CICI - Industrial Recruitment Meeting

Manufacture, Design and Implementation of Panels and Structural Shapes

Hota GangaRao, Ray Liang and PV Vijay
ghota@mail.wvu.edu

October 22, 2008
FRP Composite Panels

For extremely wide range of applications:
- wall, floor, roof, housing,
- bridge deck, pavement, board walk,
- bulkhead, marina…….
Prospective Market: Bridge Decks

- $50 B was spent on highways and bridges in 1999
- $8.1 B Federal funded bridge projects in 2002
- $2-3 B estimated bridge decks annual market

The Lions Gate Bridge (Vancouver, British Columbia, Canada) truss and deck sections were replaced during 10-hour night closures.
Bridge Decks

Prodeck 8 Composite Deck

Prodeck 4 Composite Deck
FIELD DEMONSTRATION
Market Street Bridge, Wheeling, WV – Jointless Bridge

GENERAL INFORMATION
Location: Ohio County, Wheeling, WV
State District Number: 6
Owner: West Virginia Division of Highways
Contractor: JD & E Associates; Wheeling, WV
Date of Construction Completion: July 2001
Superstructure: Steel plate girders
Deck Type: FRP- Creative Pultrusion: Superdeck™

GEOMETRY
Number of Spans: 1
Out-to-Out Length: ~180’
Center-to-Center Bearing Length: 177’
Skew: 0°
Number of Lanes: 2
Deck Width: 56’
No. of Steel Girders and Spacing: 7 at 8’-6”
FRP Pavement Panel

Central I-beam (112 ft. long)

I-Beams on left side (12ft. 6 inches)

Edge I-beam flanges may be trimmed to obtain C-shaped channel

13 ft 13 ft

8.7 ft 8.7 ft

Direction of hollow core cells

Figure 2: Panel layout and connections

New University High School
Morgantown, WV
Rapid Housing

FRP composite home being erected at BRP Inc. manufacturing facility
Waterfront Structures

- $3.4 billion U.S. marina decking industry
- Est. 5.1 billion board feet market by 2005

(Marina Today, July 2002)
Gel-Coated Composite Panels for Trailer Siding
# Summary of Potential Market Impact

<table>
<thead>
<tr>
<th>Applications</th>
<th>Annual market</th>
<th>Projected FRP market share</th>
<th>Projected FRP annual market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway signposts</td>
<td>$100-200 million</td>
<td>10%</td>
<td>$15 million</td>
</tr>
<tr>
<td>Guardrail posts</td>
<td>$50 million</td>
<td>5%</td>
<td>$2.5 million</td>
</tr>
<tr>
<td>Guardrail railing</td>
<td>$180 million</td>
<td>5%</td>
<td>$9 million</td>
</tr>
<tr>
<td>Bridge decks</td>
<td>$2-3 billion</td>
<td>2%</td>
<td>$50 million</td>
</tr>
<tr>
<td>Utility poles</td>
<td>$4 billion</td>
<td>5%</td>
<td>$200 million</td>
</tr>
<tr>
<td>Natural gas pipes</td>
<td>$8 billion</td>
<td>2%</td>
<td>$160 million</td>
</tr>
<tr>
<td>Marina decks</td>
<td>$3.4 billion</td>
<td>5%</td>
<td>$170 million</td>
</tr>
<tr>
<td>Army bridging</td>
<td>$40 million</td>
<td>10%</td>
<td>$4 million</td>
</tr>
<tr>
<td>Air Force towers</td>
<td>$40 million</td>
<td>10%</td>
<td>$4 million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$18.36 billion</strong></td>
<td><strong>Overall 3.35%</strong></td>
<td><strong>$615 million</strong></td>
</tr>
</tbody>
</table>
A Case Study: The Pultrusion Program
ONR Grant No. N00014-04/05-1-0050/96

Objective
To demonstrate feasibility of an automated pultrusion process for producing composite sandwich panels (4’ x 3.5” x unlimited length) which results in a product with improved mechanical performance and reduced production cost in relation to VARTM process

Target panel: 1/4” FRP face sheets with 3” balsa core

Milestones: 2004 Pultruded GFRP vs. NSWC VARTM
2005 Pultruded GFRP vs. NGSS VARTM
2006 Pultruded CFRP
2007 High Temp Infused GFRP

Each ship would use ~ 200,000 sq ft of flat composite panel
Vacuum-Assisted Resin Transfer Molding (VARTM)

Seeman's Composite Resin Injection Molding Process (SCRIMP)
- Hybrid of VARTM and vacuum bagging
- Process developed and patented by Seemann's Composites
- Single-sided tooling
- Injection achieved through high-permeability surface layer to cause through-the-thickness flow
Pultrusion of GFRP Panel
High Temperature Resin Infusion Process

1) Placement of fabric
2) Applying resin for impregnation
3) Placement of core panel
4) Top moving oven in position
SEM Micrographs of Fiber/Resin Interface

- **Pultruded**
  - WVU 20.0kV 12.9mm x 100 SE(U) 7/29/2004
  - 500μm

- **VARTM**
  - WVU 20.0kV 15.7mm x 150 SE(U) 9/9/2004
  - 300μm

- **Pultruded**
  - WVU 20.0kV 12.9mm x 700 SE(U) 7/29/2004
  - 50.0μm

- **VARTM**
  - WVU 20.0kV 15.8mm x 800 SE(U) 9/9/2004
  - 50.0μm
The high performance of carbon fiber has not translated into a proportionate property improvement of CFRP composites over GFRP, due to the carbon sizing incompatible with VE. Carbon/epoxy should be recommended.
Finite Element Modeling of FRP Composite Sandwich Panels and Joints

Deflection contours by 3D orthotropic solid model for 40”x100” CFRP panel
Conclusions

• FRP composites can be used for a wide range of structural and non-structural panels in addition to conventional structural shapes, including wall panels, floor panels, pavement panels, bridge decks, marina dock panels, mining panels, housing panels, sound barrier boards, retaining wall, etc, with each representing a huge market potential.

• Certain technological innovations and breakthroughs are needed to arrive at economical and durable FRP composite products and systems.

• The objective will be to develop, evaluate and implement FRP composite panel systems with emphasis on joints and multi-functionality as well as design/manufacturing innovation and cost effectiveness.

• Yr 1 Deliverables: will provide design procedure for optimized FRP panel system with simplified connections as specified by Industry (e.g. pavement, housing, bridge deck, sound barrier…).