Steel Fiber Reinforced Concrete Overlays for Bridges

Missouri Department of Transportation
March 10, 2016
WHY??????
WHY????

L0745  08-19-14
IS 270 E over Rte N
Span 2 Underdeck
Protective Mesh Fence Panels to Catch Spalling Deck
Installed by MoDOT BM July 2014
WHY?????

L0745 St. Louis Co. 8-3-15
EB I-270 over Rte N
Bottom Span 2
L0745 St. Louis Co. 8-3-15
EB I-270 over Rte N
Bay Span 1 Heavy Saturation
L0745 St. Louis Co. 8-3-15
EB I-270 over Rte N
Girder 1 - Span 1 - Heavy Eff.
15% Section Loss - South Face
A0628 Cape Girardeau US 61
Span #2, South side patches and Efflorescence
Options

- Redeck - depends on structure type / condition / traffic & future “plans”
- Replace – traffic impacts & future “plans”
- Hydro Demolition with Latex Concrete Wearing Surface
- Partial / Full Depth Repair with Wearing Surface
- Continue cycle of patching – wait for divine intervention
- Explore other options
SFRC Overlay

- Option of Steel Fiber or Woven Wire Fabric
- Modified Deck Repair
- 45# of Fiber in B2
- 1”-1.5” Fibers ASTM A820
- 2000 Fibers / Pound
- Aspect Ratio of 40 – 60
- 4” nominal thickness
- Dead Load
- Curbs / Safety
Construction – L0745
Construction – L0745
Steel Fiber Concrete Testing

- **Strength**
  - Compressive strength (AASHTO T22)
  - Split tensile strength (AASHTO T198)
  - Modulus of rupture (AASHTO T177)

- **Permeability**
  - Permeable voids (ASTM C642)
  - Surface resistivity (AASHTO T-358)

- **Freeze-Thaw Resistance**
  - AASHTO T161

- **Slump/Air**
  - AASHTO T119/AASHTO T152
Steel Fiber Properties

- ASTM A820 Type II
- Minimum tensile strength: 50 ksi
- Cut sheet steel
- Crimped
- Length: 1”
- Diameter: 0.02”
## Mix Designs

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
<th>No Fibers</th>
<th>With Fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>pcy</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>pcy</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Slag</td>
<td>pcy</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Total Cementitious</td>
<td>pcy</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Water</td>
<td>pcy</td>
<td>250</td>
<td>250</td>
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<tr>
<td>W/C Ratio</td>
<td></td>
<td>0.42</td>
<td>0.42</td>
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<tr>
<td>Design Air</td>
<td>%</td>
<td>6.0</td>
<td>6.0</td>
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<tr>
<td>Coarse Aggregate</td>
<td>pcy</td>
<td>1793</td>
<td>1778</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>pcy</td>
<td>1223</td>
<td>1223</td>
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<tr>
<td>Fibers</td>
<td>pcy</td>
<td>0</td>
<td>45</td>
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<tr>
<td>AEA dose</td>
<td>oz/cwt</td>
<td>0.551</td>
<td>0.586</td>
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<tr>
<td>WR dose</td>
<td>oz/cwt</td>
<td>9</td>
<td>9</td>
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</tbody>
</table>
Compressive Strength (with and without steel fibers)

![Bar chart showing compressive strength at different ages and with or without steel fibers.](image-url)
Modulus of Rupture
(with and without steel fibers)

![Bar Chart](image)

- **Average Modulus of Rupture (psi)**
  - No Fibers
  - With Fibers

- **Age (days)**
  - 35 days

3/22/2016
Split Tensile Strength (with and without steel fibers)
Surface Resistivity (with and without steel fibers)

![Bar graph showing average surface resistivity (kiloohm*cm) at 28 days of age, comparing samples with and without fibers.](image)
Permeable Voids (with and without steel fibers)
Durability Factor (with and without steel fibers)
# Steel Fiber Effects Summary

<table>
<thead>
<tr>
<th>Test</th>
<th>Change</th>
<th>Change (% of control - no fibers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump</td>
<td>Decreased</td>
<td>-¹⁄₄” to -1”</td>
</tr>
<tr>
<td>Air Content (pressure-method)</td>
<td>Decreased</td>
<td>Variable</td>
</tr>
<tr>
<td>Compressive Strength (1,7,28-day)</td>
<td>-</td>
<td>-1% to -4%</td>
</tr>
<tr>
<td>Modulus of Rupture (35-day)</td>
<td>Increased</td>
<td>+8%</td>
</tr>
<tr>
<td>Split Tensile Strength (28-day)</td>
<td>Increased</td>
<td>+4%</td>
</tr>
<tr>
<td>Surface Resistivity (28-day)</td>
<td>Decreased</td>
<td>-36%</td>
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<tr>
<td>Permeable Voids (28-day)</td>
<td>-</td>
<td>+2%</td>
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<tr>
<td>Durability Factor</td>
<td>-</td>
<td>+3%</td>
</tr>
</tbody>
</table>
Finishing Steel Fiber Concrete
Steel Fiber Concrete Sample After Split Tensile Test
Steel Fiber Concrete Samples
After Split Tensile Test
Steel Fiber Concrete Sample After Split Tensile Test
Steel Fiber Concrete Sample After Modulus of Rupture Test
Steel Fiber Concrete Sample After Modulus of Rupture Test
Additional Steel Fiber Effects

- Fibers stick out of concrete
  - Harder to finish
  - Sharp ends
- Fibers held tensile test specimens together
  - Fibers bridged fracture plane, keeping test specimens in one piece
- Concrete clumps
  - One steel fiber manufacturer notes that clumps can form in steel fiber concrete
Conclusion

L0745  St. Louis Co.  9-15-2015
WB I-270 & Rt. N
Many open cracks in new unbonded overlay