VIRGINIA SELF-CONSOLIDATING CONCRETE BRIDGE PROJECTS

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AASHTO Subcommittee on Construction
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VIRGINIA SELF-CONSOLIDATING CONCRETE BRIDGE PROJECTS

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VDOT
Outline

• Why Self Consolidating Concrete
• Benefits and concerns
• Tests
• Bridge projects
  – Bebo arch
  – Bulb-T beams
    • Normal weight
    • Lightweight
Self Consolidating Concrete
Why Self Consolidating Concrete?
High Workability
Consolidation
Smart Road Bridge

regular HPC column exhibits poor consolidation
Corrosion

Poor consolidation
Benefits

- No consolidation concerns
- Faster construction
- Reduced noise and increased safety because vibrators are not used
- Less labor required
- Smoother surface finish
Regular Concrete
Self Consolidating Concrete
Smooth Surface Finish
SCC Concerns

- Loss of stability, segregation
- Air-void system
- Increased shrinkage
- Formwork pressure and tightness
Formwork
Materials and Testing
SCC Mix Designs

- Higher cementitious material
- Lower coarse aggregate content
- Increased fine aggregate
- Smaller maximum size aggregate
- Polycarboxylate based HRWRA
- Viscosity modifying admixture
Aggregate

- Maximum size
- Shape, texture, void content
- Difference in density between the coarse and fine aggregates
- Grading
- Combined grading
No Segregation

Tube of SCC 4 ft long
Freeze-Thaw Resistance

Poor resistance

Good resistance
SCC Tests

24 in
L-box and U-Box
Bridge Applications

- Arch Bridge, 2001
- Test Beams, 2003
- Rte 33 Beams, 2005
SCC Arch Bridge (2001)
## Arch Bridge Mix Proportions (lb/yd³)

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>488</td>
</tr>
<tr>
<td>Slag</td>
<td>262</td>
</tr>
<tr>
<td>Fine/Coarse aggregate</td>
<td>50/50</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>#68</td>
</tr>
<tr>
<td>w/cm</td>
<td>0.37</td>
</tr>
</tbody>
</table>

AEA, HRWRA, no VMA
## Arch Bridge Properties at 28 Days

<table>
<thead>
<tr>
<th>Batch</th>
<th>Comp. Strength (psi)</th>
<th>Avg. Perm. (coul)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unrodded</td>
<td>Rodded</td>
</tr>
<tr>
<td>Slag #1</td>
<td>7390</td>
<td>----</td>
</tr>
<tr>
<td>Slag #2</td>
<td>7670</td>
<td>8020</td>
</tr>
</tbody>
</table>

- 8,000 psi
- 1500 coulombs
- 45 in deep
- 60 ft long
# Bulb-T Mix Proportions

<table>
<thead>
<tr>
<th>Materials</th>
<th>Amount, lb/yd³</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>480</td>
</tr>
<tr>
<td>Slag</td>
<td>320</td>
</tr>
<tr>
<td>Fine/Coarse agg (%)</td>
<td>50/50</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>#67</td>
</tr>
<tr>
<td>w/cm</td>
<td>0.33</td>
</tr>
</tbody>
</table>

AEA, HRWRA, and VMA
<table>
<thead>
<tr>
<th>Property</th>
<th>B1</th>
<th>B2</th>
<th>B2 Rodded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comp (psi)</td>
<td>8340</td>
<td>8800</td>
<td>8520</td>
</tr>
<tr>
<td>Permeability (coulomb)</td>
<td>750</td>
<td>533</td>
<td>664</td>
</tr>
</tbody>
</table>
SCC Test Beam
Instrumentation

- Vibrating wire gages
- Thermocouples
SCC Test Beam

Developed theoretical ultimate moment and shear capacity.
Rte 33 over Pamunkey River (2005)
### Rte 33 Mix Proportions (lb/yd³)

<table>
<thead>
<tr>
<th>Material</th>
<th>SCC</th>
<th>Regular</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>480</td>
<td>510</td>
</tr>
<tr>
<td>Slag</td>
<td>320</td>
<td>340</td>
</tr>
<tr>
<td>CA</td>
<td>1451</td>
<td>1731</td>
</tr>
<tr>
<td>FA</td>
<td>1411</td>
<td>1029</td>
</tr>
<tr>
<td>Water</td>
<td>272</td>
<td>336</td>
</tr>
<tr>
<td>w/cm</td>
<td>0.34</td>
<td>0.40</td>
</tr>
<tr>
<td>VMA (fl. oz./yd³)</td>
<td>23</td>
<td>0</td>
</tr>
</tbody>
</table>

AEA, WR+R, HRWRA, and DCI were used.
# Rte 33 Properties at 28 Days

<table>
<thead>
<tr>
<th>Property</th>
<th>B1 (SCC)</th>
<th>B2 (SCC)</th>
<th>B3 (Regular)</th>
<th>B4 (Regular)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comp. (psi)</td>
<td>10,110</td>
<td>10,700</td>
<td>7,960</td>
<td>7,610</td>
</tr>
<tr>
<td>E ($10^6$ psi)</td>
<td>4.86</td>
<td>5.35</td>
<td>5.26</td>
<td>4.98</td>
</tr>
<tr>
<td>Splitting (psi)</td>
<td>820</td>
<td>755</td>
<td>675</td>
<td>565</td>
</tr>
<tr>
<td>Perm (coul)</td>
<td>869</td>
<td>996</td>
<td>1,011</td>
<td>985</td>
</tr>
</tbody>
</table>
Bugholes – Rte 33

SCC

Regular
SCC Beams – Rte 33
<table>
<thead>
<tr>
<th>Fiber Reinforced SCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Evaluate the feasibility of fiber reinforced self consolidating concrete.</td>
</tr>
<tr>
<td>• Evaluate the workability, flowability and consolidation of fiber reinforced self consolidating concrete.</td>
</tr>
<tr>
<td>• Physical testing to assess the degree of consolidation, strength, modulus of elasticity, and tensile/flexure performance relative to crack control and durability.</td>
</tr>
<tr>
<td>• Target Date October 2006</td>
</tr>
</tbody>
</table>
Lightweight SCC

- Bridge: Rte 17 over Rte 15/29 in Fauquier County
- Two spans, each 97 ft 7 in.
- 53 in Bulb-T beams
- Minimum 8,000 psi and maximum 1500 coulombs
- Target Date June 2011
Conclusions

• SCC with high workability, proper strength, and adequate durability can be produced using locally available materials.

• Attention must be paid to formwork, segregation, the air-void system, and shrinkage
Conclusions

• Check the air-void system

• Increase air content or select the right combination of admixtures to obtain a satisfactory air-void system

• Reduce shrinkage by using more and larger coarse aggregate, and low water content

• Decrease segregation by using more fines and well-graded combined aggregates, and a VMA (if necessary).
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