HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

NATIONAL HIGH PERFORMANCE CONCRETE FOLLOW UP SURVEY RESULTS

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HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

Outline

- HPC Introduction
- 2006 National HPC Survey
  - Alternative Reinforcement
  - Self-Consolidating Concrete
  - Lightweight HPC
- Conclusion

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2006-07 FOLLOW-UP SURVEY RESULTS

Introduction

Cost of Corrosion-“Deficient Bridges”

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Introduction – Cost of Substructure Corrosion

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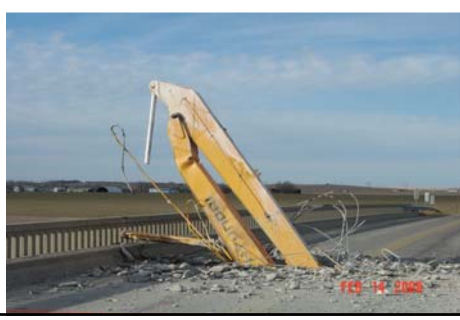
Introduction – Accident Damage



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2006-07 FOLLOW-UP SURVEY RESULTS

Introduction – Act of God Damage

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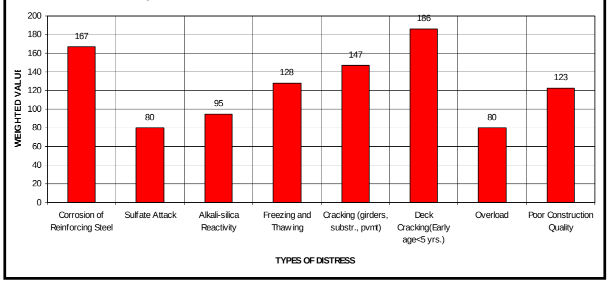
2006-07 FOLLOW-UP SURVEY RESULTS

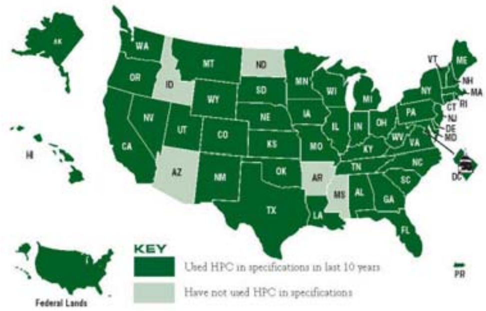
HPC TEAM Meeting - MAY 2004
NATIONWIDE HPC SURVEY (2003) RESULTS

Slide 14

QUESTION 3 - WEIGHTED VALUE SUMMARY FOR TYPES OF DISTRESS EXPERIENCED



HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS



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HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

PURPOSE

- Quantify the number and application of high performance concrete (HPC) projects across the nation,
- Obtain information on the use of high performance reinforcement.
- Follow-up to earlier HPC Survey 2003

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2006-07 FOLLOW-UP SURVEY RESULTS

QUESTIONNAIRE

- Prepared by a task force of the FHWA High Performance Concrete Technology Delivery Team
- Members of task force include
  - State DOT
  - Industry
  - FHWA

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2006-07 FOLLOW-UP SURVEY RESULTS

SURVEY DISTRIBUTION

- Survey sent to:
  - 50 States
  - Federal Lands Highway
  - Puerto Rico
  - District of Colombia (DC)

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2006-07 FOLLOW-UP SURVEY RESULTS

Survey Topics

- General Use of HPC
- HPC for Permeability Benefit
- HPC for Strength Benefit
- Self-Consolidating Concrete
- Lightweight HPC
- Alternative Reinforcement

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2006-07 FOLLOW-UP SURVEY RESULTS

Survey Topics (cont.)

- Alternative Reinforcement
  - Stainless Steel Reinforcement
  - Stainless Steel Clad Reinforcement
  - Epoxy Coated Reinforcement
  - Galvanized Reinforcement
  - MMFX Microcomposite (MMFX-2) Reinforcement
  - FRP Reinforcement
    - GFRP
    - CFRP
    - AFRP

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2006-07 FOLLOW-UP SURVEY RESULTS

Survey Topics (cont.)

- General Section
  - Primary characteristics of HPC tested
  - Method for specifying HPC
  - Number of projects planned and constructed
  - HPC Specification
  - Percentage of HPC used in the last 3 years (check)

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HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

State/Prov. --->	AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA	HI	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
General Use of HPC — For the structural elements listed below, select the range which best reflects the number of HPC *constructed bridges where fly ash, slag, silica fume, or other mineral admixtures are being/have been used for increased durability, but without permeability																										
Structural Element — Number of Bridges -- [LEGEND: 0 = NONE, 1 = 1-10, 2 = 11-20, 3 = 21-30, 4 = 31-50, 5 = >50, 6 = No Answer]																										
Deck overlays	1	2	0	0	2	0	0	2	3	0	0	2	5	0	1	5	1	1	3	0	0	5	0	1	0	1
Deck	1	1	1	1	5	1	1	3	5	1	0	1	1	1	4	1	2	1	5	0	0	1	3	0	1	0
Superstructure	1	1	0	0	5	0	0	3	5	1	0	0	1	1	3	1	0	1	5	0	0	1	1	0	1	0
Substructure	1	0	0	0	5	0	0	3	5	1	0	0	0	0	4	0	0	1	5	0	0	1	1	3	0	0
HPC for Permeability Benefit — For the structural elements listed below, select the range of coulomb values which best reflects the project specified permeability the majority of the time.																										
Structural Element — Coulomb Values -- [LEGEND: 1 = 0-1000, 2 = 1001-2000, 3 = 2001-3000, 4 = 3001-4000, 5 = >4001, 6 = Not Specified/No Answer]																										
Deck overlays	6	1	6	6	6	2	6	2	3	4	6	6	6	6	2	6	6	2	1	2	2	6	6	6	6	6
Deck	6	6	6	2	6	2	6	3	3	2	6	2	6	1	2	6	6	2	2	2	2	6	6	6	1	6
Superstructure	6	6	6	6	6	6	6	3	3	3	6	6	6	1	3	6	6	2	1	2	2	6	6	6	1	6
Substructure	6	6	6	6	6	6	6	3	1	2	6	6	6	6	3	6	6	2	2	2	2	6	6	6	6	6
HPC for Strength Benefit — For the structural elements listed below, select the compressive strengths which best reflects the project specified compressive strengths the majority of the time.																										
Structural Element — Compressive Strength (psi) -- [LEGEND: 1 = Less or Equal to 3000, 2 = 3001-4000, 3 = 4001-5000, 4 = 5001-6000, 5 = 6001-8000, 6 = >8000, 7 = No Answer]																										
Deck	4	5	5	2	2	3	3	3	4	5	3	2	3	4	3	3	3	2	3	3	3	3	3	4	2	3
Structural Element — Comp. Strength psi--[LEGEND: 1=Less or Equal to 3000, 2=3001-4000, 3=4001-5000, 4=5001-6000, 5=6001-8000, 6=8001-10,000 7=10,001-12,000, 8= > 12,001, 9=No Answer]																										
Superstructure	6	5	9	9	2	5	9	3	6	6	2	6	3	6	5	3	9	6	4	5	3	3	6	4	6	5
Structural Element — Compressive Strength (psi) -- [LEGEND: 1 = Less or Equal to 3000, 2 = 3001-4000, 3 = 4001-5000, 4 = 5001-6000, 5 = 6001-8000 6 = >8000, 7 = No Answer]																										
Substructure	4	7	7	7	2	5	7	3	3	3	2	7	3	7	3	3	7	3	3	2	2	3	3	4	7	1
Self-Consolidating Concrete — For the structural elements listed below, select the range which best reflects your State's use of self-consolidating concrete.																										
Structural Element — Number of Bridges -- [LEGEND: 0 = NONE, 1 = 1-10, 2 = 11-20, 3 = 21-30, 4 = 31-50, 5 = >50, 6 = No Answer]																										
Superstructure	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Substructure-Pier and Pier Caps	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Substructure - Footings	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Substructure - Piles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Substructure - Drilled Shafts	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Precast Members	0	0	0	0	0	1	0	0	1	0	0	0	1	0	3	1	0	0	2	0	2	0	1	0	0	0
Lightweight HPC — For the structural elements listed below, select the range which best reflects your State's use of lightweight HPC (110 to 125 pcf).																										
Structural Element — Number of Bridges -- [LEGEND: 0 = NONE, 1 = 1-10, 2 = 11-20, 3 = 21-30, 4 = 31-50, 5 = >50, 6 = No Answer]																										
Deck	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Superstructure	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substructure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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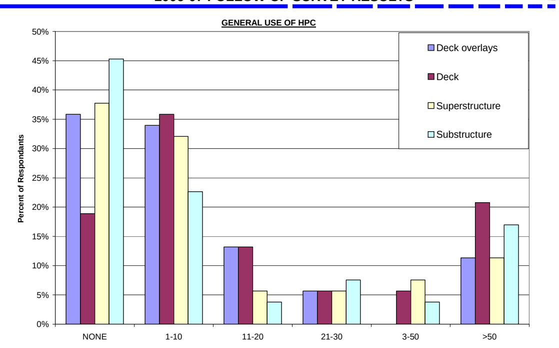
HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS



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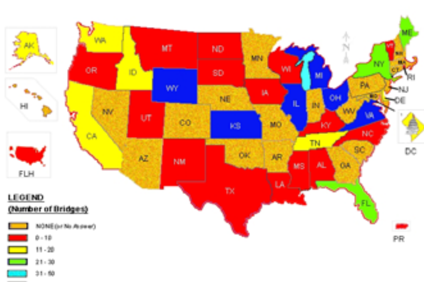
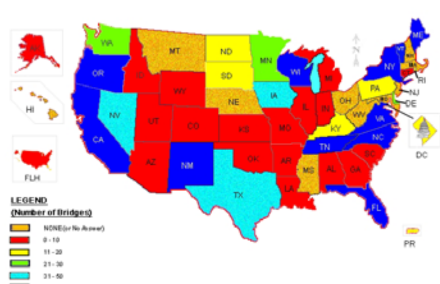
FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE

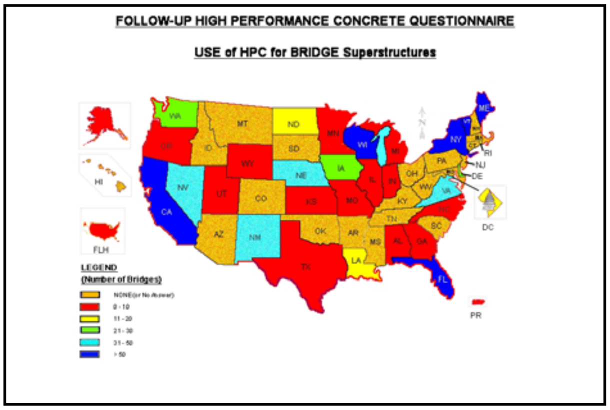
USE of HPC for Deck Overlays

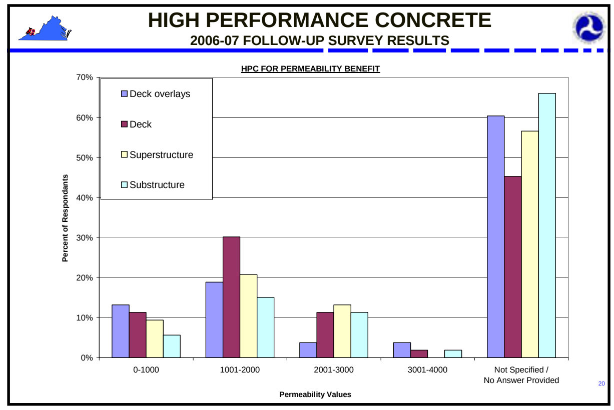


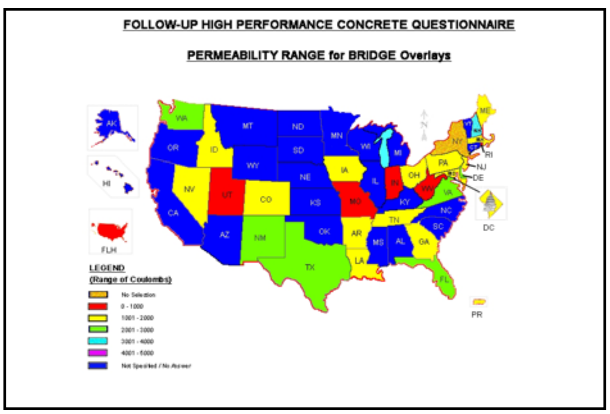
FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE

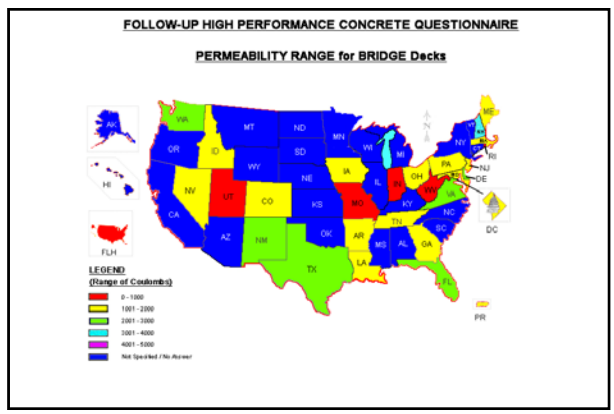
USE of HPC for BRIDGE Decks

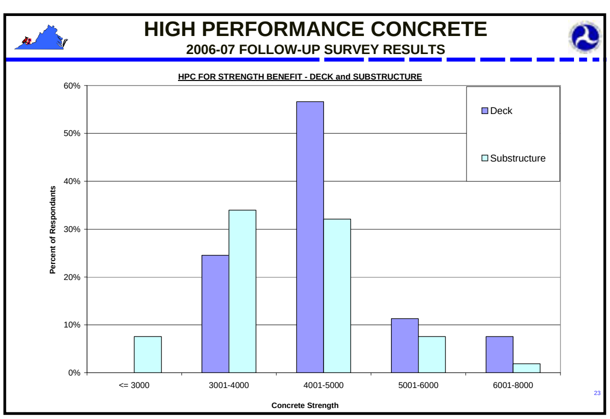


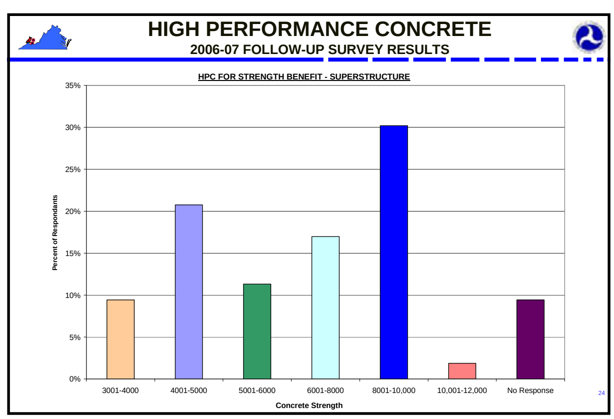

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE of HPC for BRIDGE Superstructures
LEGEND
(Number of Bridges)
NONE (or No Answer)
0 - 10
11 - 20
21 - 30
31 - 50
> 50

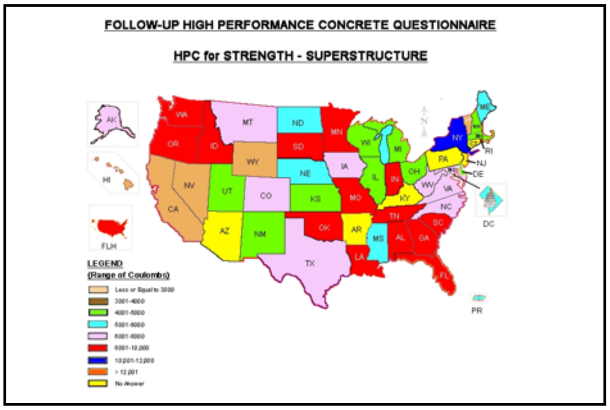

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
HPC FOR PERMEABILITY BENEFIT
Deck overlays
Deck
Superstructure
Substructure
Percent of Respondants
0-1000
1001-2000
2001-3000
3001-4000
Not Specified / No Answer Provided
Permeability Values

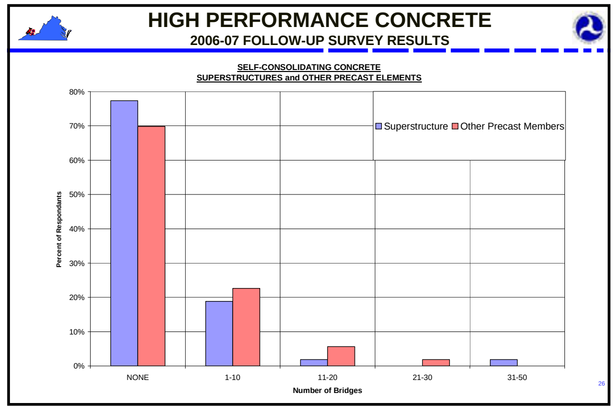

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
PERMEABILITY RANGE for BRIDGE Overlays
LEGEND
(Range of Coulombs)

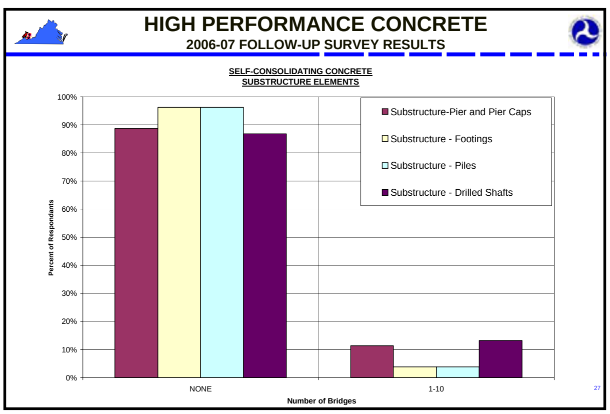

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
PERMEABILITY RANGE for BRIDGE Decks
LEGEND
(Range of Coulombs)

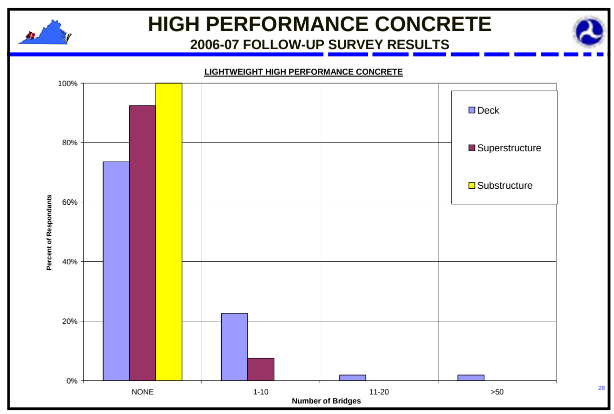

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
HPC FOR STRENGTH BENEFIT - DECK and SUBSTRUCTURE
Deck
Substructure
Percent of Respondants
<= 3000
3001-4000
4001-5000
5001-6000
6001-8000
Concrete Strength

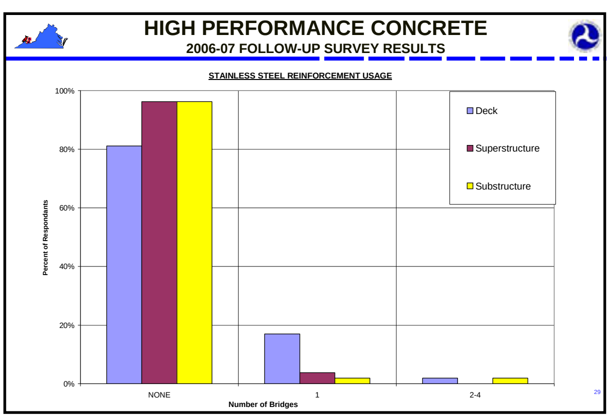

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
HPC FOR STRENGTH BENEFIT - SUPERSTRUCTURE
Percent of Respondants
3001-4000
4001-5000
5001-6000
6001-8000
8001-10,000
10,001-12,000
No Response
Concrete Strength

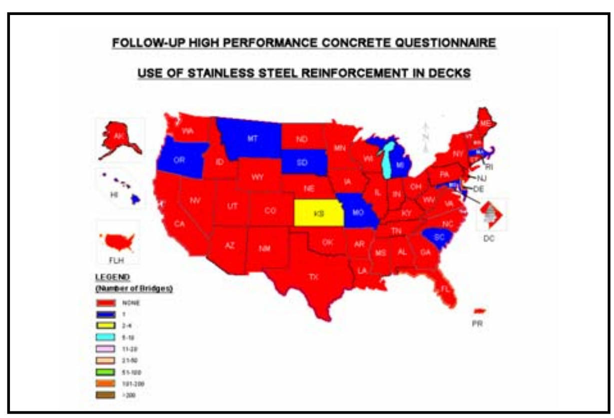

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
HPC for STRENGTH - SUPERSTRUCTURE
LEGEND
(Range of Coulombs)
FLH
DC
PR

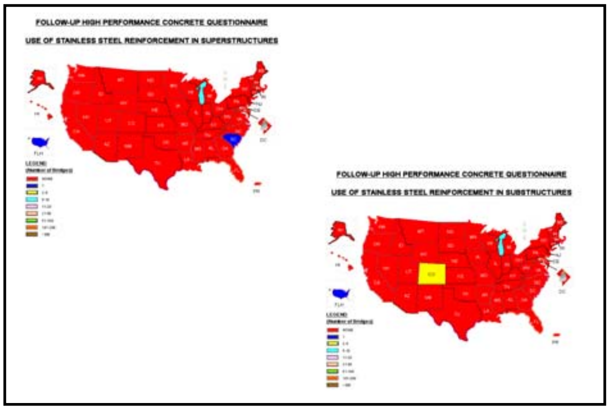

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
SELF-CONSOLIDATING CONCRETE
SUPERSTRUCTURES and OTHER PRECAST ELEMENTS
Superstructure
Other Precast Members
Percent of Respondants
Number of Bridges
NONE
1-10
11-20
21-30
31-50
0%
10%
20%
30%
40%
50%
60%
70%
80%
26

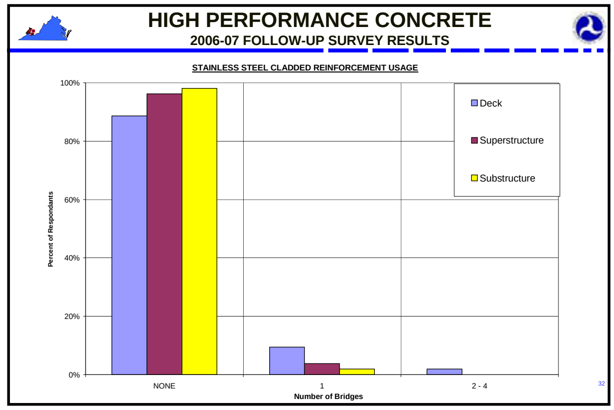

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
SELF-CONSOLIDATING CONCRETE
SUBSTRUCTURE ELEMENTS
Substructure-Pier and Pier Caps
Substructure - Footings
Substructure - Piles
Substructure - Drilled Shafts
Percent of Respondants
Number of Bridges
NONE
1-10
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
27

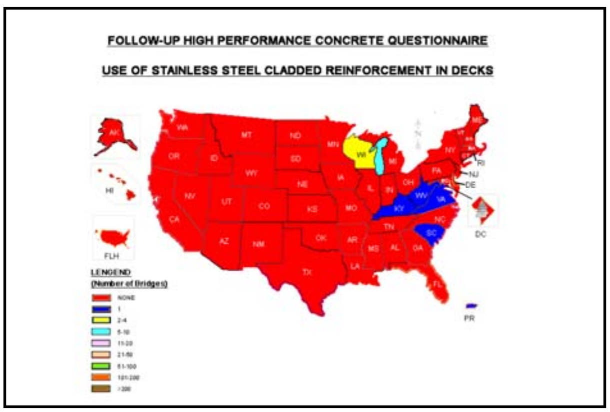

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
LIGHTWEIGHT HIGH PERFORMANCE CONCRETE
Deck
Superstructure
Substructure
Percent of Respondants
Number of Bridges
NONE
1-10
11-20
>50
0%
20%
40%
60%
80%
100%
28

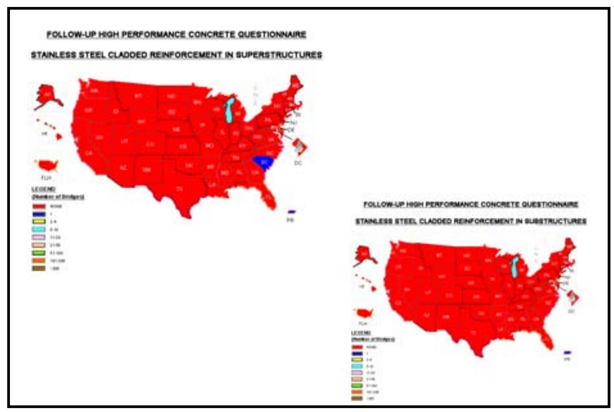

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
STAINLESS STEEL REINFORCEMENT USAGE
Deck
Superstructure
Substructure
Percent of Respondants
Number of Bridges
NONE
1
2-4
0%
20%
40%
60%
80%
100%
29

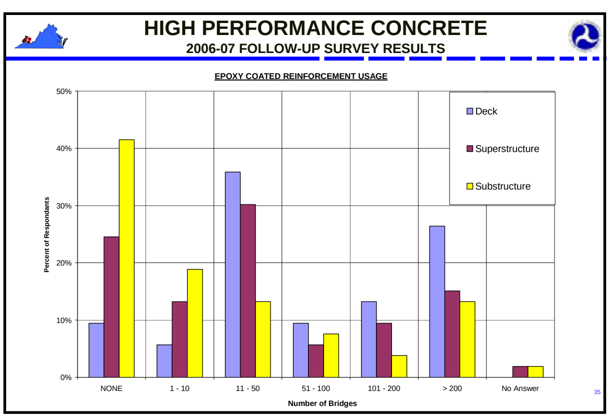

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE OF STAINLESS STEEL REINFORCEMENT IN DECKS
LEGEND
(Number of Bridges)
FLH
DC
PR

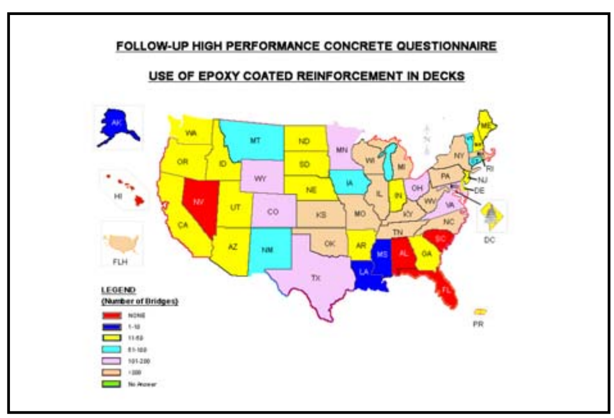

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE OF STAINLESS STEEL REINFORCEMENT IN SUPERSTRUCTURES
FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE OF STAINLESS STEEL REINFORCEMENT IN SUBSTRUCTURES

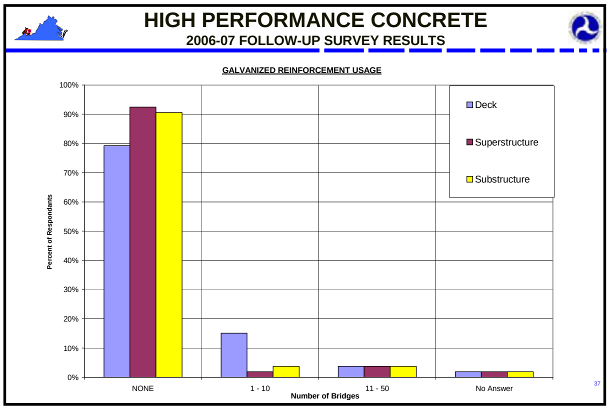

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
STAINLESS STEEL CLADDED REINFORCEMENT USAGE
100%
80%
60%
40%
20%
0%
Percent of Respondants
Deck
Superstructure
Substructure
NONE
1
2 - 4
Number of Bridges
32

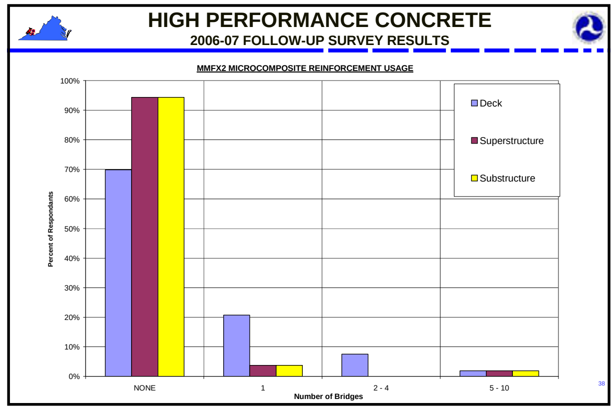

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE OF STAINLESS STEEL CLADDED REINFORCEMENT IN DECKS
HI
FLH
DC
PR
LENGEND
(Number of Bridges)
NONE
1
2-4
5-10
11-20
21-50
51-100
101-200
>200

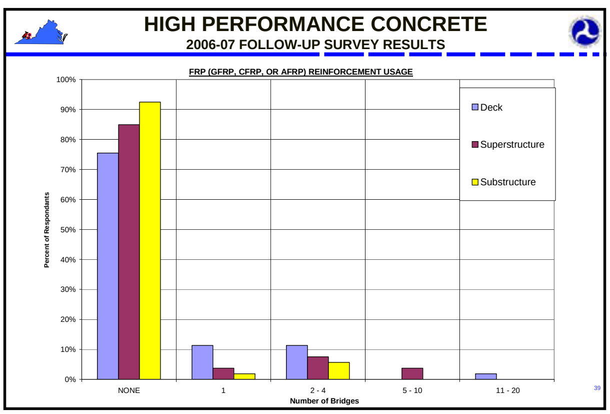

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
STAINLESS STEEL CLADDED REINFORCEMENT IN SUPERSTRUCTURES
FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
STAINLESS STEEL CLADDED REINFORCEMENT IN SUBSTRUCTURES

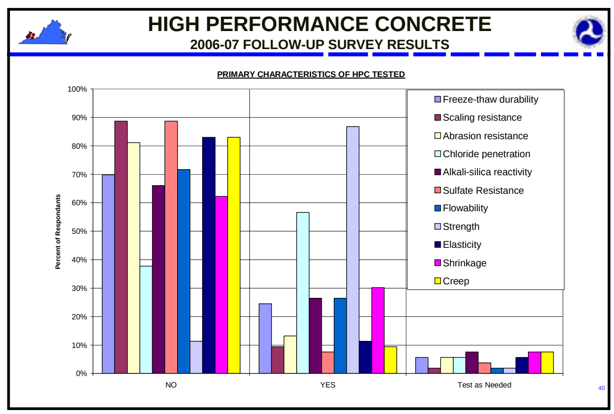

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
EPOXY COATED REINFORCEMENT USAGE
50%
40%
30%
20%
10%
0%
Percent of Respondants
Deck
Superstructure
Substructure
NONE
1 - 10
11 - 50
51 - 100
101 - 200
> 200
No Answer
Number of Bridges
35

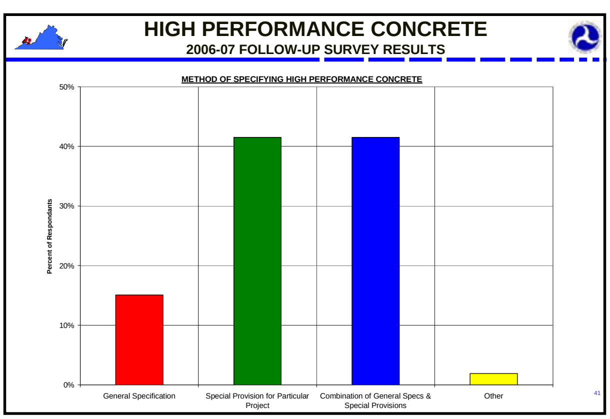

FOLLOW-UP HIGH PERFORMANCE CONCRETE QUESTIONNAIRE
USE OF EPOXY COATED REINFORCEMENT IN DECKS
HI
FLH
DC
PR
LEGEND
(Number of Bridges)

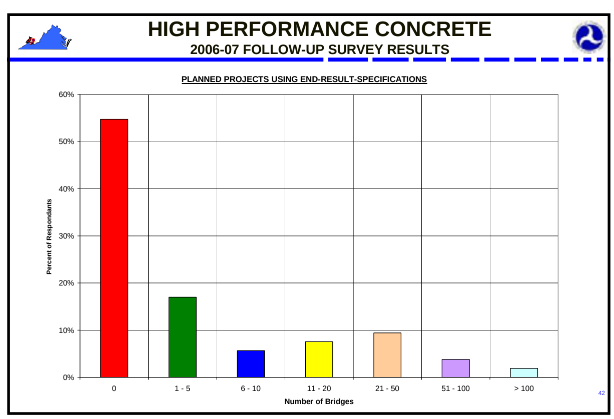

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
GALVANIZED REINFORCEMENT USAGE
Percent of Respondants
Deck
Superstructure
Substructure
NONE
1 - 10
11 - 50
No Answer
Number of Bridges
37


HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
MMFX2 MICROCOMPOSITE REINFORCEMENT USAGE
Percent of Respondants
Deck
Superstructure
Substructure
NONE
1
2 - 4
5 - 10
Number of Bridges
38

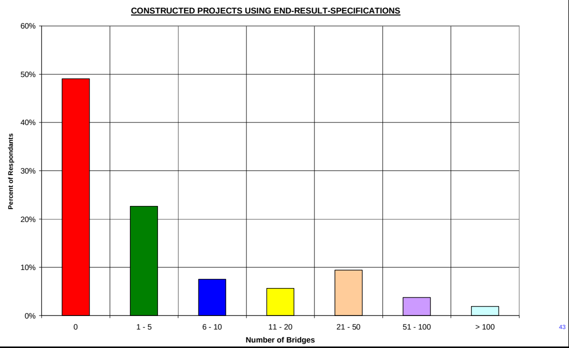

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
FRP (GFRP, CFRP, OR AFRP) REINFORCEMENT USAGE
Percent of Respondants
Deck
Superstructure
Substructure
NONE
1
2 - 4
5 - 10
11 - 20
Number of Bridges
39


HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
PRIMARY CHARACTERISTICS OF HPC TESTED
Percent of Respondants
Freeze-thaw durability
Scaling resistance
Abrasion resistance
Chloride penetration
Alkali-silica reactivity
Sulfate Resistance
Flowability
Strength
Elasticity
Shrinkage
Creep
NO
YES
Test as Needed
40


HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
METHOD OF SPECIFYING HIGH PERFORMANCE CONCRETE
Percent of Respondants
General Specification
Special Provision for Particular Project
Combination of General Specs & Special Provisions
Other
41

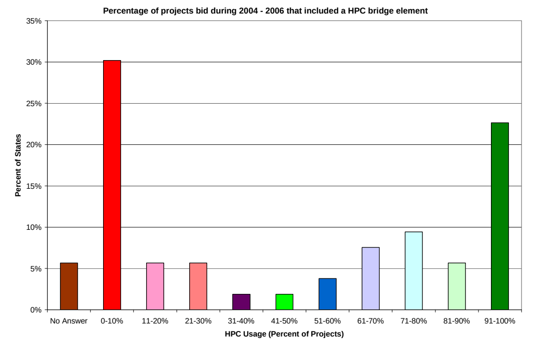

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS
PLANNED PROJECTS USING END-RESULT-SPECIFICATIONS
Percent of Respondants
0
1 - 5
6 - 10
11 - 20
21 - 50
51 - 100
> 100
Number of Bridges
42

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS



43

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS



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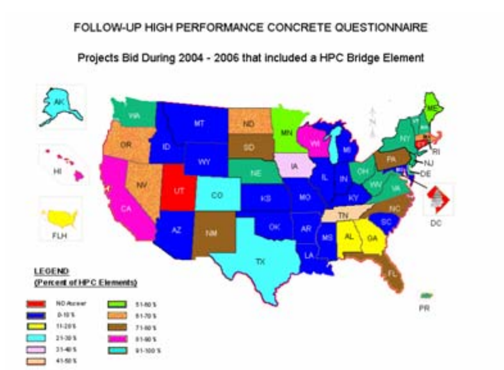
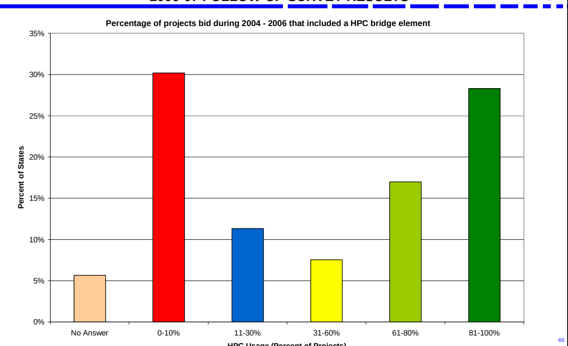


HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS



46

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

Conclusions

- ***HPC Provides***
  - ***Extension of service life***
  - ***Reduced Maintenance***
  - ***Lower Life Cycle Cost***
- ***Significant progress in HPC Implementation in the past 15 years, however, more needs to be done***
- ***State DOTs and Industry have taken advantage of strength and durability of HPC***

47

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

Conclusions (cont)

- ***Researchers and academia have provided solutions to design and construction problems***
- ***FHWA has supported the research, development, deployment and implementation of HPC through the many programs and initiatives described above***
- ***FHWA will continue to ensure that public and private sector partnerships be strengthened for successful implementation of HPC***

48

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

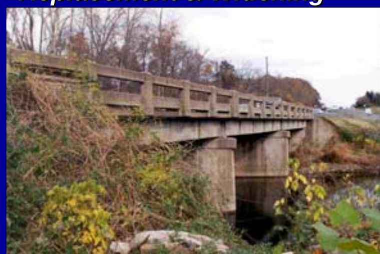
HIGH PERFORMANCE CONCRETE
2006-07 FOLLOW-UP SURVEY RESULTS

QUESTIONS?

THANK YOU

51

Route 15/29 SBL Bridge Superstructure Replacement & Widening



NOVA District

We Keep Virginia Moving

AGENDA

- Existing Structure
- Scope
- Accelerated Construction Procedure
- Construction Staging (Superstructure)
- Preparatory Work (Substructure)
- Questions

We Keep Virginia Moving

EXISTING STRUCTURE

Location: Route 15/29 SB Bridge over Broad Run, Prince William County

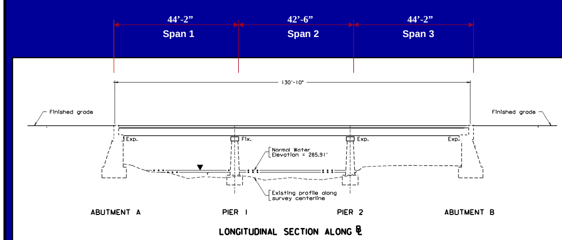
Superstructure: 3-Span, Concrete T beam, Simply Supported

Substructure: Wall Type Piers & Abutments

Year Built: 1952

Condition in 2005: Severe Deterioration of Superstructure

We Keep Virginia Moving



Bridge Elevation

We Keep Virginia Moving

Bridge Views

Profile View

Approach Roadway View

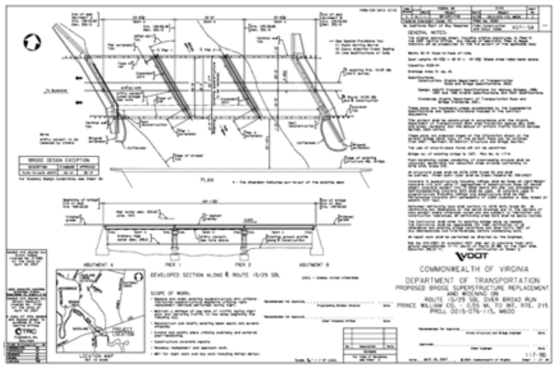
AGENDA

We Keep Virginia Moving

SCOPE

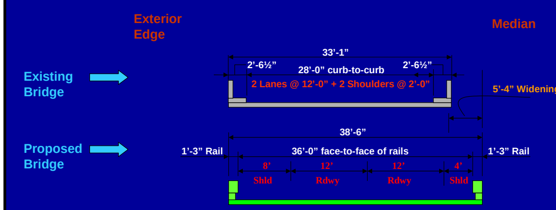
- Replace & Widen Superstructure
- Minimize Traffic Disturbance
  - Construction at Night only
  - Maintain 1 Lane of Traffic at Night
  - Restore Traffic to Normal (2 Lanes) at Day
  - Complete Work in 12 Nights

We Keep Virginia Moving



Plan & Elevation

Existing & Proposed Bridge Width



AGENDA

Typical Section
(Looking North, Station Ahead)

ACCELERATED CONSTRUCTION PROCEDURE (MODULAR CONSTRUCTION)

1. Preparatory Work
   - Maintain all Traffic Lanes
   - Widen Approaches
   - Modify Substructure for Modular Superstructure
2. Superstructure Replacement
   - Maintain 1 Lane of Traffic at Night
   - Remove Designated Portions of Superstructure
   - Replace with Modular Segments
   - Restore traffic to Normal (2 Lanes) at Day
   - Accomplish Work in 12 Nights
3. Overlay the Bridge and Approaches

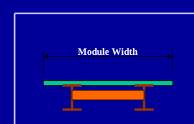
PROPOSED MODULAR STRUCTURE

Module Configuration:
Each Module Consists of a Prefabricated Conc. Deck on Two Steel Beams
Module Width Arrangement in Transverse Section: (12'- 11") (9'-0") (8'- 9") (7'-10")
Module Length = Span Length (~ 44')
Max. Module Weight = ~35 tons (~30 tons w/ Lightweight Concrete)

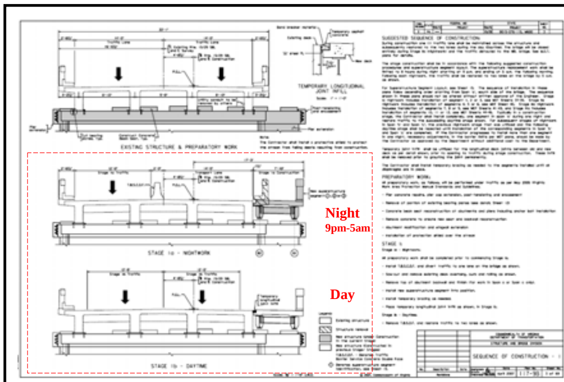
Longitudinal Joints between Modules:
Grouted/Waterproofed Keyways

Diaphragms between Modules:
Field Installed Steel Diaphragms

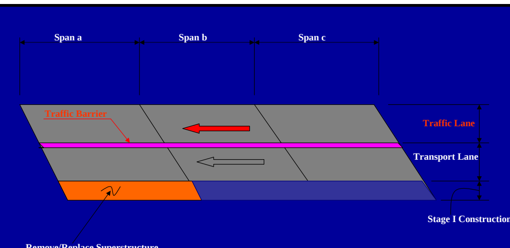
Deck Parapets:
Plant Cast Concrete



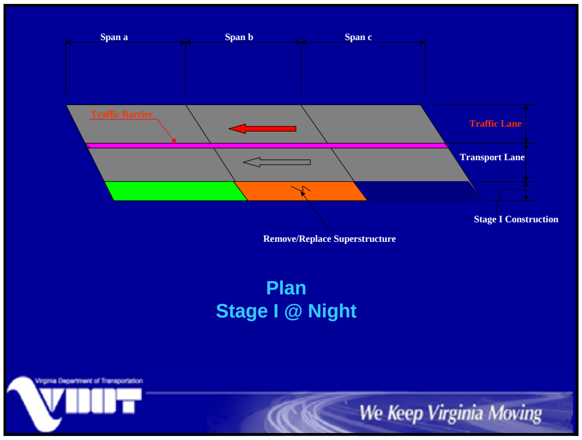
AGENDA

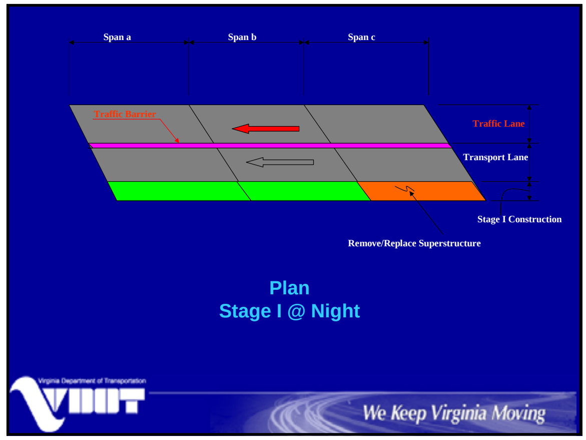


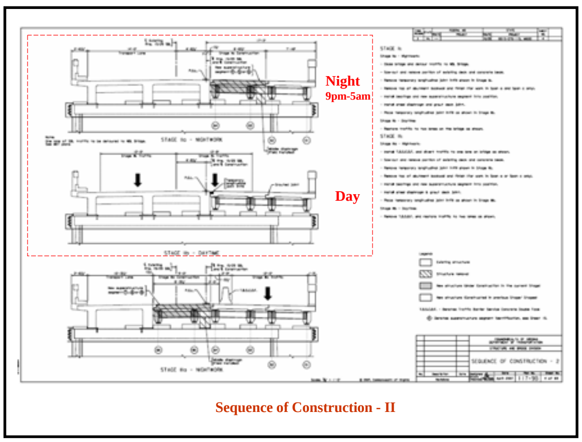
Sequence of Construction -I

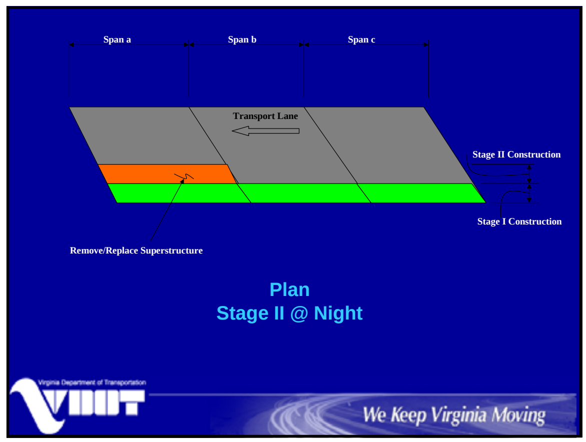


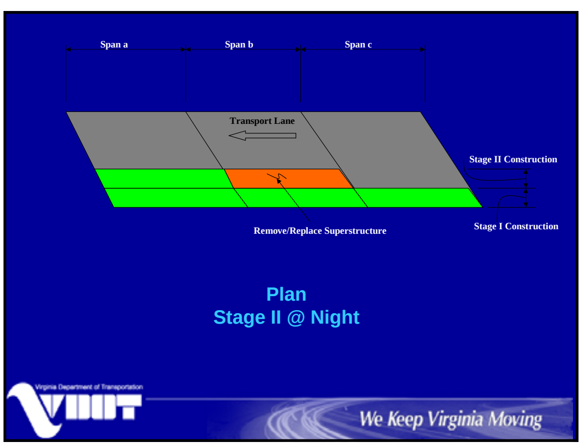
Plan
Stage I @ Night

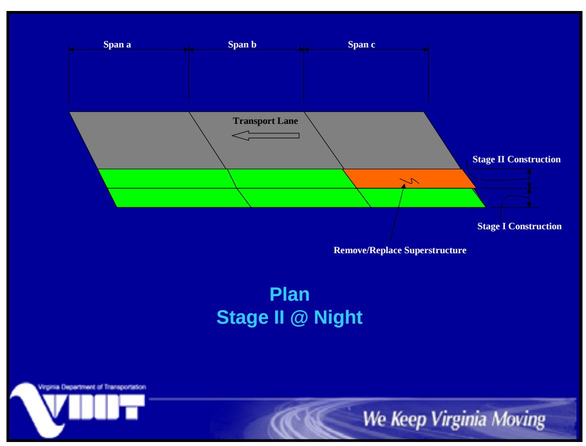

Span a
Span b
Span c
Traffic Barrier
Traffic Lane
Transport Lane
Stage I Construction
Remove/Replace Superstructure
Plan
Stage I @ Night
Virginia Department of Transportation
We Keep Virginia Moving

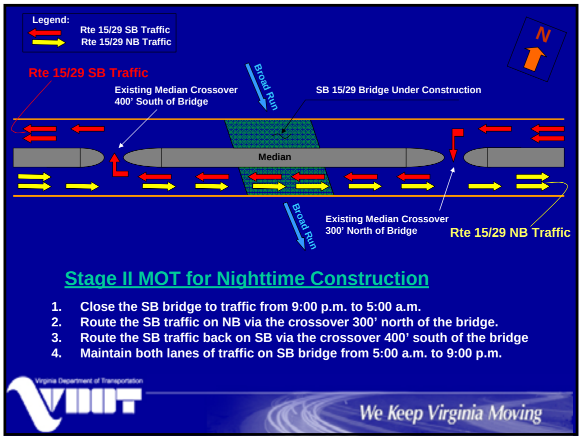

Span a
Span b
Span c
Traffic Barrier
Traffic Lane
Transport Lane
Stage I Construction
Remove/Replace Superstructure
Plan
Stage I @ Night
Virginia Department of Transportation
We Keep Virginia Moving

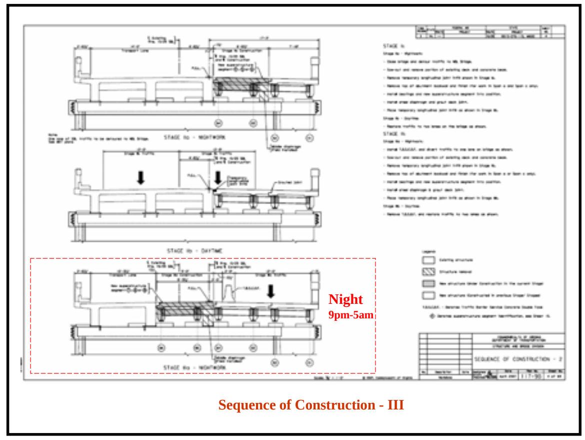

Night
9pm-5am
Day
Sequence of Construction - II

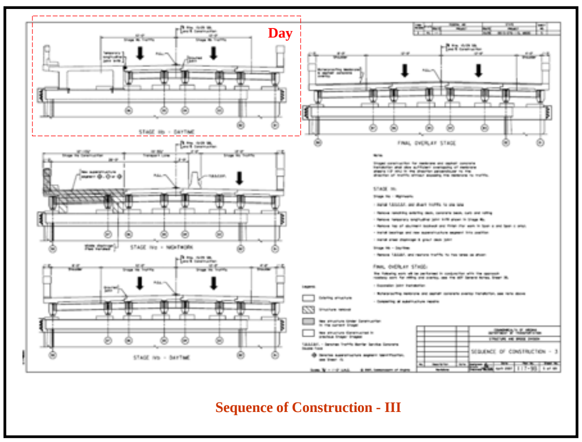

Span a
Span b
Span c
Transport Lane
Stage II Construction
Stage I Construction
Remove/Replace Superstructure
Plan
Stage II @ Night
Virginia Department of Transportation
We Keep Virginia Moving

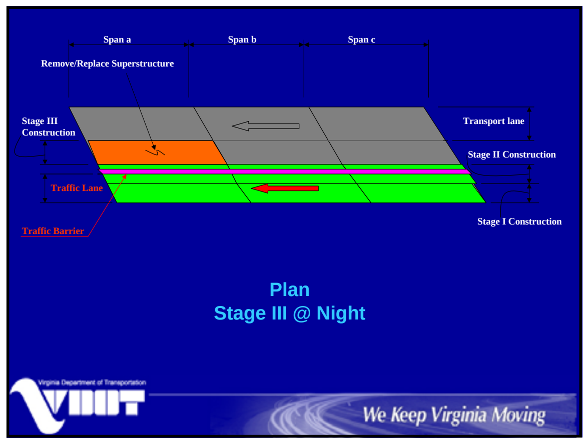

Span a
Span b
Span c
Transport Lane
Stage II Construction
Remove/Replace Superstructure
Stage I Construction
Plan
Stage II @ Night
Virginia Department of Transportation
We Keep Virginia Moving

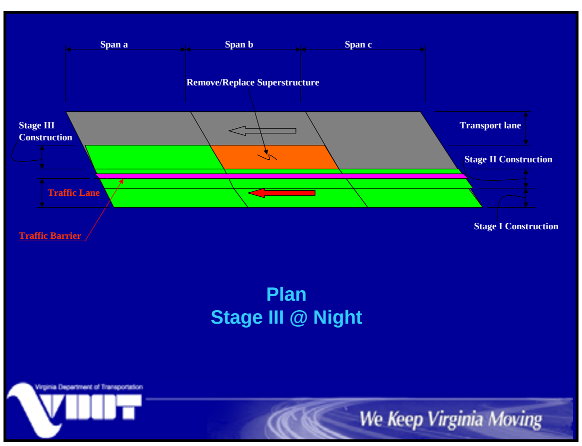

Span a
Span b
Span c
Transport Lane
Stage II Construction
Stage I Construction
Remove/Replace Superstructure
Plan
Stage II @ Night
Virginia Department of Transportation
We Keep Virginia Moving

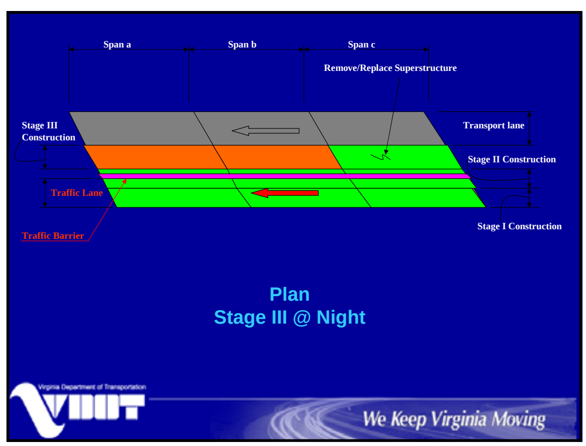

Legend:
Rte 15/29 SB Traffic
Rte 15/29 NB Traffic
N
Rte 15/29 SB Traffic
Broad Run
Existing Median Crossover
400' South of Bridge
SB 15/29 Bridge Under Construction
Median
Broad Run
Existing Median Crossover
300' North of Bridge
Rte 15/29 NB Traffic
Stage II MOT for Nighttime Construction
1. Close the SB bridge to traffic from 9:00 p.m. to 5:00 a.m.
2. Route the SB traffic on NB via the crossover 300' north of the bridge.
3. Route the SB traffic back on SB via the crossover 400' south of the bridge
4. Maintain both lanes of traffic on SB bridge from 5:00 a.m. to 9:00 p.m.
Virginia Department of Transportation
VDOT
We Keep Virginia Moving

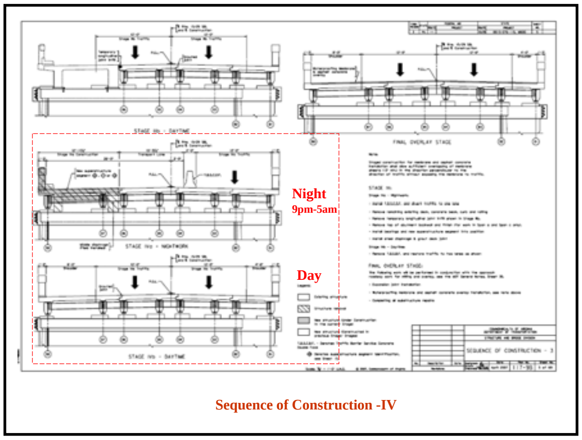

Night
9pm-5am
Sequence of Construction - III

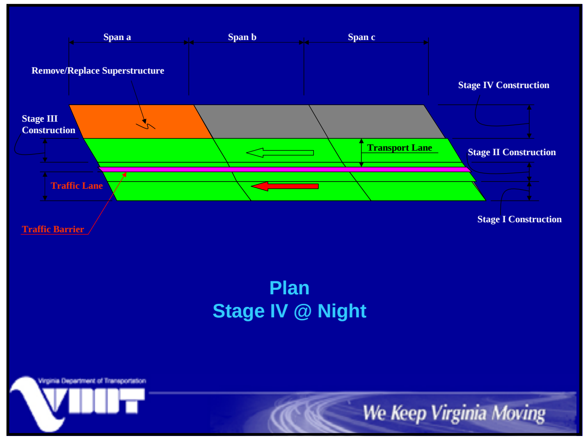

Day
FINAL OVERLAY STAGE
Sequence of Construction - III

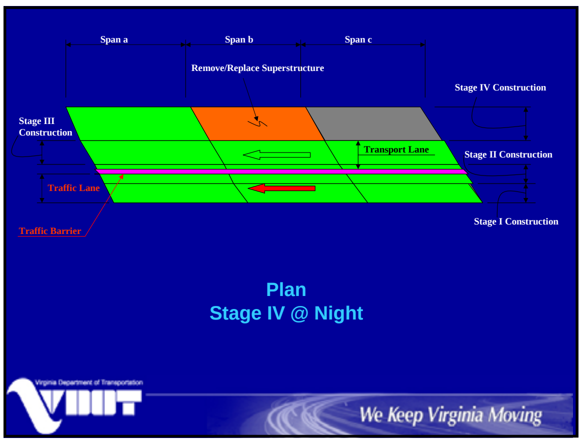

Span a
Span b
Span c
Remove/Replace Superstructure
Stage III
Construction
Transport lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage III @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving

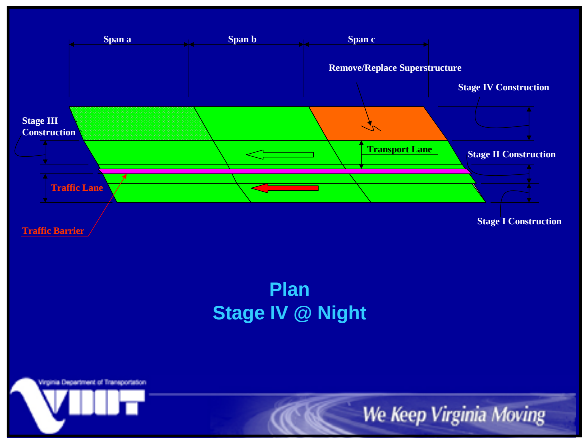

Span a
Span b
Span c
Remove/Replace Superstructure
Stage III
Construction
Transport lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage III @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving

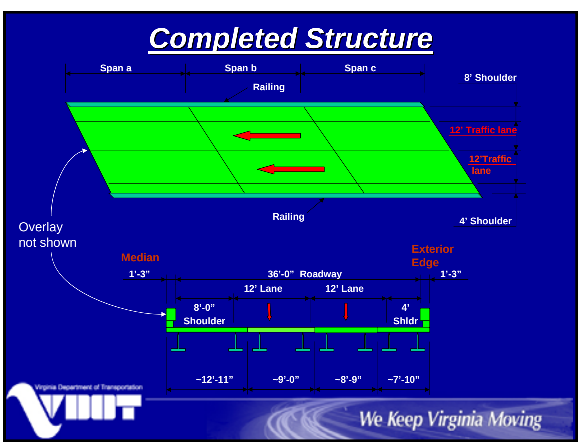

Span a
Span b
Span c
Remove/Replace Superstructure
Stage III
Construction
Transport lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage III @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving

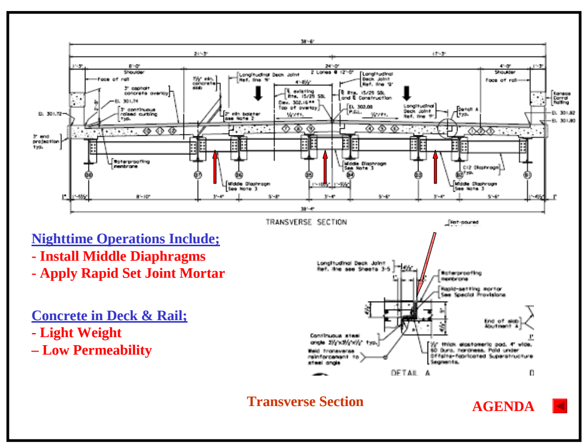

Night
9pm-5am
Day
Sequence of Construction -IV

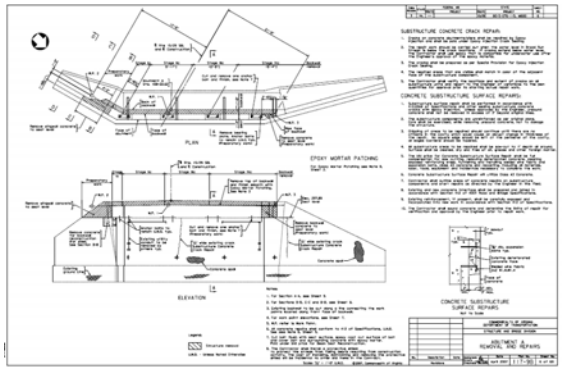

Span a
Span b
Span c
Remove/Replace Superstructure
Stage IV Construction
Stage III Construction
Transport Lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage IV @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving


Span a
Span b
Span c
Remove/Replace Superstructure
Stage IV Construction
Stage III Construction
Transport Lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage IV @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving

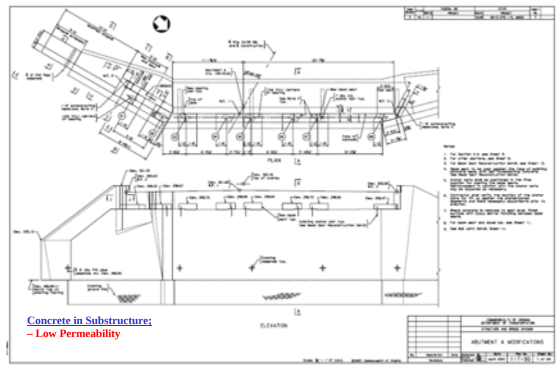

Span a
Span b
Span c
Remove/Replace Superstructure
Stage IV Construction
Stage III Construction
Transport Lane
Stage II Construction
Traffic Lane
Traffic Barrier
Stage I Construction
Plan
Stage IV @ Night
Virginia Department of Transportation
VDOT
We Keep Virginia Moving


Completed Structure
Span a
Span b
Span c
8' Shoulder
Railing
12' Traffic lane
12'Traffic lane
Overlay not shown
Railing
4' Shoulder
Median
Exterior Edge
1'-3"
36'-0" Roadway
1'-3"
12' Lane
12' Lane
8'-0" Shoulder
4' Shldr
~12'-11"
~9'-0"
~8'-9"
~7'-10"
Virginia Department of Transportation
VDOT
We Keep Virginia Moving


TRANSVERSE SECTION
Nighttime Operations Include;
- Install Middle Diaphragms
- Apply Rapid Set Joint Mortar
Concrete in Deck & Rail;
- Light Weight
– Low Permeability
DETAIL A
Transverse Section
AGENDA

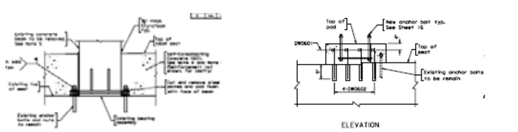


Abutment A Modifications
(Repair & Removal)

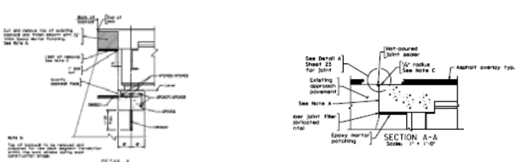


Concrete in Substructure;
– Low Permeability

Abutment A Modifications
(Widening & Beam Seat Reconstruction)



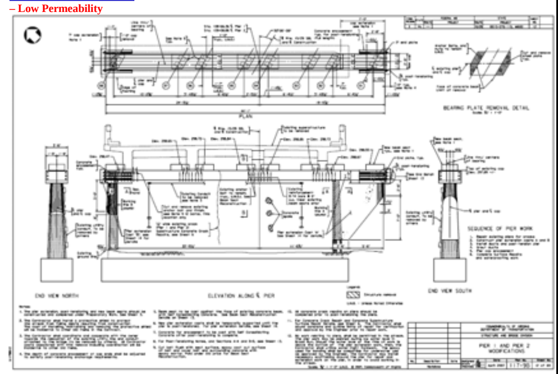
Beam Seat Reconstruction
(Self –Consolidating Concrete)



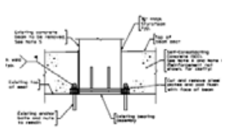
Backwall Removal & Modification (Nighttime Operation)

Abutment Modifications

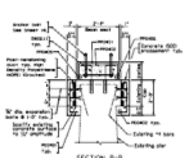
Concrete in Substructure;
– Low Permeability



(Repair, Removal, Widening & Beam Seat Reconstruction)



Beam Seat Reconstruction
(Self –Consolidating Concrete)



Beam Seat Reconstruction &
Encasement of Post-Tensioning
(Self –Consolidating Concrete)

AGENDA

Pier Modifications

UHPC or UHPFRC

Ultra High-Performance
Fiber-Reinforced Concrete

Celik Ozyildirim, Ph.D., P.E.
Research Council, VDOT

Virginia Concrete Conference, March 2008

UHPC HISTORY

- 1994: Development of Bouygues, Lafarge, and Rhodia, France
- 1997: Sherbrooke, Canada Footbridge
- 2001: Bourg lès Valence, France Highway Bridges
- 2002: Seoul, Korea Footbridge of Peace

UHPC

- Compressive strengths ≥ 30,000 psi
- High ductility
- Very low permeability
- Lighter, thinner, and more durable structural sections
- High shear capacity in bending

UHPC

- Two of the primary sources for these enhancements:
  - Finely graded and tightly packed nature of concrete constituent materials (no coarse aggregate)
  - Steel or synthetic fibers

UHPC

UHPC

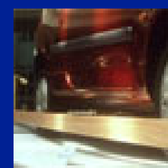
- Bus shelter in Tucson, AZ

UHPC

- Light rail transit station, Calgary, Canada
- Canopies 20 mm (0.8 in) thick

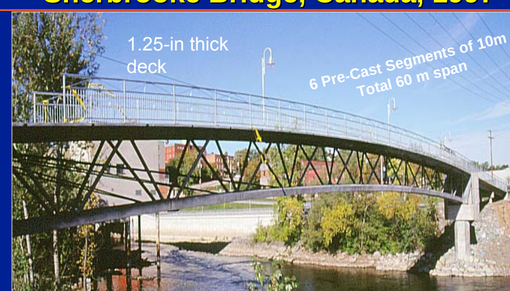
UHPC

- 6x10 ft panel, 1-inch thick carries 2,000 lb car.



UHPC AT TFHRC

Sherbrooke Bridge, Canada, 1997



Footbridge of Peace Seoul, Korea, 2002

Bourg lès Valence
Bridges,
France

Opened in 2001,
UHPC Beams

UHPC, Wapello County, Iowa

- Three 110-ft beams, 27'-2" ft wide deck
- Beams cast in Canada in 2005
- Opened to traffic in 2006

UHPC Beams

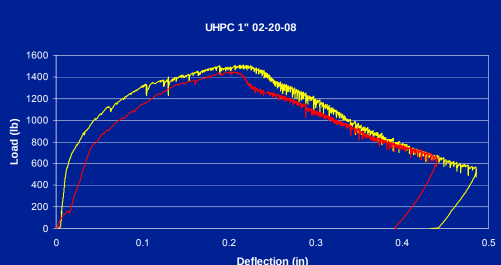
- Route 624 over Cat Point Creek, Richmond County, Virginia
- 10 spans: 81 ft 6 in each
- Five 45-in bulb-T beams per span
- One span with UHPFRC

UHPC

UHPC Compressive Strength

Test	psi (average of 3)
1	30,456
2	30,747
3	30,492
4	27,275

Flexural Strength Test



UHPC

UHPC

UHPC

UHPC

UHPC

UHPC

UHPC

UHPC

Thank You

Corrosion Resistant Reinforcing Steel (12 Projects)

Michael Sprinkel, P.E.
Associate Director – VTRC
Julius Volgyi, P.E.
Structure and Bridge – VDOT
Richard Weyers, P.E PhD
Professor-VPI&SU

Why Use CRR?

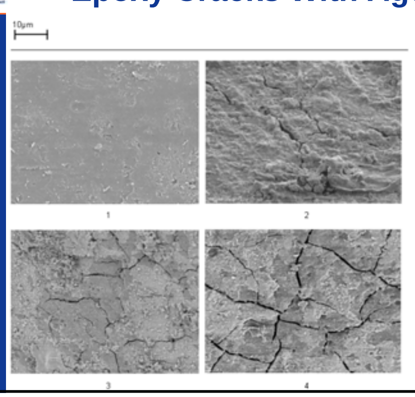
- Lab and field studies evaluated the performance of uncoated reinforcement (UR), epoxy coated reinforcement (ECR) and corrosion resistant reinforcement (CRR) in decks.

Disadvantages of ECR in decks

- Cracks are 33 % wider when ECR is used.
- Epoxy loses adhesion to steel as it ages.
- The permeability of epoxy increases with age.
- Epoxy cracks with age.

Epoxy Loses Adhesion With Age

Epoxy Cracks With Age



Why Use CRR?

- Time to corrosion of UR and ECR was estimated at 25 to 50 years for VDOT concretes (1977-1995).
- ECR was estimated to increase the time to corrosion-induced spalling by only 5 years.
- Time to corrosion for CRR is $\geq$ 4.5 times that of UR.
- Time to corrosion of CRR was estimated at more than 200 years.

Why Use CRR?

- Crack control is better than ECR.
- Corrosion protection in cracks is better than ECR.
- Initial cost is $\geq$ ECR.
- Life cycle cost is < ECR.

Section 223 Steel Reinforcement

CRR shall conform to the requirements of one of the following standards:

- ASTM A1035/A1035M – 05 Standard Specification for Deformed and Plain, Low-carbon, Chromium, Steel Bars for Concrete Reinforcement.
- ASTM A955/A955M - 06a Standard and Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement.
- AASHTO Designation: MP 13M/MP 13-04, Standard Specification for Stainless Steel Clad Deformed and Plain Round Steel Bars for Concrete Reinforcement.

Section 223 Steel Reinforcement

- Revisions being reviewed by VDOT Specifications committee and the FHWA.

ASTM A1035/A1035M

- Will have an upper limit on yield strength as ductility may still be an issue.
- Has been adopted into the AASHTO LRFD Construction Specifications.
- Has not yet been adopted into the design specifications.

Available Products

- MMFX-2 by Steel Corporation of America, Inc.
- EnduraMet 32 by the Carpenter Company
- 2101, 2201, 2205, 304, 316 Stainless Steels

VDOT Plan to Use CRR

- 2007: modify design standards to specify CRR in decks (one to one replacement for Grade 60 rebars).
- January – December 2008: Advertise 12 projects (approximately 10%).
- January – December 2009: Advertise 24 – 30 projects (approximately 30%).
- January 2010: Full implementation.

Thank you.

Questions?

VTRC
Virginia Transportation
Research Council

Virginia Concrete Conference
March 7, 2008

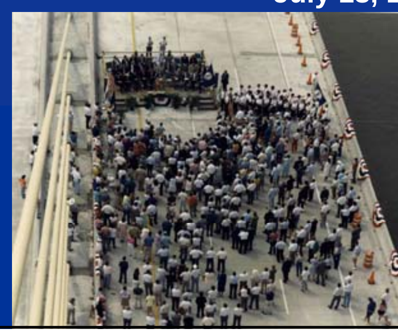
VDOT EXPERIENCE WITH GROUTED TENDONS IN VARINA-ENON PRECAST SEGMENTAL POST-TENSIONED BRIDGE

Michael Sprinkel, P.E.
Associate Director
VTRC

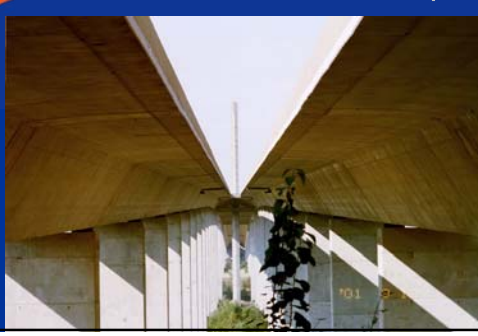
Claude S. Napier, P.E.
Division Bridge Engineer
FHWA – VA

Bridge Construction and Typical Segment

Dedication Ceremony July 18, 1990



I- 295 Varina-Enon Bridge 28 spans



2001 Varina-Enon Inspection: hole in duct; rust on strand & void in duct; rust was confined to vicinity of hole


VTRC


VTRC
Expansion Joint - 2001


VTRC
Expansion Joint - 2001


VTRC
Tendons at Exp. Joints


VTRC
Where is the “Beef” (i.e., GROUT)?
10/17/2001


VTRC
Where is the “Grout”
Vertical Post-Tensioned Anchors

I 295 Failed Tendon (5-30-2007) Why did it fail in 17 years?

Concerns?

- Long Term Performance of Structure
- Preventive Maintenance Requirements to Extend Service Life
- Future Rehabilitation Costs
- In-Depth Inspection Requirements
  - What Techniques?
  - How Frequently?
- Health Monitoring Requirements
  - Short Term Monitoring
  - Long Term Monitoring

I 295 Failed Tendon (5-30-2007) Why did it fail in 17 years?

Why did tendon fail in 17 years?

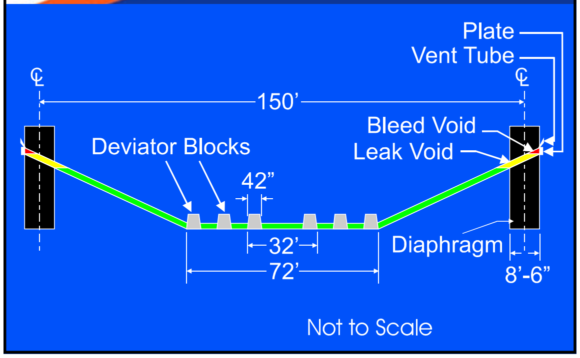
- Original grout (water, cement, admixture)
- Vacuum grout (high performance)
- Original grout and vacuum grout
- Chloride ions (none found)
- Carbonation of grout (original grout at failure)
- Moisture (grout has high moisture content)
- Oxygen (voids in tendons, unsealed vent tubes and inspection holes)
- Combination of factors

Concerns About Grouts in Tendons

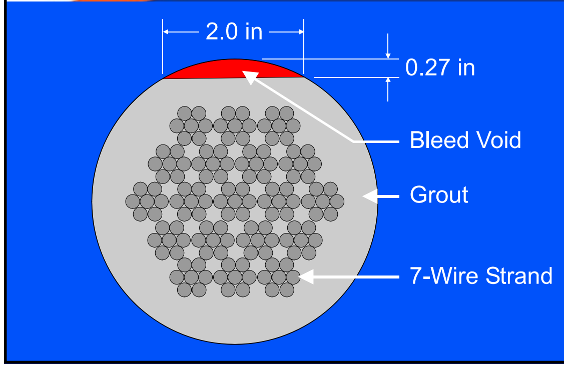
- Voids due to bleeding and segregation (Bleeding in grouts used prior to 2000 was approximately 4 percent. In a 150 ft long tendon, 4 percent bleeding can cause 6 ft of void at the high points in the tendon)
- Voids due to incomplete grouting and leaks

Wick Induced Bleed Test
cement and water, aluminum powder, high performance prepackaged grout

Tendon in Typical Span



Tendon Section



Tendon Inspection and Repair

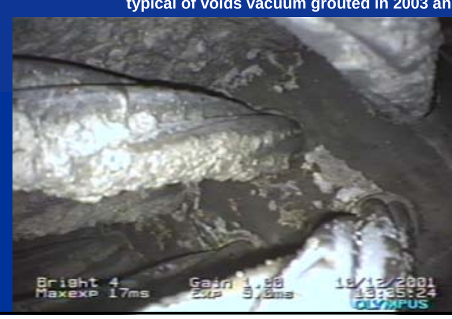
- Inspected tendons for voids in grout, flaws in ducts, and corrosion of strands and anchors (visual, wire probes, sounding, and bore scope) (2001 and 2002)
- Vacuum grouted some voids (2003 and 2004)
- Sealed some tendons (2003 and 2004)
- Replaced 2 tendons (1 failed, 1 with 3 broken wires) (2007)
- Evaluated condition of tendons using Magnetic Flux (approximately 80 % of each duct) (2007)
- Twenty tendons selected for detailed evaluation by removal of a 2-ft section of duct (18 because of corrosion in bore scope pictures, 1 because of Magnetic Flux measurements by Dr Al Ghorbanpoor and 1 because of his visual inspections) (2007)
- Plan to monitor tendons representing 6 conditions (2008)

2001 Varina-Enon Inspection: plugged drain; water submerges tendon; situation of 2nd tendon replaced which had 3 broken wires

Horizontal Tendon Vent (10-12-2001)

grout on wall suggests duct was filled

Horizontal Tendon Void (10-12-2001): PT bearing plate, strands, grout and void, no corrosion of strands; typical of voids vacuum grouted in 2003 and 2004




VTRC
I 295 Failed Tendon (5-22-2007)


VTRC
Failed Tendon


VTRC
Failed Tendon


VTRC
Failed Tendon


VTRC
Slices of Failed Tendon in Lab at VTRC


VTRC
Failed Section

Failed Section

8 Ft Downstream of Failed Section

Grouted Section

Magnetic Flux Testing

Section Loss Identified by MF

Grout Moisture Content

Tendon	Broken wires	Section loss	color	Moisture content, %	Absorption, %
NP13T10	2	7 wires 5.3 %	Gray	32.8	35.5
SP12T9	1	4.8 wires 3.6 %	Gray (bottom)	36.6	39.5
SP12T9	1	4.8 wires 3.6 %	White (top)	21.6	36.5

Monitoring 6 Tendon Conditions

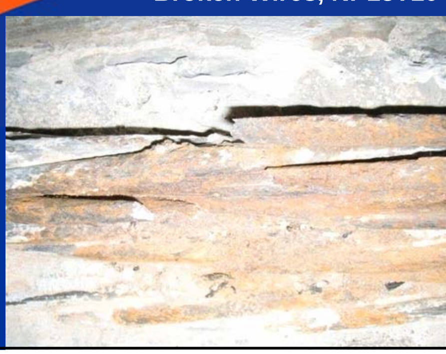
1. Voids, no vacuum grout (45 per cent of tendons)
2. Voids, incomplete vacuum grout
3. Drying shrinkage cracks in grout
4. Small section with minor pitting corrosion
5. Pitting corrosion and several broken wires
6. Vacuum grouted tendon with broken wires

Voids, no vacuum grout

Voids, incomplete vacuum grout

Shrinkage Cracks

Broken Wires, NP13T10



Vacuum Grouted Broken Wire, SP12T9

Tentative Conclusions

- Tendons have voids
- Approximately 55 % of tendons were vacuum grouted
- Grout typically has high pH and high moisture content
- Corrosion typically associated with access to oxygen and absence of grout

Recommendations

- Vacuum grout tendons with accessible voids
- Repair ducts and vacuum grout tendons subjected to detailed inspections
- Monitor tendons representing 6 tendon conditions using visual inspections through transparent duct repairs, half cell and rate of corrosion measurements and acoustic emission sensors.

Recommendations

- Consider Other Health Monitoring Technologies Based on Failure Analysis
- Determine Future In-Depth Inspection Requirements
- Perform Additional Repairs As Recommended from On-going Evaluation of Bridge

Acknowledgements

- Steve Sharp and staff, Research Scientist VTRC
- Gary Martin and staff, VDOT Bridge Engineer
- Claude Napier, FHWA
- Rudy Maruri, FHWA
- Denney Pate and staff, Figg Bridge
- VSL staff

GEORGIA TECH

VTRC
Virginia Transportation Research Council

U.S. Department of Transportation
Federal Highway Administration

HOKIES

Precast Prestressed Concrete Beams and Girders

For Virginia Highway Bridges

Rodney T. Davis, PhD, PE
Virginia Transportation Research Council

Economical Bridge Designs Using Normal Weight Concrete

Virginia PCBT's set as simple spans, CIP deck

- Span to beam depth h ratio of 18 to 21, with 20 being about optimal
- Beam spacing up to about 10 feet
- Beam Concrete 8000psi
- Beam web width 7 inches
- Equivalent of 0.8 ½"dia. strands per inch of beam depth h
- Deck concrete 4000psi
- Continuity diaphragms and integral backwalls

Economical Bridge Designs

Virginia PCBT's set as simple spans, CIP deck

- Span to beam depth h ratio greater than 20
- Beam spacing of about 10 feet maintained with span to depth ratios up to 24 requires LW deck
- Beam Concrete 8000psi (normal weight unless reduced superstructure weight is needed, reduced modulus and reduced self-weight offset in pretensioned beams)
- Lightweight deck concrete up to 5000psi and down to 110 pcf
- Add beam lines only if necessary

Spliced Girder Superstructures

- Use typical spliced girder construction for spans from 170 feet to 380 feet
- Try span to girder depth h ratios of 21 at the pier and 29 near midspan
- Girder concrete strength 8000psi
- Use individual splices with moment capacity as reinforced concrete section
- Use conventional 4000psi CIP deck
- Use 4 or more tendons, spread them out in web
- Need P/T duct specification similar to Florida DOT, but we don't need nor want the plastic duct

Spliced Girder Superstructures

- Girder weight has important influence as span length increases
- Modify section
- Reduce beam and deck densities
- Add girder lines
- Increase girder strength last option
- Pier segments use custom form
- No massive elements in girders

Properties for Design
Tensile Strength

- Lightweight concretes are exhibiting about 7/8th of the tensile strength of the equivalent normal weight concrete
- Slower cure results in higher tensile strength relative to the compressive strength

Tensile Strength of Typical 8000psi Beam Concretes		
Failure mode	NWC	LWC
Splitting Tensile	0.090 f_c'	0.080f_c'
Beam Rupture	0.085 f_c'	0.075 f_c'
Tension Field	0.060 f_c'	0.055 f_c'

Properties for Design
Modulus of Elasticity

- Modulus of elasticity of lightweight concrete is dependent on the volume of lightweight aggregate, and the paste density
- Modulus of elasticity of normal weight concrete is dependent on the type of aggregate, and the paste density

Modulus of Elasticity of Typical 8000psi Beam Concretes		
	NWC	LWC
At Transfer	4200-5600 ksi	3100-3300 ksi
In Service (VA)	5000-6500 ksi	3300-3500 ksi
Dried at 50% RH		3100 ksi

Properties for Design
Creep Coefficient for P/S plus Self-weight

- Beam concretes using slag (and presumably fly ash) show a marked increase in early age creep as well as strength when cured at lower temperatures (less than 135 degF)
- Range of values in the table are for peak concrete temperatures during curing from 130 to 165 degF
- Creep from prestess transfer and self-weight is complete in 7 to 60 days depending on curing regiment

Creep Coefficient for Typical 8000psi Beam Concretes		
Interval	NWC	LWC
Transfer to day 7 - 60	0.25 -1.2	0.25 - 1.2

Properties for Design
Autogenous Shrinkage of Beam Concrete

- Use of lightweight aggregates is known to reduce autogenous shrinkage and its associated stresses
- This is a difficult strain to measure as it is occurring during the accelerated curing of the beams
- Vertical cracking of beams during cooling and before prestress transfer indicates that the beam has shortened during the curing process
- Reduces camber at transfer

Autogenous Shrinkage Strain for Typical 8000psi Beam During Accelerated Cure		
	NWC	LWC
Microstrain	about 250	lower

Properties for Design
Total Shrinkage of Beam Concrete

- Lightweight concrete exhibited more shrinkage than the normal weight concrete after leaving the form
- Beams cured at lower temperature showed more shrinkage after leaving the form than beams cured above 150 degF

Total Shrinkage Strain for Typical 8000psi Beams		
	NWC	LWC
Microstrain	about 350	about 350-450

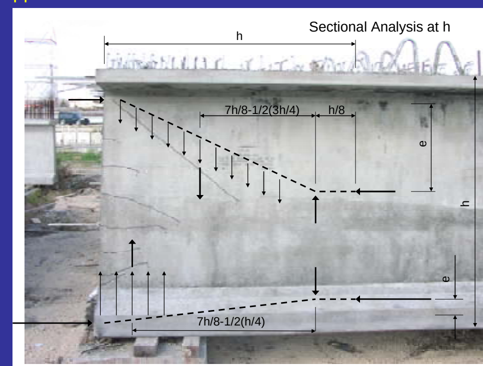
Mix Design
Beam Concretes

Typical 8000psi Beam Concrete Constituents		
	NWC	120 PCF LWC
Portland Cement	450 pcy	480 pcy
Slag	300 pcy	320 pcy
Water	232 pcy	248 pcy
w/cm ratio	0.31	0.31
Fine Aggregate	1050 pcy	1150 pcy
Coarse Aggregate	2100 pcy	1050 pcy

Problem Areas - Precast Prestressed Beams and Girders

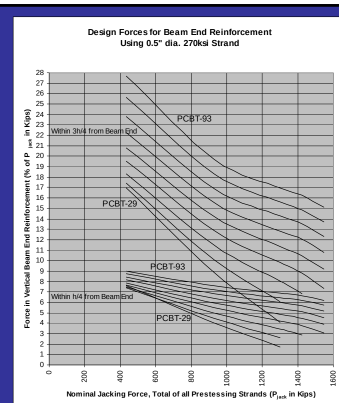
- Beam end cracking at transfer of prestress
- Thermal stress induced web cracking and cold joints
- Creep and shrinkage, camber growth

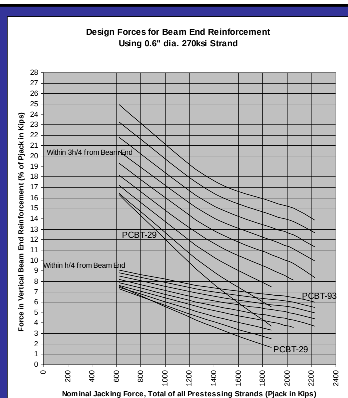
Upper and Lower Strut-and-Tie Models for Beam End Design



Working Stress for Vertical Beam End Reinforcement

- 22ksi for normal weight concrete in non-aggressive environments
- 19ksi for lightweight concrete
- 16ksi for aggressive environments, spliced girder segment ends





Curing Method of Precast Prestressed Beams

- Higher temperature, shorter duration
  - Lower final tensile and compressive strength
  - Little creep and less shrinkage after prestress transfer
  - Improved production
- Lower temperature, longer duration
  - Higher final tensile and compressive strength
  - More creep and shrinkage after prestress transfer
  - Camber growth may be unacceptable for LW beams, and will not meet 50% camber growth spec

Fabrication of Beams

- Casting should proceed quickly and continuously
- Upon initial set enclosure temperature should be ramped at a rate such that the form temperature does not exceed the concrete temperature by more that a few degrees
- Beam temperature should be kept constant until transfer strength has been achieved
- Strands should be cut as quickly as possible after steam has been stopped
- Best results have been achieved when ramp rate is slower, and transfer strengths are above 6400psi

Rte. 33 over the Mattaponi River at West Point, Virginia

Count On Concrete for Long Life & Value

A Contractors Footprint in the Deck!

How Can Contractors Contribute to Long Life & Value in Full Depth Precast/Prestressed Deck Systems?

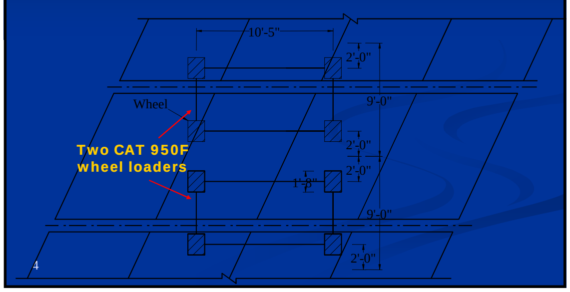
- Address Construction Means & Methods in the Shop Drawing Phase.
- Panel Production
- Handling, Transport, & Storage
- Field Engineering & Accuracy of Installation
- Erection
- Transverse & Longitudinal Joints

Means & Methods in the Shop Drawing Phase

- Will construction be top-down, or bottom-up? If top-down, will add'l reinforcing be required for setting operation? (live loading of installation equipment on partially completed deck)
- Will producers standard lifting and handling embeds be adequate for setting operation? If not, can producer install embeds that will also accommodate contractors setting operation?
- How will panels be supported in place prior to keyway grouting? Haunch Support Angles? Leveling Bolts?

Construction Loading For Top-Down Erection

CAT 950F wheel loader
(machine weight is 35,000 lbs)



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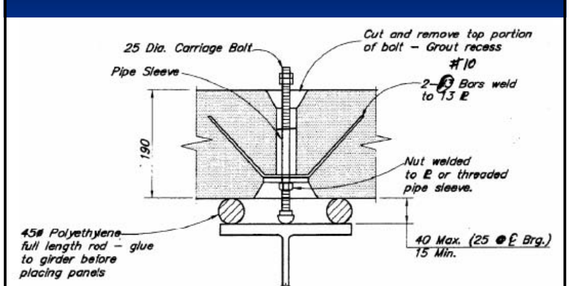
Older Panel Elevation adjustment method. Angle support system is preferred.



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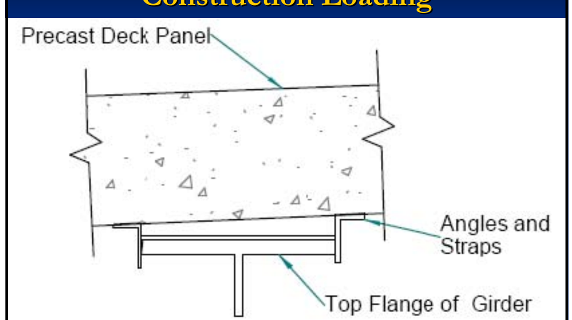
Size Panel Supports For Construction Loading



Panel Production

- Have a competent contractor employee interact with the panel supplier during initial casting operation and as necessary thereafter to verify embed location and overall conformity to dimensional requirements.
- Challenge the panel supplier to perform better than his specified tolerances require.

Checking Bulkhead Lay-out, Skyline Bridge Deck Panel Form

8

Handling, Transport, & Storage

- Develop a formal lifting, transport, and jobsite storage (if necessary) plan.
- Set panels from delivery truck into final position whenever possible. Avoid stockpiling panels on jobsite.
- If panels must be stored on site, improve storage area as necessary to insure its load bearing characteristics and stability under adverse weather conditions.
- If stacking is required, always use square blocking material. (4x4 or 6x6, not 4x6)
- Periodically check stockpiles for unexpected settlement and modify as required

Panel Handling

10

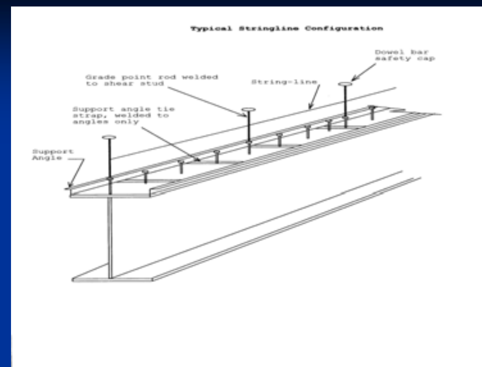
Blocking Supports Panel in Crowned Position

11

Variable Height Blocking for Bottom Panel Preserves Crown.
Square Blocking For All Successive Panels.

Field Engineering & Accuracy of Installation

- Top of girder elevations should be shot twice, by different instrument men if possible.
- Set grade points to coincide with transverse panel joints, or multiples thereof.
- Install string-lines set at a constant vertical offset along centerline of girders above grade points for use in installation of panel support devices.
- Project management should inspect string-lines for common plane between girders, and smooth vertical transitions between spans or into abutments as applicable PRIOR to any panel erection or installation of panel supporting devices.



Panel Erection

- Inspect panels for dimensional irregularities and remediate prior to erection.
- Lay-out termination points on girders for each panel.
- Adjust rigging so that panels hang at roughly the same cross slope as the girders.
- If leveling bolts are used for panel support and elevation control, check and set elevation as each panel is installed, and once panel is on grade, use torque wrenches to compare torque values between the bolts of each panel. Actual torque values are insignificant, but adjust until all bolts for each panel fall within a range of 10%. This procedure will minimize the occurrence of hard point bearing areas in the panels prior to haunch grouting.

Panel Erection

16

Panel Erection

17

Transverse & Longitudinal Joints

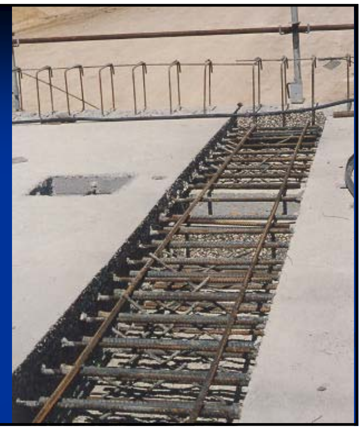
- Joints between precast panels have historically been a source for moisture intrusion and corrosion.
- Most joints are "*wet cast*" in that they are filled with a high performance cast-in-place concrete after erection.
- Research is currently under way that investigates the possibility of "match cast" transverse panel joints. Match casting would eliminate the need for CIP closures, and the waterproofing of the joint would be obtained by either an epoxy gel, or a thin compressed neoprene strip adhered to one side of the joint.

Wet Cast Joints

- Project specifications generally call for either water-blasting or sand-blasting to be performed in advance of joint filling operations under the wet cast method.
- The best condition would be for the precast supplier to sand-blast joint surfaces as soon as possible after form removal. The form finish paste would be removed from the surface, and both coarse and fine aggregate would be visible on the bonding plane. Immediately prior to the placement of the CIP joint fill material, the contractor would perform a high pressure water-blast of the bonding planes. The water-blasting removes any deleterious material deposited since sand blasting, and properly moisture impregnates the surfaces for the best bond with the chosen joint fill CIP concrete.

Wet Cast Joint

Note Exposed Aggregate Surface



Match Cast Joints

(Not currently utilized in full depth deck panels, but hopefully coming soon!)

- Closely inspect joints for any irregularities
- Grind off any form seam or joint marks that might interfere with tightness of joint.
- Sand or water-blast surface to obtain good bonding profile for chosen epoxy.
- Use epoxy gel with enough set time and in appropriate temperature conditions to allow for minute adjustments of panel as may be required without premature set.

Thank You

- Special Thanks to:

Dr. Maher Tadros P.E., Leslie D. Martin Professor of Civil Engineering at University of Nebraska for his Contribution of pictures used in this presentation.

FULL DEPTH PRECAST DECK PANELS – A PRECASTER'S PERSPECTIVE

BAYSHORE CONCRETE PRODUCTS

GOAL / OBJECTIVE

- COLLECTIVELY, WE (OWNERS, DESIGNERS, PRECASTERS, & ENGINEERS) NEED TO DEVELOP FULL DEPTH DECK PANELS THAT ARE A COST EFFECTIVE ALTERNATIVE, CREATES EFFICIENT CONSTRUCTION METHODS, AND PROVIDES A LONG LASTING, MAINTENACE FREE BRIDGE DECK.

OVERVIEW

- CONCRETE CHARACTERISTICS
- TOLERANCES
- JOINT DETAILS
- SURFACE FINISH
- SHEAR POCKETS
- PANEL GEOMETRY
- FORMWORK

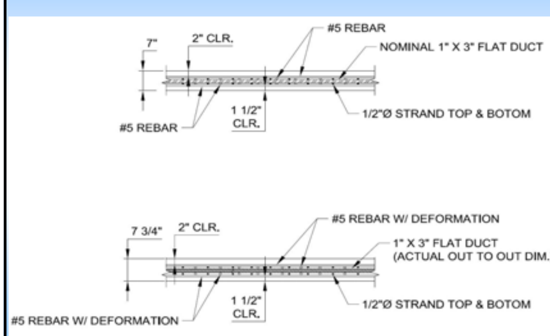
CONCRETE CHARACTERISTICS

- HIGH PERFORMANCE CONCRETE
  - PERMEABILITY – ASTM C1202 – 56 DAY DURATION
  - SCALING – ASTM C 672 – 80 DAY DURATION (50 CYCLES)
  - FREEZE-THAW – ASTM C 666 - 180 DAY DURATION
  - CREEP – ASTMC 512 - 120 DAYS TO 13 MONTH DURATION
  - STRENGTH – ASTM C 39 – 28 DAY DURATION
- CONCRETE MIX TESTING
  - ALLOW TIME PRIOR TO PRODUCTION
- STORAGE REQUIREMENTS
  - MINIMIZE STORAGE NEEDED PRIOR TO ERECTION
  - CALCULATE / ESTABLISH TIME FOR CREEP/SHRINKAGE TO OCCUR

TOLERANCES

- PRECAST CONCRETE TOLERANCES
- CRSI TOLERANCES
- ACTUAL DUCT O.D.
- COVER REQUIREMENTS

TOLERANCES

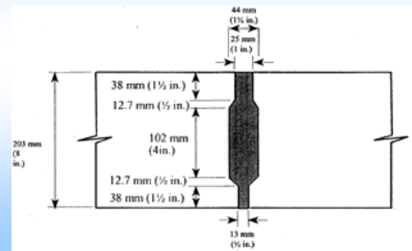


JOINT DETAILS

•POUR BACK STRIP WITH PROJECTING BARS

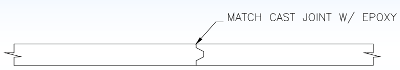
JOINT DETAILS

• FORMED FACES/SHEAR KEYS WITH EPOXY



JOINT DETAILS

• MATCH CAST FACES WITH THIN EPOXY BOND



RIDING SURFACE

- PANEL FINISHED SURFACE AS RIDING SURFACE
  - ➢ISSUES WITH PANEL IRREGULARITIES & DIFFERENTIAL CAMBER
- PANEL WITH SACRIFICIAL THICKNESS FOR GRINDING / GROOVING
  - ➢BEST RESULTS FOR RIDEABILITY
  - ➢FASTER APPROACH TO PUT PANELS IN SERVICE VERSUS AN OVERLAY
  - ➢QUALITY OF THE CONCRETE FOR THE RIDING SURFACE IS INHERENT TO THE PANEL CONCRETE
- PANEL WITH ROUGHENED SURFACE FOR BONDING TO OVERLAY

PANEL TO GIRDER SHEAR CONNECTIONS

- TWO FOOT SPACING OVER EACH GIRDER LINE (AASHTO REQ.)
- STEEL BEAMS – STUDS CAN BE SHOT AFTER PANEL PLACEMENT
- CONCRETE BEAMS – STUDS CAN BE GROUTED IN PLACE
- CONCRETE BEAMS – STUDS CAN BE CAST IN TOP OF GIRDERS
- SHEAR POCKET SPACING COULD BE INCREASED

DECK PANEL GEOMETRY

- TRUCKING ISSUES TYPICALLY REQUIRE 8'-0" TO 10'-0" MAX WIDTH
- KEEP DIMENSIONS RELATIVELY CONSISTENT TO REDUCE COSTS
- CONSIDER PANEL WEIGHTS FOR SHIPPING
- DIFFERENTIAL CAMBER BETWEEN PIECES MAY OCCUR

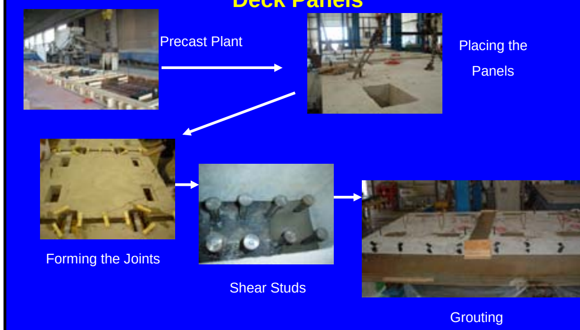
FORMWORK

- MATCH CAST FORM WORK IS EXPENSIVE (ESP.W/ PRESTRESSING) AND TIME CONSUMING
- RIGID/MACHINED SIDE FORMS FOR SHEAR KEY – SHOULD ELIMINATE THE “NEED” FOR MATCH CASTING
- MAXIMIZE PANEL LAYOUT FOR PRESTRESS BEDS
- LOCATE PRESTRESS STRAND ON 2-INCH SPACING

Deck Panel Research at Virginia Tech

Matt Swenty

Construction of Full Depth Concrete Bridge Deck Panels



Research Areas

Specification for Haunch and Pocket Grout

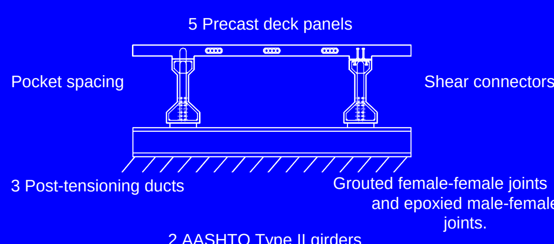
- Compressive and Tensile Strength
- Low Shrinkage
- Good Flow
- Good Cohesion
- Evaluate through ASTM and mock-up tests

Horizontal Shear Connectors - Push Off Tests

Examined a wide variety of connector details and grout types

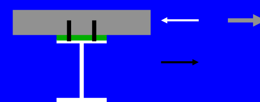
AASHTO equation for horizontal shear strength of smooth surfaces was best design equation

Lab Mockup



Time Dependent Behavior

- Deck panels are post-tensioned and then connected to girders (steel or concrete)
- Over time the deck wants to creep and shrink but is restrained by the girders
- Self-equilibrating stresses develop over time, along with restraint stresses in continuous systems
- Deck loses precompression over time



Design Recommendations

Girder Type	Number of Spans	Required Initial P/T (psi)
Steel	1	200
	2	650
	3 or more	500
PCBT	1	200
	2	200
	3 or more	200
AASHTO	1	200
	2	200
	3 or more	200

Panel to Panel Connections

Female-female narrow keyed grouted post-tensioned joint

Narrow non-prestressed joint with drop-in rebar

Wide cast-in-place joint with interlocking hairpin reinforcement

Woodrow Wilson Bridge Inspection

Continuing and Future Work

- Panel-to-panel joint evaluation
- Shear stud pocket performance
- Field implementation and testing

Thank You