Lightweight Concrete – VDOT Experiences for Bridge Decks & Overlays

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Outline

• Lightweight Concrete (LWC)
• VDOT deck applications with sand LWC
  ➢ Route 269 (old Route 60)
  ➢ Route 60 near Bueno Vista
  ➢ Route 33
• Low cracking concrete decks: LWC option
• All LWC
• VDOT overlay applications with sand LWC
  ➢ I-64 Dunlap Creek
• Conclusions
LWC Benefits

• Low modulus of elasticity and high inelastic strain capacity
• Internal moist curing
• Low thermal coefficient of linear expansion
• Improved contact zone between the aggregate and the paste
Pantheon

Almost 2,000 years old!

LWC dome
LWC Use

• Reduced loads on the substructure
• More efficient structural design
  (longer spans)
• Reduced cracking
• Improved durability
• Accelerated bridge construction
VDOT Field Applications

• Since 1961 mainly in deck widening projects.

• Mainly LW coarse aggregate and normal weight fine aggregate (sand LWC) in beams, decks, and overlays. Maximum fresh density 120 lb/ft$^3$.

• All LWC; both fine and coarse aggregate LW in deck. Maximum density 105 lb/ft$^3$. 
Route 269 – 1979 LWC Deck

212-ft long two span, LW aggregate absorption=18%
No transverse cracks at the 33 year visit
Route 269

Laboratory freeze-thaw testing
Field performance satisfactory
Freezing and Thawing – ASTM C 666

Two weeks moist cure and at least 1 week drying and tested in 2% NaCl solution. ASTM C 330 indicates 2 weeks drying.
Route 269 – 1983 Pictures
Route 269 – 2008 Pictures
No visual change between the 1983 and 2008 pictures indicating satisfactory freeze-thaw and abrasion/wear resistance!
Route 60 over Maury River - 1984
Skew, some exposed aggregates, no cracks at 30 year visit, good performance
• Over the Mattaponi River, 3,454-ft long bridge - 2,195 ft with lightweight concrete beams and deck.

• Over the Pamunkey River, 5,354-ft long bridge - 2,169 ft with lightweight concrete beams and deck.

• 200 and 240 ft spans in four-span spliced girders; and > 120 ft spans in continuous for LL units.
Route 33 over Mattaponi River

LWC deck = 5,000 psi
LWC beam = 8,000 psi
LW CA absorption = 5% to 6%
Route 33 over Pamunkey River
Route 33 over Pamunkey River

Ground section. Deck is performing satisfactorily!
Low Cracking Deck Study - LWC

2012
(i) Winchester, Staunton District
(ii) Lynchburg District
(iii) Opal, Culpeper District

2013
(iv) Nokesville, NOVA District
(v) Fredericksburg District
(vi) Richmond District

2014
(vii) Stafford, NOVA
Opal Bridge - 2012

Two 128’ spans
4 beams per span with LW SCC, LWC deck
Low Cracking Deck Study - LWC

Winchester (2 Years)

No Crack

Opal (1 ½ Years)

No crack on LWC deck. Cracks in NWC approach slab

Lynchburg (1 ½ Years)

After 2 winters no cracks on deck

I-95 Expressway, Stafford (6 months)

No Crack
Low Cracking Decks

Drying shrinkage cracking can be minimized with the use of one or more of the following options:

- LWC with LW coarse aggregate
- Normal weight Concrete (NWC) with SRA (shrinkage reducing admixture)
- Shrinkage Compensating Concrete (Type K)

Proper concrete placement, consolidation and curing are important.
Normal weight concrete: total cementitious materials content shall be $\leq 600 \text{ lb/} \text{yd}^3$. If 28-day drying shrinkage is $> 0.035\%$, SRA shall be used to reduce the shrinkage to acceptable level.

Lightweight concrete: total cementitious materials content shall be $\leq 650 \text{ lb/} \text{yd}^3$ and the maximum fresh density shall be $\leq 120 \text{ lb/} \text{ft}^3$. 
All LWC

- Route 198 (Dutton Road) over Harper Creek
- Cast-in place all LWC deck, backwalls, parapets, and substructure modifications with a maximum density of 105 lb/ft$^3$ (2016)
LWC Overlays on I-64 over Dunlap Creek
Overlays on I-64

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

RSLMC – Rapid set with Latex Modified Concrete
SFC – Silica Fume Concrete
LWCA – Lightweight coarse aggregate, PLWFA – Partial lightweight fine aggregate,
SRA – Shrinkage Reducing Admixture
LWC Overlays on I-64

Prepared in RMC Truck
Hydro-Demolition to Remove Deteriorated Concrete
Overlay Curing
Prompt application of wet burlap
# Mixture Proportions (lb/yd³)

<table>
<thead>
<tr>
<th>Material</th>
<th>SFC- LWCA</th>
<th>SFC-PLWFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I/II portland cement</td>
<td>632</td>
<td>612</td>
</tr>
<tr>
<td>Silica fume</td>
<td>48</td>
<td>46</td>
</tr>
<tr>
<td>LWCA, ½ in</td>
<td>790</td>
<td>----</td>
</tr>
<tr>
<td>Normal weight CA, ½ in</td>
<td>----</td>
<td>1600</td>
</tr>
<tr>
<td>LWFA</td>
<td>----</td>
<td>495</td>
</tr>
<tr>
<td>NWFA</td>
<td>1486</td>
<td>645</td>
</tr>
<tr>
<td>w/cm</td>
<td>0.40</td>
<td>0.41</td>
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</tbody>
</table>
## Compressive Strength – EBL

<table>
<thead>
<tr>
<th>Test</th>
<th>Age (d)</th>
<th>SFC-LWCA</th>
<th>SFC-PLWFA</th>
<th>RSLMC</th>
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</thead>
<tbody>
<tr>
<td>Compressive strength (psi)</td>
<td>1</td>
<td>3180</td>
<td>2960</td>
<td>3690*</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4010</td>
<td>3760</td>
<td>----</td>
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<tr>
<td></td>
<td>28</td>
<td>5930</td>
<td>6200</td>
<td>5280</td>
</tr>
</tbody>
</table>

*3.5 hours 3020 psi
EBL

Length Change (%)

Time (days)

SFC-LWCA1
SFC-LWCA2
SFC-LWCA3
SFC-LWCA4
SFC-PLWFA1
SFC-PLWFA2
SFC-PLWFA3
LWC Overlays on I-64

- SFC with lightweight coarse aggregates or partial weight fine aggregate had shrinkage values as high as 0.06%.
- Exhibited tight cracks (less than 0.1 mm).
Conclusion

• LWC properly consolidated and cured is performing satisfactorily.

• LWC has reduced cracking potential.

• LWC even with drying shrinkage values considered high for NWC has been performing well.
Acknowledgements

- FHWA
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Thank You.