Procurement & Design of Composite Fender Piles to Meet MOTEMS

Presented by:

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Courtesy: NC State University & Lancaster Composites
Environmental Criteria for Piles

- **Restricted Treatments of Timber Piles**
  - Creosote – not allowed
  - ACZA – becoming restricted / prohibited

- **Alternative Piles**
  - Steel - $$$ and corrosion, driving windows
  - Concrete – also $$, driving windows
  - Coated or wrapped timber
    - Increased cost over untreated
    - Abrasion can lead to accessible core
  - Greenheart or Ipe Wood - $$$ & lead time
  - FRP composite piles ← today’s focus
Why Composite Piles: Life Cycle Cost

- ~$90 per LF for untreated pile every 1 to 3 years
- ~$250 per LF treated pile every 25+ years
What is a Composite Pile

- Fiber Reinforced Plastic (FRP)
  - Fiberglass Layers
  - Epoxy Resin
- Fiberglass Layer Orientation

M&N Recommends Concrete Fill

Stress

Strain

Mild Steel

ERP
ASTM D6109
• 4 Point Bending
• 5 Samples
• cyclic and to failure
• Moment & Stiffness

Modes of Failure - Bending
• Major concern is crushing of hollow FRP at top
• ASTM C496 – intended for concrete
• Concerned with abrasion, fatigue, etc.
• Optimally incorporate energy absorber at top

Modes of Failure - Connections

Courtesy: Harbor Technologies

Steel pipe with HDPE sleeve
Connection away From face
Fender Piles

Energy = \( \frac{1}{2} \cdot P \cdot d \)

- Want Flexibility and Strength
- High Hits \( \rightarrow \) Low Energy \( \rightarrow \) High Shears
Based on Elastic Response:

\[ E_{\text{fender}} = F_A \cdot C_b \cdot C_m \cdot E_{\text{vessel}} \]  

(3-16)

- Use tested values for strength & stiffness
- Verify for full range of vessel impact elevation
- Connection design per AISC, NDS, ACI depending on materials
- In many ways, similar to other methods
Concrete fill full height of pile because:

- Top of Pile Shear
- In-Soil Interface (no stiffness change)
Fatigue and Softening

- Fatigue may limit life
- Softening = more energy absorption
Don’t Mix with Timber Piles

- Stiffer pile steals all the load

Timber (16” Ø Douglas Fir $EI \approx 2E6 \text{ kip*in}^2$)

FRP (16” Ø $EI \approx 3E6 \text{ kip*in}^2$)
From UFGS 35 59 13.14 Type 5 (old, not perfect)

- Stiffness & Flexure (D6109)
- Crushing (ASTM C496)
- Density (D792)
- Water Absorption (D570)
- Brittleness (D746)
- Weatherability (D6662)
- Flame Spread (E84)
- Compressive Mod (D695)
- Tensile props (D638)
- Circumferential (D1599)
- Chemical Resistance (D543)
- Fiber percent by volume or weight
- Laminate void content

- Also need: HDPE sleeve, concrete fill, tolerance, and driving specs, etc.
• Drives similar to concrete or timber
• Drive pile, cut, place HDPE sleeve, connect
• Can also use driving shoes to close section at tip
- Piles available up to 115 ft in length
- Creates discontinuity in response, must be tested
- M&N recommends against using them
Possible as Bearing Pile

• Hollow: Global and local buckling
• As reinforced concrete section – is there a cost advantage?
• Connections – concrete plug or steel
• Lack of ductility (need to detail like timber)
Conclusions

- Composite Piles are cost effective vs timber over their lifespans
- Meet environmental requirements
- Require close coordination with manufacturer
- Can be MOTEMS compliant
Questions?

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