Fiber-Reinforced Polymer (FRP)

Composite Bridge Decking for Moveable Bridges

A Highways for LIFE Project

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Delivering innovative technology.

20 yr. DOT Experience

10 yr. Research at Buffalo

Technology Deployment

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Highways for Life (HfL)  
Technology Partnerships Program

“... The purpose of the Technology Partnership Program is to work with the highway construction industry to accelerate the adoption of promising innovations. “
Composite Bridge Decking for Moveable Bridges

Needs

- Light-weight
- Solid surface (protect superstructure, capture runoff, smooth & quiet ride)
- No rust or fatigue issues
- Long term durability (e.g. wearing surface bond and skid resistance)
- Affordable cost
- Adaptable to different situations
Problem

- There are few good alternatives for lightweight decks that are needed on moveable bridges. The original design on many bridges called for open steel grating but this is no longer considered a prudent choice.
- FRP decking is light but proprietary systems have limited competitiveness.
- There have been some troubles with wearing surfaces.
Design Approach -
Priority of Design Parameters

1. Performance
   - Strength - given
   - Stiffness – very important because it affects serviceability issues and long term durability (cracking/spalling of wearing surface, deterioration of attachment detailing and panel-panel joints)

2. Constructability

3. Weight

4. Cost

5. Speed of installation
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Description
Composite Bridge Decking for Moveable Bridges

d=4 ½”
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Composite Bridge Decking for Moveable Bridges
## Composite Bridge Decking for Moveable Bridges

<table>
<thead>
<tr>
<th>Panel type</th>
<th>Weight</th>
<th>Weight w/ thin wearing surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty</td>
<td>16 psf</td>
<td>20 psf</td>
</tr>
<tr>
<td>Alternating E-grout</td>
<td>27 psf</td>
<td>31 psf</td>
</tr>
<tr>
<td>E-grout in top cells</td>
<td>24 psf</td>
<td>28 psf</td>
</tr>
<tr>
<td>Empty but enhanced with carbon fiber</td>
<td>16 psf</td>
<td>20 psf</td>
</tr>
</tbody>
</table>

Depth: 4 7/8”
Composite Bridge Decking for Moveable Bridges

“Details”

- Connection to supporting steel
- Cross slope and haunch provisions
- Field Joint between panels
- Wearing surface
- Bridge railing
Cross Slope & Haunch

Pre-fab

5/8” STAINLESS STEEL HOLLO-BOLT

T/ EXIST. STEEL REF. ELEV. 0'-0"

FASTENING CLIP

EXISTING W21 GIRDER
Wearing Surface

1st course: 3/8” stone shop applied w/ adhesive

2nd course: field applied for a total depth of 5 3/8”
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Field Joints

Seal with aluminum tape

Fill on-site with E-grout
Railing
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Analysis / Testing
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- **Coupon Testing**
- **Subcomponent Testing**
- **3'x10' Test Panels**
- **Proof-Test Details**
- **Load Test**
- **NDE/SHM**
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Material Testing

Tube Testing

Panel Testing
  • Flexure
  • Fatigue
  • Ultimate
  • Shear
  • Local deformation
  • Fire resistance
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3 Panel Types
Composite Bridge Decking for Moveable Bridges

Fatigue test

Fatigue Testing
Flexure Testing (Positive & Negative Bending Moment)
10’ span
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Wide side down

Wide side up

Similar response in + and - bending
Consistency among Panels
(empty panels at 10’ span)
## Composite Bridge Decking for Moveable Bridges

### Summary of Empty Panel Tests

**10’ span**

<table>
<thead>
<tr>
<th>Panel ID No.</th>
<th>Instrument used</th>
<th>Cross-section position</th>
<th>Max or Failure Load (kips)</th>
<th>Displacement at max or failure load (inch)</th>
<th>Flexural stiffness k (kip/inch)</th>
<th>Tested date</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>String pot &amp; LVDT &amp; 110 kips load cell</td>
<td>WSU, WSD</td>
<td>20</td>
<td>1.38, 1.39</td>
<td>14.49, 14.4</td>
<td>05/23/2012</td>
</tr>
<tr>
<td>#2</td>
<td>String pot &amp; LVDT &amp; 110 kips load cell</td>
<td>WSD</td>
<td>20</td>
<td>1.37</td>
<td>14.72</td>
<td>05/22/2012</td>
</tr>
<tr>
<td>#3</td>
<td>String pot &amp; LVDT &amp; 110 kips load cell</td>
<td>WSD</td>
<td>20</td>
<td>1.44</td>
<td>14.32</td>
<td>05/22/2012</td>
</tr>
<tr>
<td></td>
<td>String pot &amp; 110 kips load cell &amp; 2 strain gages</td>
<td>WSD</td>
<td>61 (fail) crush at top</td>
<td>4.45</td>
<td>13.91</td>
<td>05/24/2012</td>
</tr>
<tr>
<td>#4</td>
<td>String pot &amp; LVDT &amp; 110 kips load cell &amp; 1 strain gage</td>
<td>WSD</td>
<td>20</td>
<td>1.4</td>
<td>14.05</td>
<td>05/22/2012</td>
</tr>
</tbody>
</table>
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Failure Mode
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Empty Panel taken to Failure: 10-ft span
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Panel testing at 2-ft c.c. support
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Panel #5-epoxy-WSD

Panel #6-epoxy-WSU
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Summary
Penn State Conclusions

1. Tubes are very elastic.
2. Alternating epoxy grout increases panel stiffness by 45%.
3. Symmetrical section is good for + & - bending.
4. Failure mode of unfilled section is compressive failure of tubes. Panel partially recovers with lessened capacity after crushing.
5. Fatigue results in very small loss of stiffness.
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Summary

1. Strength demands are easily met.
2. Empty section is sufficiently stiff for close stringer spacing. (2’ to 3’ c.c.)
3. Alternatives to grout are available to provide stiffness.
4. 5 3/8” deck weighs 16 psf w/o grout or wearing surface.
5. Pliable adhesive ensures bond of wearing surface.
6. Options exist for attaching and providing cross slope.
7. Low modulus epoxy grout is used to prevent cracking at field joints.
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Next Steps

1. Proof of Concept Deck Installation
2. Compare field data to FEA

Future Demonstration Project