REHABILITATION OF I-64 DUNLAP CREEK BRIDGES USING HIGH-PERFORMANCE LINK SLSABS AND OVERLAY MATERIALS: ABC COMPONENTS

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2017
Project Location

I-64 Dunlap Creek Bridges

VDOT Staunton District Bridge Offices

Virginia Transportation Research Council in Charlottesville
Original 1963 Plan
Existing Condition in 2014

$150k Shotcrete
Year: 2000
Outline

• Two Bridges built in 1963 to 1966
• Problems:
  • Leaking joints: damage to bridge seat, bearings, and substructure
  • Deck corrosion
• Rehabilitation
  • Bearings, Bridge seat
  • Hydro-demolition
  • Deck Extension and Micro Virginia Abutment
  • Fiber Reinforced Concrete in Closure Pours (Link Slabs)
  • Overlays
  • General rehabilitation – Parapet sealing
Considerations for Jointless Deck Retro-Fit

- **Joint Closures (Link Slabs) at Piers**
  - Existing Superstructure Configuration – 5 Simple Spans
  - Proposed Deck Configuration – 5-Span Continuous
  - Link slab separated from beam top flange by $\frac{1}{2}$” neoprene
    - Remove Shear Studs at end
    - Place foam between flange and pour

- **Bearing Configuration**
  - Proposed Bearing Fixity Configuration –
    - F-E Bearing configuration acceptable Spans 1 - 4
    - Reverse F-E on Span 5 to deliver Expansion at Abutments
    - Abutment Expansion supports Deck Extension
Considerations for Jointless Deck Retro-Fit

- **Pier Capacity**
  - Pier capacity is checked against revised longitudinal loads
    - Deck continuity presents single thermal center
    - Cumulative force delivered to piers
    - Short piers typically greatest concern due to stiffness
  - Existing pier design found adequate for retrofit

- **Deck Extension**
  - Deck end joints occur between Backwall and Approach Slab
  - Accommodates total movement each end
Joint Elimination: Closure Pour (Link Slab)

- Eliminate joints
- Place closure pour
### 2014 Plan & Elevation View

**Work Performed:**
Fall-2014 / Summer-2015

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#### DECK CLOSURE/OVERLAY MATERIAL

<table>
<thead>
<tr>
<th>Location</th>
<th>Material</th>
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</thead>
<tbody>
<tr>
<td>![Joint Closure]</td>
<td>Latex Modified Concrete</td>
</tr>
<tr>
<td>![Joint Closure]</td>
<td>ECC: 2% PVA Fibers (0.4&quot;)</td>
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<tr>
<td>![Joint Closure]</td>
<td>HyFRC: Synthetic Fibers 1.2% PP (2&quot;)</td>
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<tr>
<td>![Joint Closure]</td>
<td>HyFRC: 0.6% Steel Fibers (2.4&quot;)</td>
</tr>
<tr>
<td>![Overlay]</td>
<td>Silica Fume Concrete</td>
</tr>
<tr>
<td>![Overlay]</td>
<td>Latex Modified Concrete</td>
</tr>
<tr>
<td>![Overlay]</td>
<td>Low Cracking Shrinkage Reducing Admixture</td>
</tr>
<tr>
<td>![Overlay]</td>
<td>Low Cracking Lightweight Coarse Aggregate</td>
</tr>
<tr>
<td>![Overlay]</td>
<td>Low Cracking Partial Lightweight Fine Aggregate</td>
</tr>
</tbody>
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Closure Pours and Overlays

WBL Rehabilitation: Fall-2014
EBL Rehabilitation: Summer-2015

SFC – Silica Fume Concrete
LW – Lightweight
SRA – Shrinkage Reducing Admixture
LMC – Latex Modified Concrete
Bearing Retrofit

- New Elastomeric Bearing Pads
- Abutment Pedestal Reconstruction
-Jackings
- Bearings at Pies
- New Elastomeric Bearing Pads
Micro-Virginia Abutment
(Scaled-down version of VA Abutment)

EXPRESSION JOINT RECONSTRUCTION (TYPE C)
Micro-VA Abutment Construction
Deck Extension & Drainage Trough
Closure Pours Can Crack

Numerous Shrinkage Cracks in the span continuity closure pour
## Project Goals

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<table>
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<tbody>
<tr>
<td><strong>Closure Pours</strong></td>
<td>3,000 psi in 24 hours*</td>
<td>Crack control: No or very tight cracks (&lt;0.1 mm) with fibers</td>
</tr>
<tr>
<td><strong>Overlays</strong></td>
<td>3,000 psi in 72 hours*</td>
<td>SFC with LW aggregates and SRA for crack control and low permeability</td>
</tr>
<tr>
<td><strong>Control material:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latex modified concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LMC) with rapid set cement</td>
<td>3,000 psi in 2.5 hours</td>
<td>Used in VA since 1997</td>
</tr>
</tbody>
</table>

*Using portland cements and supplementary cementitious material (SCM); fly ash, silica fume
SFC – Silica Fume Concrete
LW – Lightweight
SRA – Shrinkage Reducing Admixture
Joint Closure Pour

Dimensions:
- 16 feet long
- 4 feet wide
- 8-10 inches deep
- 2-3 yd³
Closure Pour Concretes

- **LMC**: Latex Modified Concrete with rapid set cement (control, no fibers)

- **ECC**: Engineered Cementitious Composite (“bendable concrete”) with PVA (polyvinyl alcohol) fibers (44 lb/yd³)

- **PP**: Polypropylene fibers (15 and 18 lb/yd³)

- **Steel fibers**: (66 and 80 lb/yd³)
Fiber Reinforcement

Steel with hooked ends

Polyvinyl alcohol

Polypropylene
Engineered Cementitious Composite (ECC)
Flexure Test - (Bendable Concrete) with PVA fibers
Engineered Cementitious Composite (ECC) Flexure Test - Deflection Hardening
Engineered Cementitious Composite (ECC)

Deflection

Tight cracks
(<0.1 mm)

Bottom
**Previous application of ECC by VDOT:**
Shear Keys - Route 645 Bridge
*(not Covington project)*

After 3 months, only ECC did not leak
Fibers added manually, some with bags, some without
Joint Closure Curing

“Wet” burlap covered with plastic for a day

Curing compound applied and opened to traffic
Joint Closure Curing - Monitoring

1-day 3,000 psi: monitored temperature and added accelerators
Temperature Development vs Age (ECC)
Fiber-Reinforced Concretes

**ECC – 44 lb/yd$^3$**

**Steel – 80 lb/yd$^3$**

**Polypropylene – 18 lb/yd$^3$**
Overlay Materials

- LMC with Rapid Set (control)
- Silica Fume Concrete (control)
- Silica Fume with shrinkage reducing admixture (SRA)
- Silica fume with lightweight aggregates
  - Lightweight coarse aggregate (<120 lb/ft$^3$ concrete density)
  - Internal curing with lightweight fine aggregate
Hydro-Demolition to Remove Deteriorated Concrete
Overlays

Mobile Mixer for LMC with Rapid Set

RMC Truck for Silica Fume Mixtures
Overlay Curing
Prompt application of wet burlap
First Survey Results Soon After Placement
Closure Pours
FRC: No cracks or very tight cracks (< 0.1 mm)
LMC: > 0.2 mm cracks

ECC with PVA fibers

LMC with Rapid Set No fibers

Tight crack

Other FRC had similar tight cracks
FRC Shrinkage Data

![Graph showing FRC Shrinkage Data with various curves for different materials and composition types. The graph plots Length Change (%) against Time (days). The materials include FRC w/ Steel, FRC w/ PP (1.0%), FRC w/ PP (1.2%), ECC, and LMC w Rapid Set. The y-axis ranges from 0 to -0.2, and the x-axis ranges from 0 to 120 days.]
Second Survey 10/26/15

WB bridge: over 1 year old (ECC and LMC with Rapid Set in closure pours, LMC with Rapid Set, SFC, SFC with SRA in overlays)

EB bridge: 3 - 4 months old (FRC with polypropylene and steel fibers in closure pours, LMC with Rapid Set, SFC with lightweight coarse aggregate or lightweight fine aggregate in overlays)
Polypropylene and steel fibers FRC: no cracks or cracks < 0.1 mm wide

ECC with PVA fibers: cracks < 0.1 mm wide with few as wide as 0.2 mm

LMC with rapid set and no fibers: cracks up to 0.4 mm and few as wide as 0.5 mm
Construction Joints were filled with Epoxy

Closure pours were exposed for visual performance evaluation. Typically, overlay would cover the closure pour eliminating the transverse joints.
Overlays 10/26/2015

- SFC: performing well (no or very tight cracks)
- LMC in left WB lane: cracks evident (high evaporation rate)
- LMC in right WB lane and EB bridge: no or very tight cracks
Overlay Shrinkage Data

Length Change (%)

Time (Days)

-0.08
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
-0.00
0
0.01
0 10 20 30 40 50 60 70

Rapid Set with Latex
Silica Fume with SRA
Silica Fume
Rapid-set Latex Modified Concrete Overlay

Extensive cracking
(Experienced high evaporation rate)
Similar observations in cracking as in the Second Survey:
FRC: tight cracks
Overlays: tight cracks but some areas extensive cracking attributed to high evaporation rate.
FRC Closure Pours

Even the FRC that did not deflection harden exhibits tight cracks. This is attributed to the presence of primary reinforcement in the closure pours.

Polypropylene – 18 lb/yd$^3$
Conclusions

- FRC with portland cements and SCM can be produced that achieves 3,000 psi within 24 hours.
- Overlay concretes with portland cements and SF reached 3,000 psi within 3 days, some within 1 day.
- Rapid Set with LMC achieves 3,000 psi within 3 hours
- Closure pours with FRC have tight cracks. Rapid set with LMC without fibers have wide cracks.
- SF overlays with SRA or lightweight aggregates are performing well with no or tight cracks
- Rapid set with LMC overlays are performing well except in limited areas due to high evaporation.
- Restoration cost I-64 EBL/WBL Bridges: $1.8-mil.
- Projected Bridge Life Extension: 30 years
Future Work

New study to address *Accelerated* strength development:

- Fiber Reinforced Concrete to gain 3,000 psi in 10 hours using portland cements and SCMs in truck mixers or mobile mixers
- Overlays to gain 3,000 psi in 24 hours using portland cements and SCMs in truck mixers or mobile mixers
- Strength investigation – threshold < 3,000-psi for opening to traffic
- Rapid Set with Latex Modified Concrete with Fiber Reinforcement
I-64 Bridge Rehabilitation Project over Dunlap Creek
Completed Project (WBL: 2014; EBL: 2015)

Thank you

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