Light Weight Cantilever Sidewalk Using Prefabricated FRP Structures

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Examples and Design Study

• Demand and Design
• FRP Benefits
• FRP Deck Details
• The First: Tower Bridge, Sacramento
• Niagara, NY Example
  – Design Details
  – Weight
  – Cost
Local Objectives across the Nation: More Pedestrian and Bicycle paths

• Nationwide initiatives to increase bicycle lanes and pedestrian paths
• Bridges are constrictions
• Squeezing lanes or sidewalks on existing vehicle bridges is difficult and unsafe
• Erecting new bridges is costly
Share the Road: Cantilever Sidewalk

- Elegant solution is to cantilever a light weight pedestrian bridge off the vehicle bridge
- Fiber Reinforced Polymer (FRP) composites are an enabling material
FRP Composite Benefits

• Light Weight
  – Decking weights are 4 to 12 psf
  – Only 20% of reinforced concrete panels

• Prefabricated Bridge Elements
  – Accelerated construction
  – Incorporate features in shop fabrication
  – Higher quality parts
  – Lower installation cost

• Corrosion Resistance to chemicals and water
  – No Maintenance
  – Lower Life Cycle Cost
Typical FRP Construction

Fiberglass Fabric + Core Material + Resin

Strong, stiff fibers surrounded by Tough, environmentally resistant, polymers
FRP Sandwich Construction

- Consists of fiberglass facing skins on fiberglass webs in foam core
- Design flexibility (stiffness, strength, size)
- Embedded steel for concentrated loads and attachments
Functional Features

Drainage scupper with grating

Curbs

Expansion joint cover plate and curb cover
Sidewalk Features

- Crown or Cross slope
- Embedded steel for connections (rail post, clip)
Sidewalk Features

- Expansion joint at span ends
- Drainage scuppers
- Seal for panel-to-panel joints
Non-Slip Wear Surface

- Quartz aggregate in polymer
- High elongation (toughness); great adhesion to FRP
- Thickness of 1/8 to ¼ inch
- High traffic
- Many standard colors; UV stable
Deck Connection: Clips

- Mechanical connection
- Clips to capture any type of beam
- Provides vertical constraint; allows for longitudinal thermal expansion
- Bolted into embedded steel that is drilled and tapped
- Provides vertical constraint; allows for longitudinal thermal expansion
The First: Tower Lift Bridge, Sacramento

- Original 3’ concrete sidewalk too narrow to support current and future bicycle and pedestrian traffic

- Long-term growth of both riverfronts depend on safe and easy access

- Weight limitations for center lift span would not allow for desired 10’ concrete sidewalk width

- Solution is FRP decking on steel framing
FRP Panels, Steel Frame
Installation
Lift Span in Motion
Wilson Burt Bridge, Niagara, NY

- Bridge length of 441 feet
- Extend sidewalk width to 6’ -4”
Design Requirements

• Loads
  – Live load of 85 psf
  – Deflection limits of L/500 between supports
  – Uplift load of 30 psf
  – Temperature differential of 100°F

• Geometry
  – Floor beam spacing of 10’ – 10”
  – Cross slope of 1.76%
  – Rail posts
  – Expansion plates at bridge ends
Design Summary

• Deck sizing is driven by deflection criteria
  – Relatively low material modulus
  – Can adjust depth; facesheet thickness; and facesheet modulus
  – Slopes from 5” to 6 3/8”

• High strength safety factors
  – Bending SF>20
  – Shear SF=14

• Uplift load determines number of clips

• High natural frequency (22 Hz)
Deck Details

Cross Sloped Panels

Cross Section

Expansion Joint Step Down
Start of Sidewalk Installation

Existing W18x50

New W8x40

Existing W18x50
Fast Installation
Clip Connection to Floor Beam
Cantilever Bridge Weight

- Sidewalk Width: 6.375 ft
- FRP Deck Weight: 7.9 psf
- FRP Deck Weight: 50.4 lb/ft
- Railing Weight: 54.0 lb/ft
- Steel Weight: 54.0 lb/ft
- Total Dead Load: 158 lb/ft

- For 440 ft length,
  - Dead Load: 69,680 lb
  - Live + Dead Load: 275,380 lb

- Concrete deck on steel pan and supports would have added 180,000 lb more dead load
Cantilever Sidewalk Costs

- Deck: $274 /ft
- Railing: $189 /ft
- Beams and Install: $270 /ft (Steel, hardware, installation)
- Total Installed Cost: $733 /ft
  or $114 /sf
- Total for Wilson-Burt Sidewalk is $322,575.
Questions and Thank You

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• FRP bridge products are manufactured in Dayton, Ohio using domestic source materials

• Installation photos and videos
  – www.compositeadvantage.com
  – www.youtube.com/CompositeAdvantage