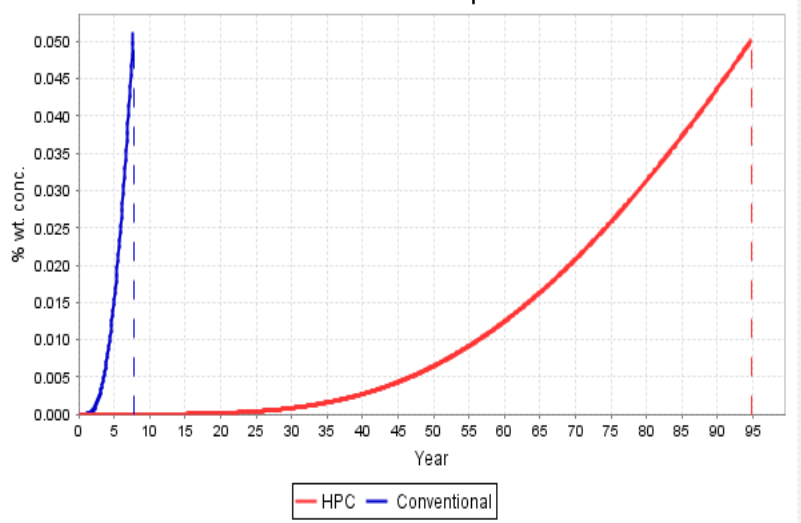
Barriers
<none>

Custom | D28 (in*in/sec): 2.4950E-9 | m: 0.4 | Hydration (yrs): 25.0 | Ct (% wt. conc.): 0.05 | Prop. (yrs): 6.0

Service Life Graphs

Service Life | Cross-section | Initiation | Conc Characteristics | Init Prob. | Init Variation





Current Analysis | Default Settings and Parameters | Online Help

Start | Google | MSN.com - Wi... | Western termi... | Tony Kojundic... | Calif_Transloa... | EQMS | 2010 | Life-365 v2.... | Microsoft Pow... | 10:47 AM

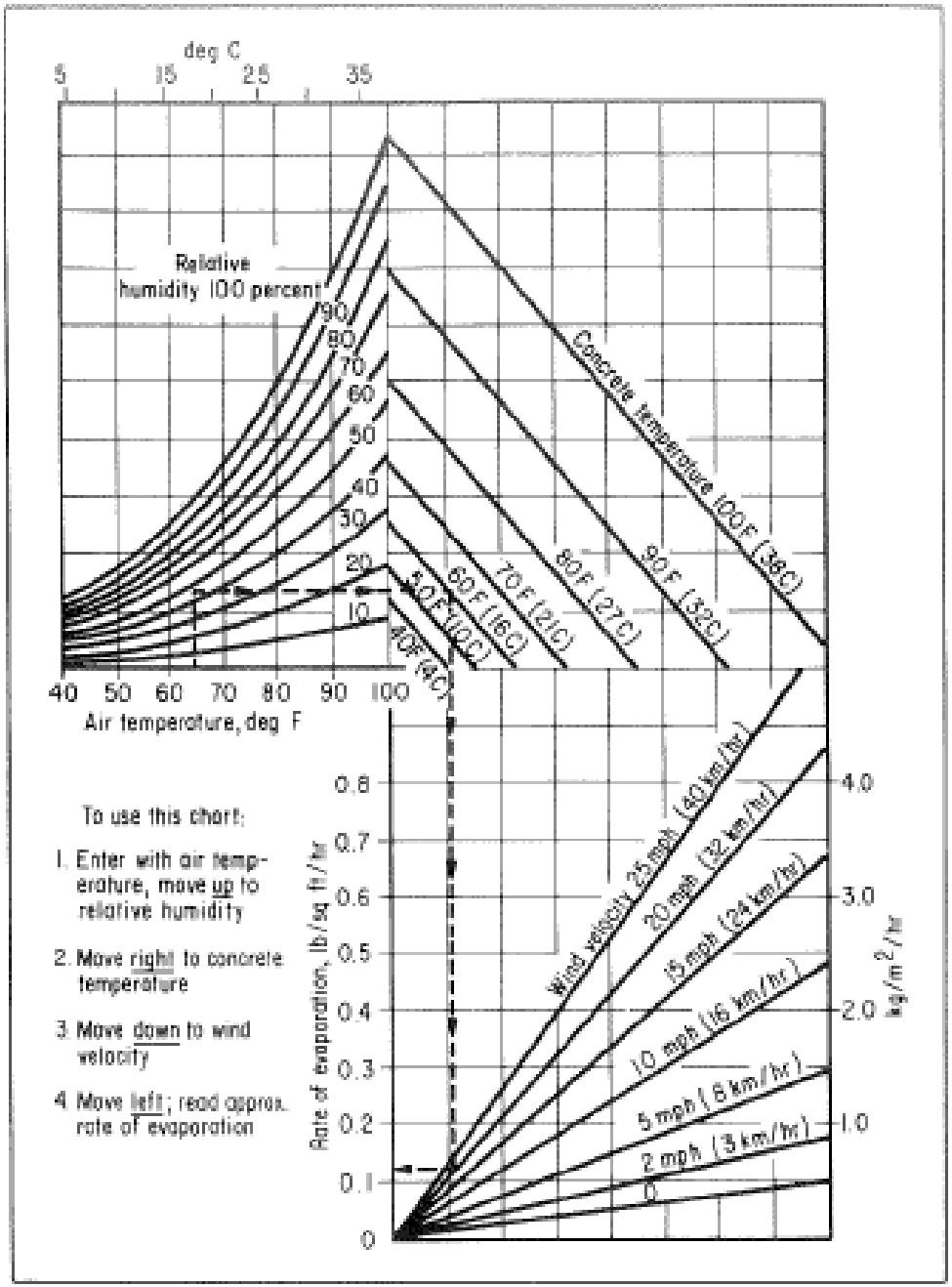
Hurricane proof - Anchored girders below design wave elevation.

HPC deck placement, finish, and cure.

Reduce hand-finish, Cure applied <20min after tine.

Fogging not always needed.
Curing is - always.

How to predict evaporation rate / cracking?


deg C
5
15
25
35
Relative humidity 100 percent
90
80
70
60
50
40
30
20
10
Concrete temperature 100 F (38C)
90 F (32C)
80 F (27C)
70 F (21C)
60 F (16C)
50 F (10C)
40 F (4C)
40 50 60 70 80 90 100
Air temperature, deg F
To use this chart:
1. Enter with air temperature, move up to relative humidity
2. Move right to concrete temperature
3. Move down to wind velocity
4. Move left; read approx. rate of evaporation
Rate of evaporation, lb/sq ft/hr
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Wind velocity 25 mph (40 km/hr)
20 mph (32 km/hr)
15 mph (24 km/hr)
10 mph (16 km/hr)
5 mph (8 km/hr)
2 mph (3 km/hr)
0
1.0
2.0
3.0
4.0
kg/m²/hr


ZK0160

Hiperpav III - *Free!*

HIPERPAV
high performance paving software

I-10.hp3 - HIPERPAV III

File Edit View Strategy Comparison Tools Help

Project Info | Strategies | Comparisons

EA JPCP

PCC Mix

Strategy	Status
New Strategy 1	Modified

- Strategy Information
- Design
- Mix Design
- Construction
- Climate
- Analysis

Validation

Cement Type: Type I

Aggregate Type: Limestone

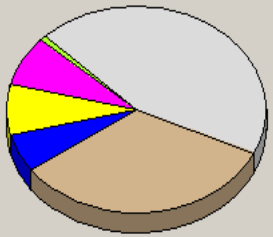
Admixtures (ASTM C494 Type): Type G - Water-reducing, high range, and retarding

Fly Ash Class: Class F (CaO <= 7%)

Batch Proportions

Content Unit: lb/yd³

Constituent	Mass
Coarse Aggregate	1750
Fine Aggregate	1300
Water	235
Cement (Type I)	310
Fly Ash	0
GGBF Slag	310
Silica Fume	30
Total	**3935**



Water to Cement Ratio is 0.76

Water to Cementitous Ratio is 0.36

PCC 28-Day Strength

Strength Type: Splitting Tensile

28-Day Strength: 520 psi

I-10.hp3 - HIPERPAV III

File Edit View Strategy Comparison Tools Help

Project Info | Strategies | Comparisons

EA JPCP

Early-Age Construction

Strategy	Status
New Strategy 1	Modified

- Strategy Information
- Design
- Mix Design
- Construction
- Climate
- Analysis

Validation

Initial Conditions

Initial PCC Mix Temperature: 65 °F

Initial Support Layer Temperature: 60 °F

(•) Base is moist

( ) Base is dry

Curing Method

Curing Method: Double Coat Liquid Curing Compound

Age Curing Applied: 0.5 hours

Age Curing Removed: 72 hours

Sawcutting (Skipping sawcutting is not recommended)

( ) Saw at Optimum Time (Early-Entry "Green" Sawcutting)

( ) User-Defined Sawing Age 7 hours

(•) No Sawing

[ ] Skip Sawcutting every: 2nd joint

Sawing Age of Skipped Joints: 24 hours

Strength for Opening to Traffic

[ ] Display strength for opening to traffic?

Strength: 350 psi

Strength Type: Splitting Tensile

I-10.hp3 - HIPERPAV III

File Edit View Strategy Comparison Tools Help

Project Info | Strategies | Comparisons

EA JPCP

Environment

Strategy	Status
New Strategy 1	Modified

- Strategy Information
- Design
- Mix Design
- Construction
- Climate
- Analysis

Validation

Data to display: Temperature

Construction Date: 8 /14/2007

Construction Time: 1 AM

Prompt to update hourly data

Display Tools

Unit: °F

Elapsed Time

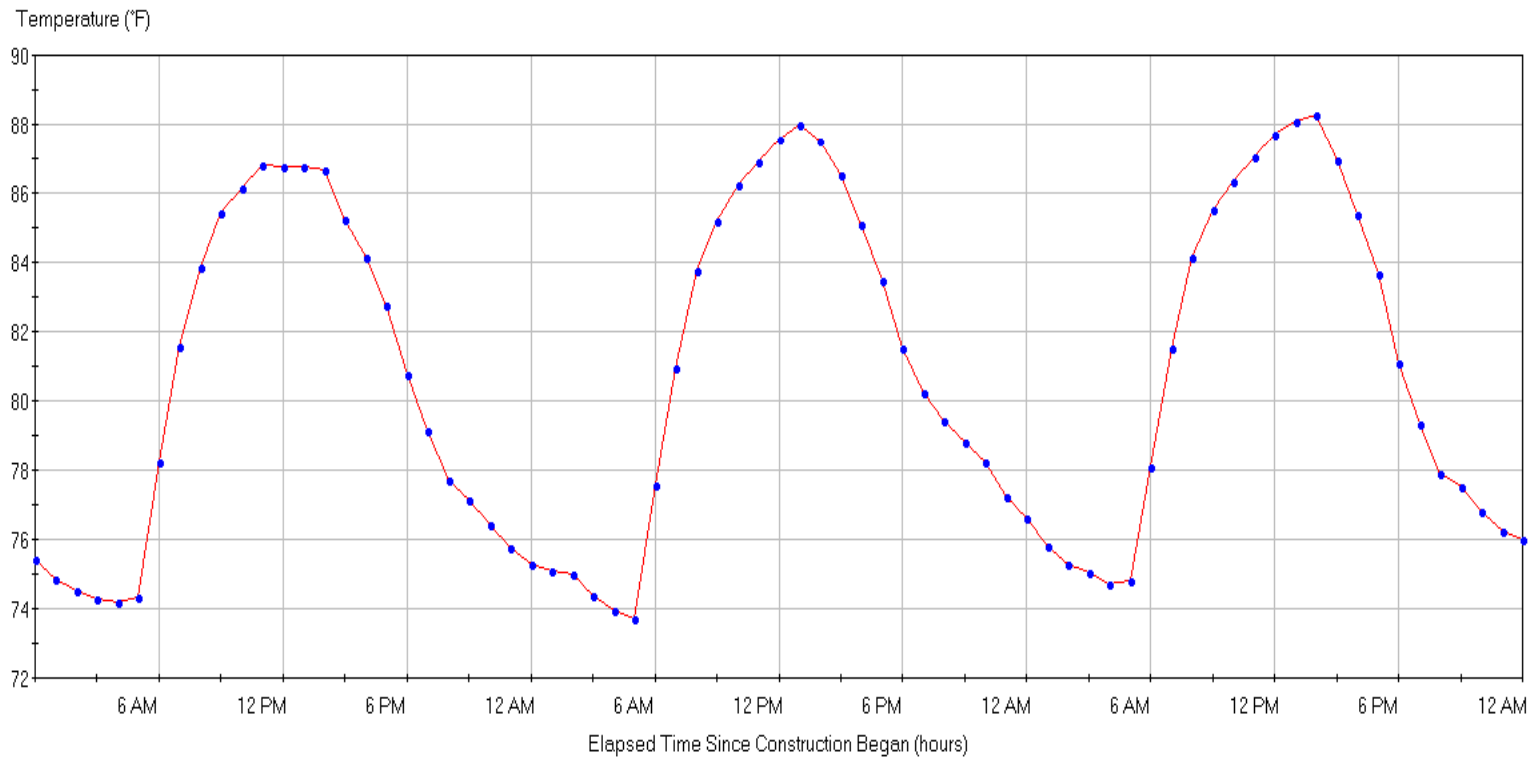
Time of Day

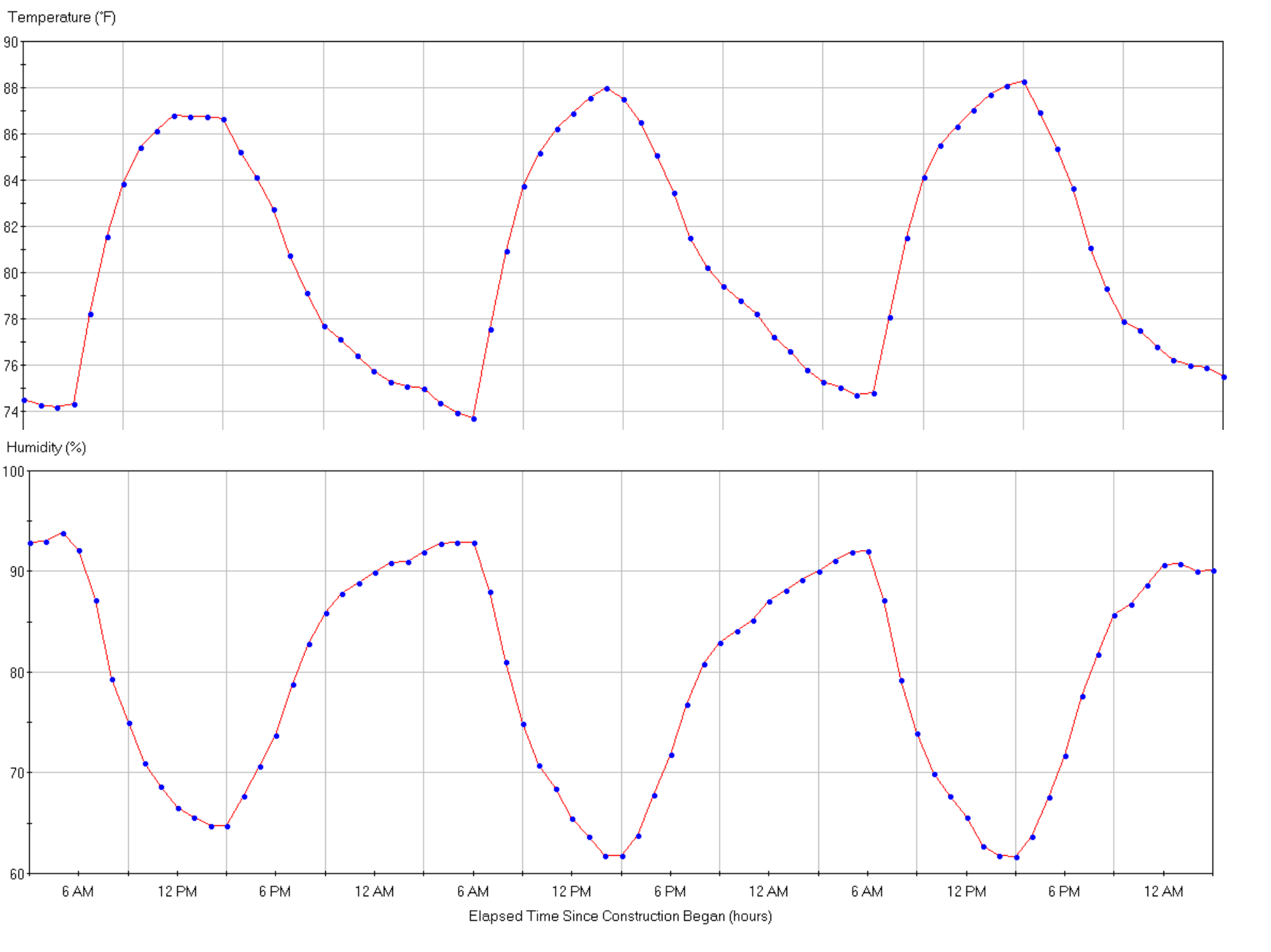
Autoscale

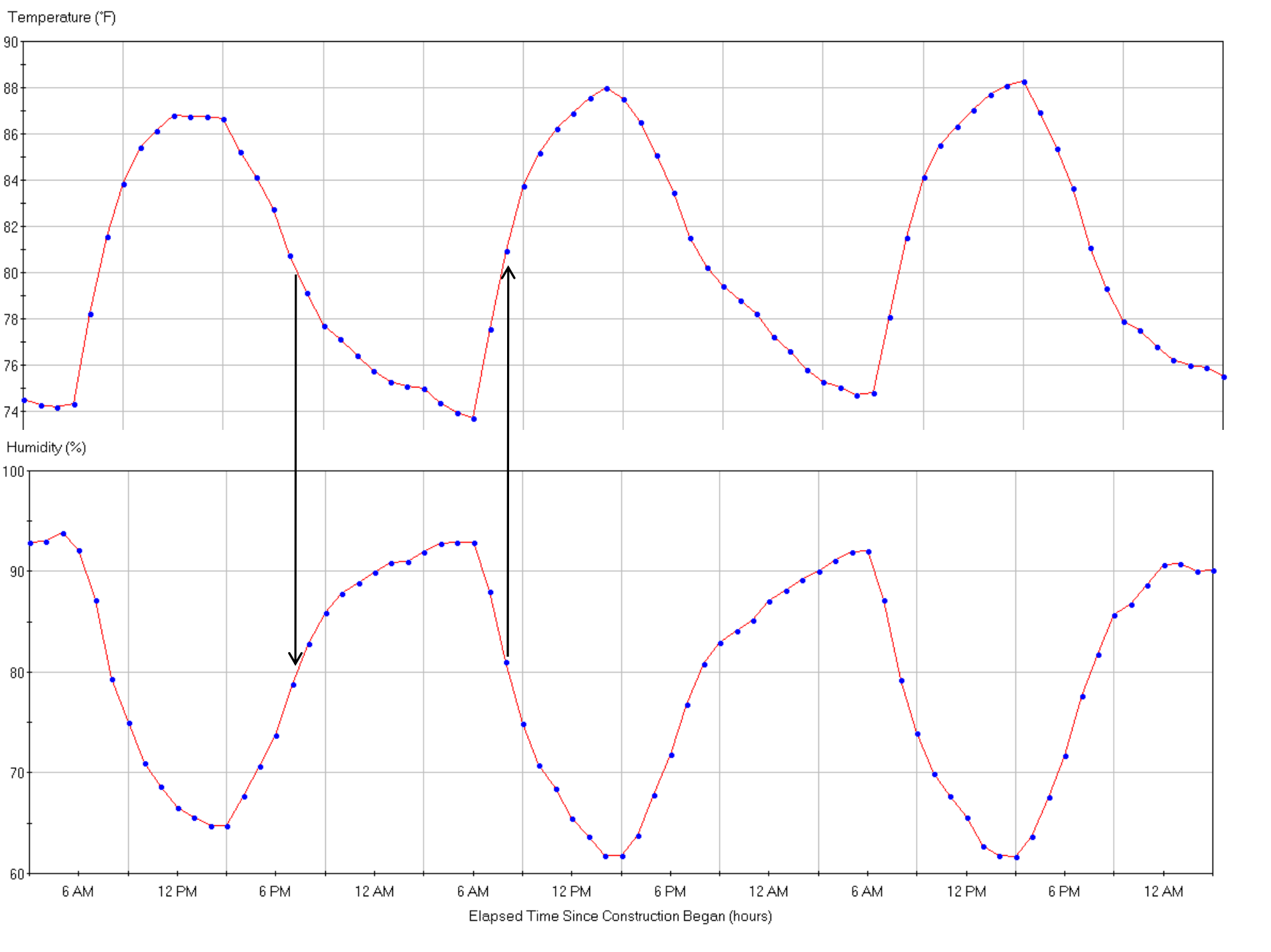
Hour	Time	Temp (°F)
0	1 AM	75.4
1	2 AM	74.8
2	3 AM	74.5
3	4 AM	74.3
4	5 AM	74.2
5	6 AM	74.3

Weather Data Tools

Estimate | Estimate All | Point | High-Low | Cold Front




Temperature (°F)
90
88
86
84
82
80
78
76
74
Humidity (%)
100
90
80
70
60
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
Elapsed Time Since Construction Began (hours)


Temperature (°F)
90
88
86
84
82
80
78
76
74
Humidity (%)
100
90
80
70
60
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
Elapsed Time Since Construction Began (hours)

I-10.hp3 * - HIPERPAV III

File Edit View Strategy Comparison Tools Help

Project Info | Strategies | Comparisons

EA JPCP

Analysis: Early-Age JPCP

Strategy	Status
New Strategy 1	Analyzed

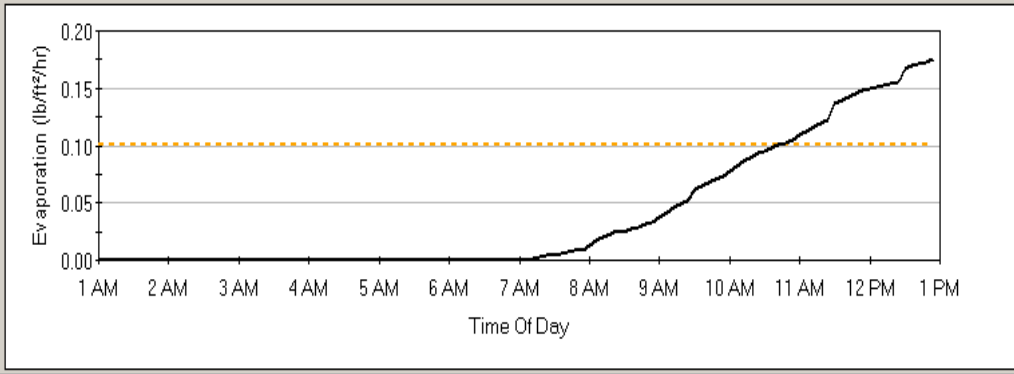
- Strategy Information
- Design
- Mix Design
- Construction
- Climate
- **Analysis**

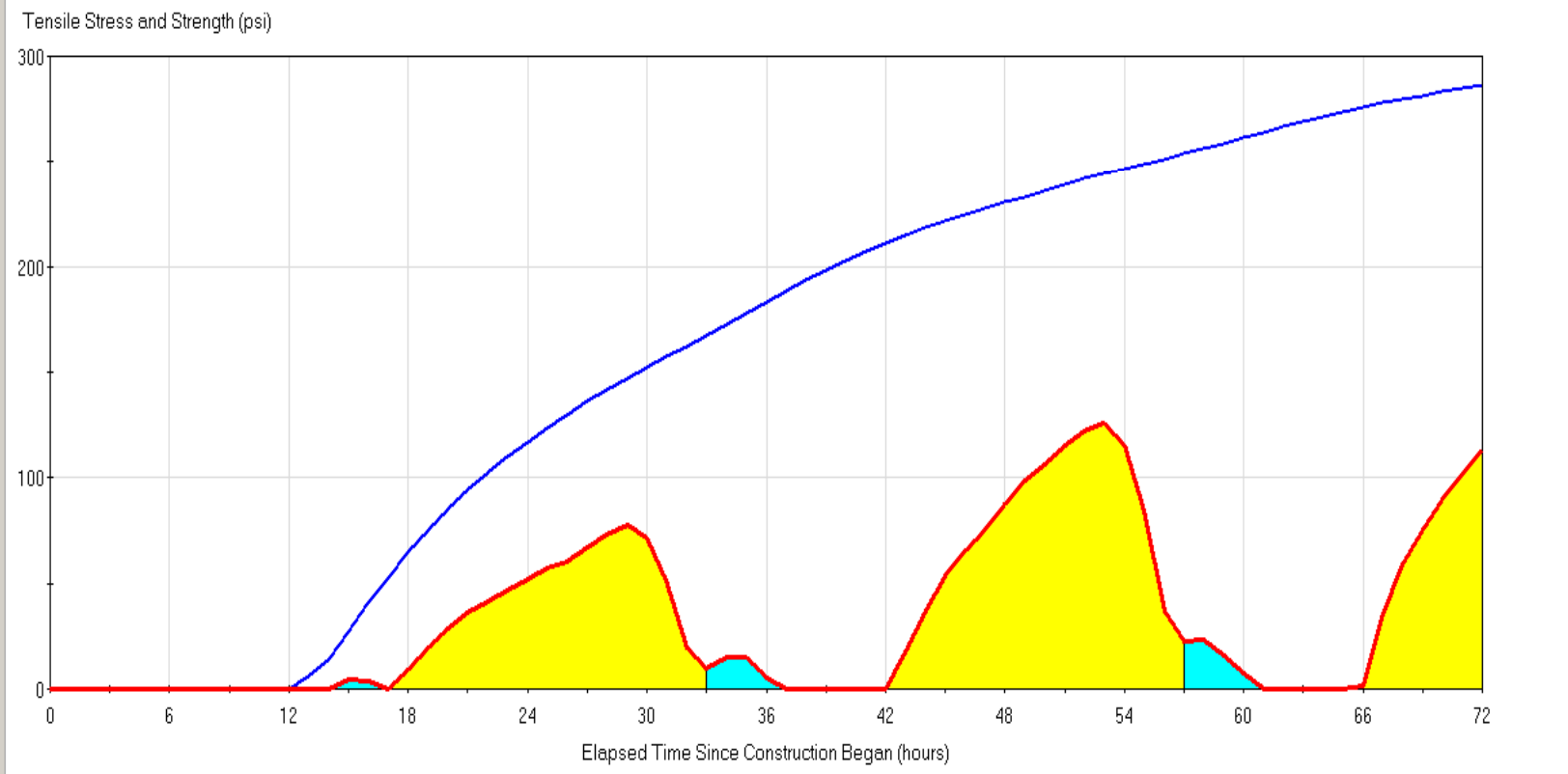
Validated - 10:27:32 AM

Geometry - Slab Width

Geometry - Transverse Joint Spacing

Elapsed Hours	Time of Day	PCC Strength (psi)	Critical Stress (psi)
0	1 AM	0.0	0.0
1	2 AM	0.0	0.0
2	3 AM	0.0	0.0
3	4 AM	0.0	0.0
4	5 AM	0.0	0.0
5	6 AM	0.0	0.0
6	7 AM	0.0	0.0
7	8 AM	0.0	0.0
8	9 AM	0.0	0.0
9	10 AM	0.0	0.0
10	11 AM	0.0	0.0
11	12 PM	0.0	0.0
12	1 PM	0.0	0.0






Expedite placing, finishing, texturing
and use immediate curing

New I-10 Twin Span

Eastbound – July 9, ‘09.

Wesbound – April 7, ’10.

Total length +10.5-miles - Longest HPC bridge in North America.

Save Our Forests Build with Concrete
www.clmasu.org

SFA
SILICA FUME ASSOCIATION

Thank you.

Questions?

Western Bridge Engineers' Seminar

think harder. concrete™