# BladeBridge: Three Design Options for a Pedestrian Bridge Made from Decommissioned 53 Meter Wind Turbine Blades

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RE-WIND NETWORK
BLADE REPURPOSING SOLUTIONS
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# Presentation Outline

1. **Introduction**
2. Three BladeBridge Concepts
3. Design
4. Conclusion

# Wind Turbine Blade Waste

- Estimated total of 43 million tonnes of wind turbine blade waste by 2050 [2]
- Waste is difficult to recycle and ends up in landfills or incinerated
- Repurposing wind-blades is the most sustainable end of life solution for these blades

*Benjamin Rasmussen, Bloomberg Green [1]*

# Previous BladeBridges

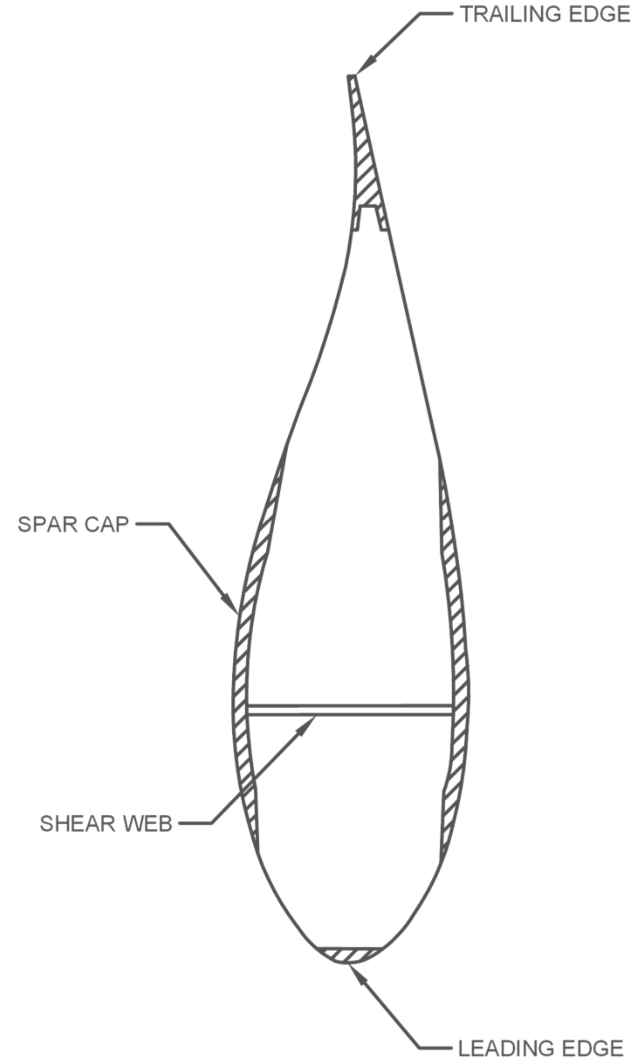
- Withstood 33 tonnes with only 9 mm of deflection at mid-span
- 6 meter span

# Previous BladeBridges

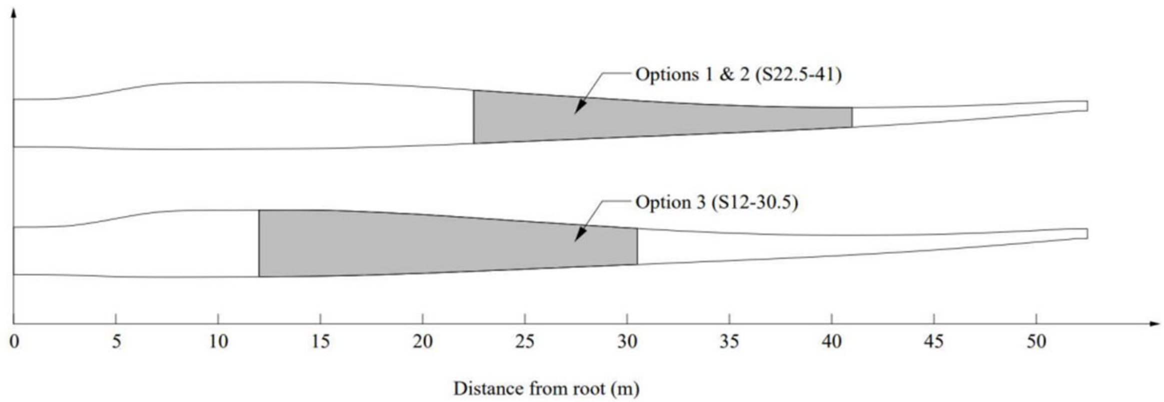
- BladeBridge installed in Ireland for pedestrian and cyclist use

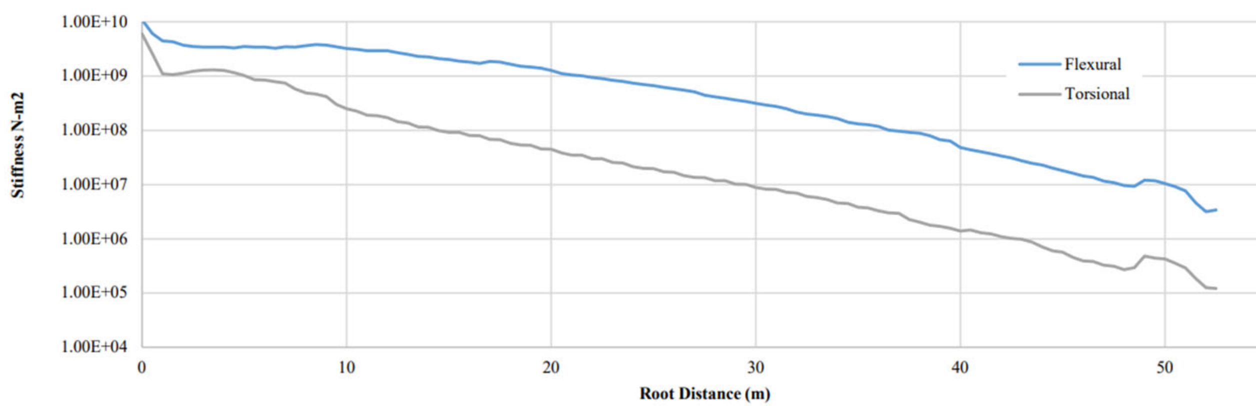
# Wind Blade Properties

- Composed of multiple layers laminated together
  - Balsa
  - Foam
  - GFRP
  - Gel Coating
- 2-3 meters wide and up to 60 meters or longer



# Wind Blade Properties



# Beaverbrook Park

- Difficult site access conditions
- Requires long span bridges to clear riparian buffer of river and protect existing trees

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# Option 1: Two Blade Simply Supported Bridge

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# Option 2: Two Blade Cantilever Bridge

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# Option 3: Single Blade Torsional Concept

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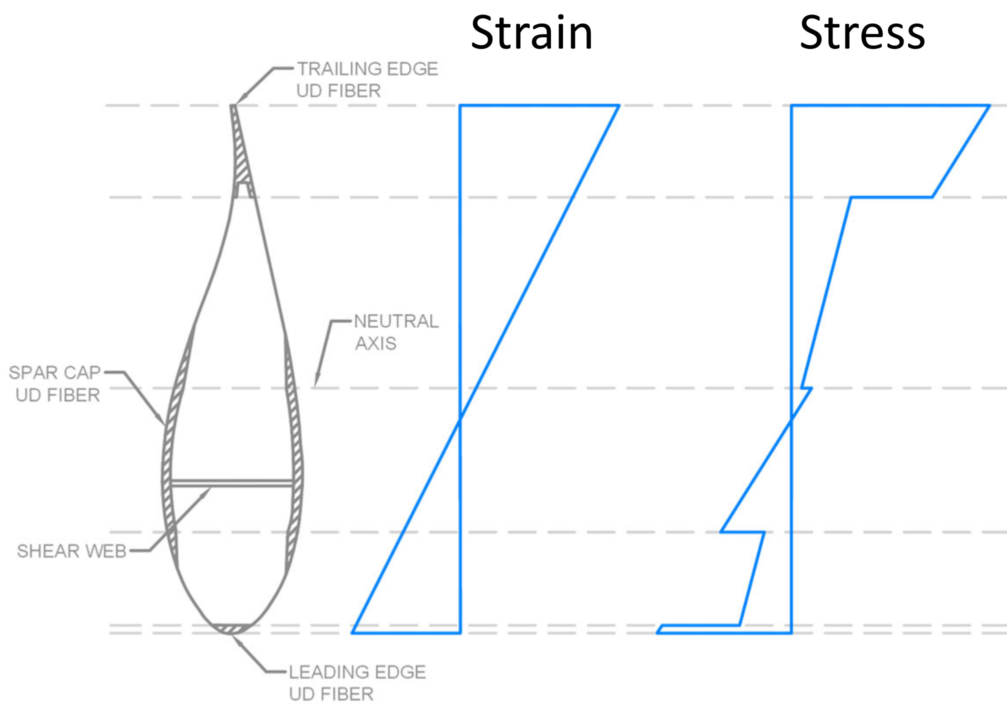
# Design Procedure

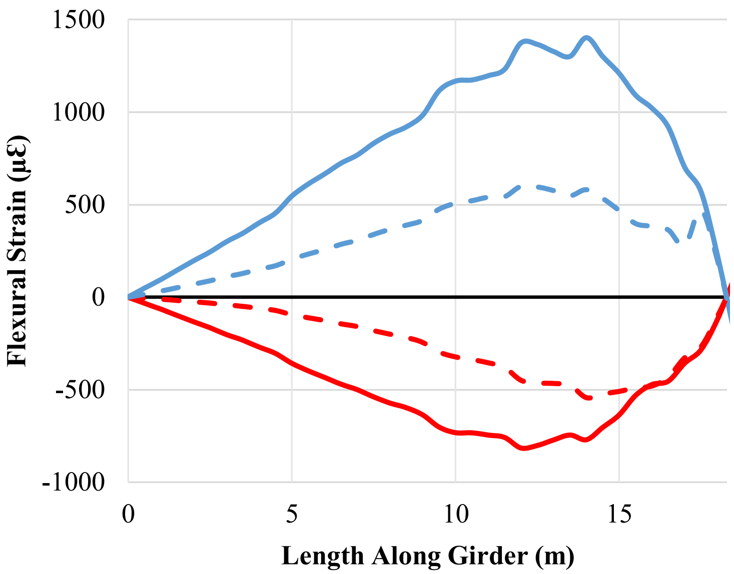
- 18.5-meter span, 2 meters wide
- 1.9 kN/m² dead load, 3.8 kN/m² live load
- Allowable Strength Design
- Unidirectional GFRP (hatched) has modulus of elasticity of 36.8 GPa [3]
- Rest of material has a modulus of 10 Gpa [4]



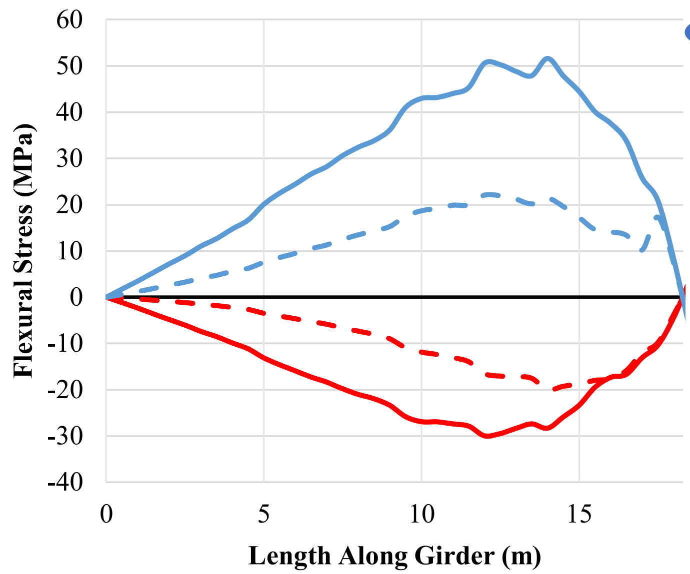
# Considered Limit States

- Material failure/strain limit
- Deflection: L/360
- Vibration from walking excitation
- Local buckling at trailing edge
- Local failure at abutments

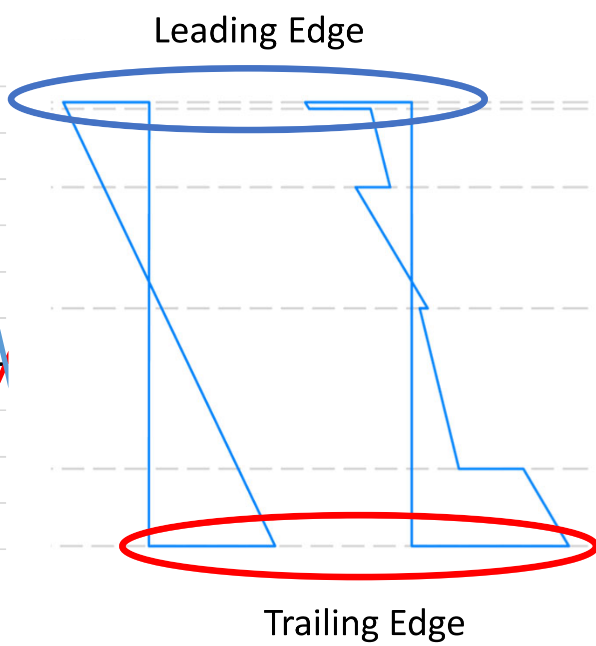
# Analysis Diagrams For Two Blade Simply Supported Design Option



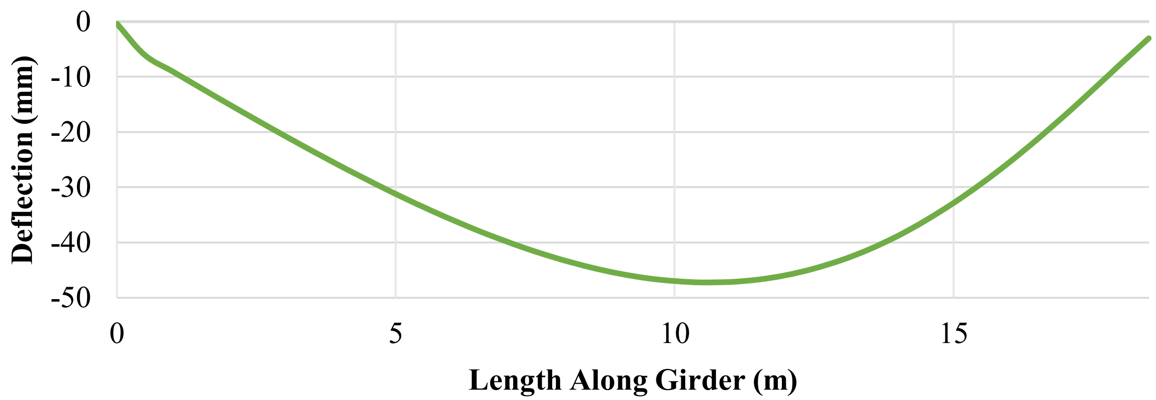

a) Flexural strain (microstrain) of uniaxial FRP along single girder.




b) Flexural stress (MPa) of uniaxial FRP along single girder.

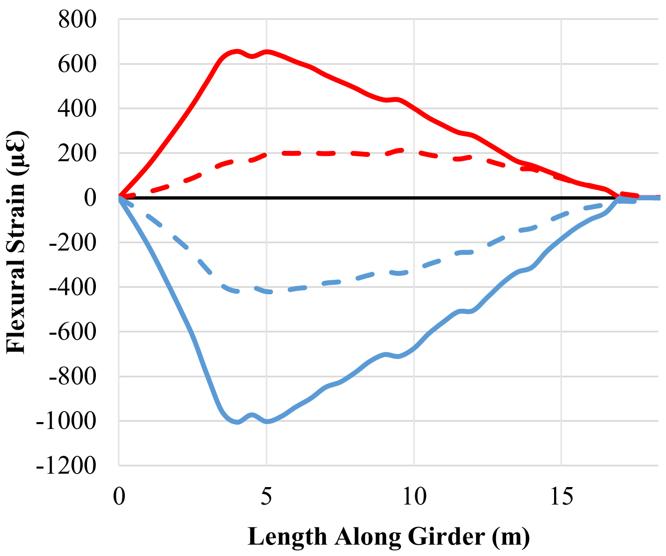


# Analysis Diagrams For Two Blade Simply Supported Design Option




c) Deflection (mm) along single girder

# Analysis Diagrams For Two Blade Cantilever Design Option

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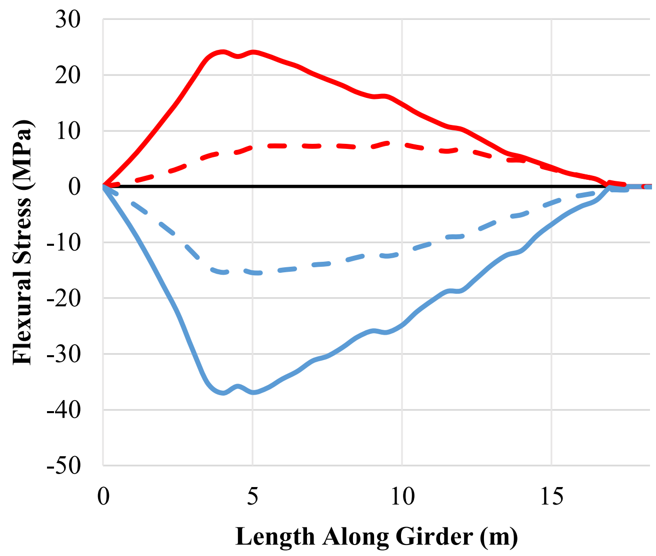


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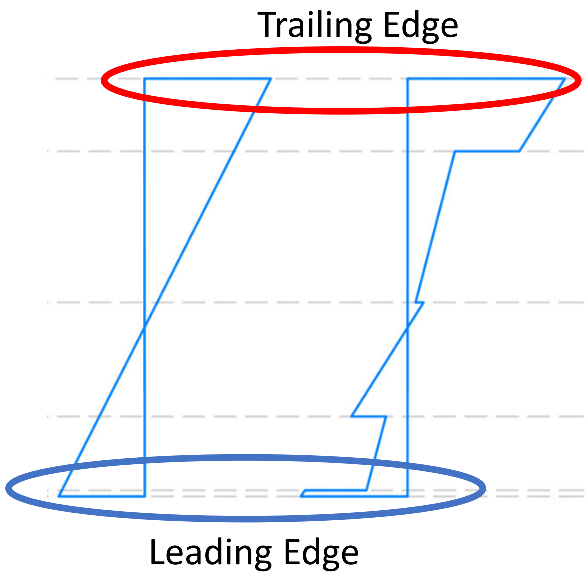
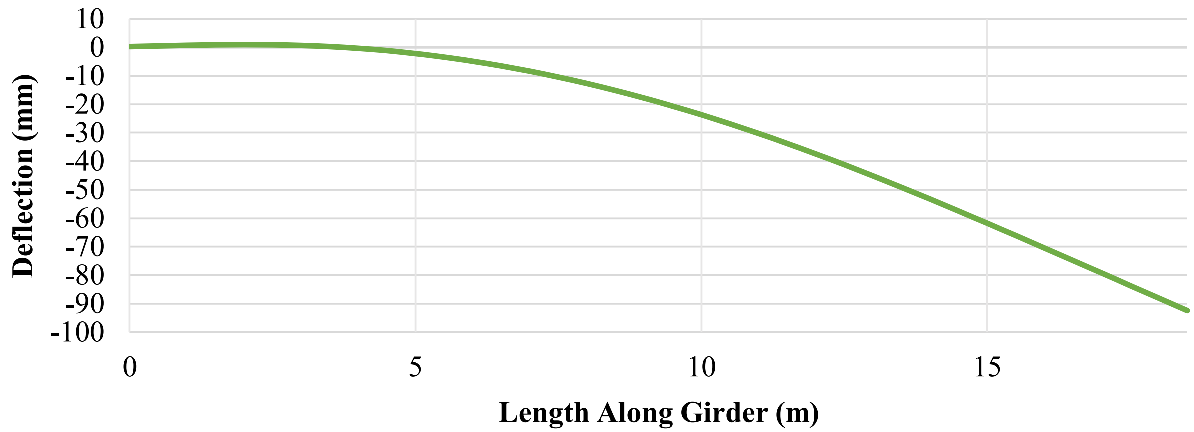
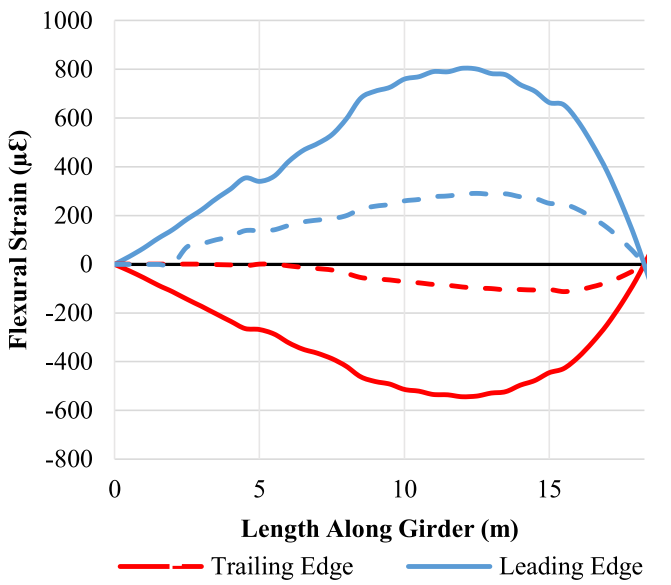


# Analysis Diagrams For Two Blade Cantilever Design Option




c) Deflection (mm) along single girder

# Analysis Diagrams For One Blade Torsional Design Option

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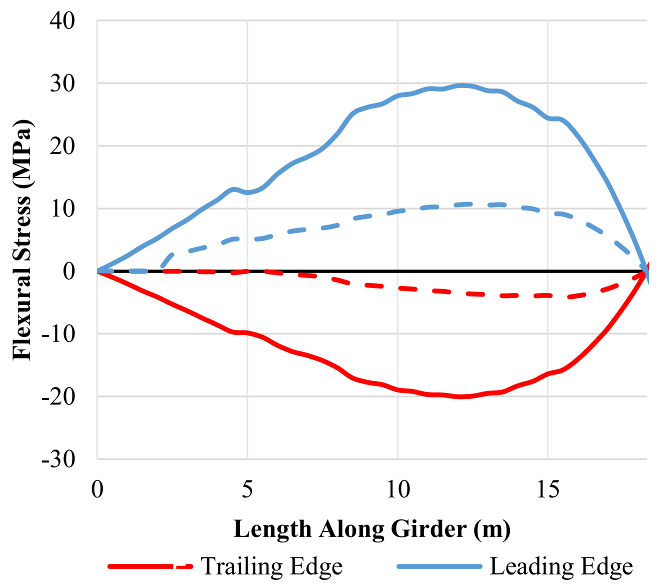
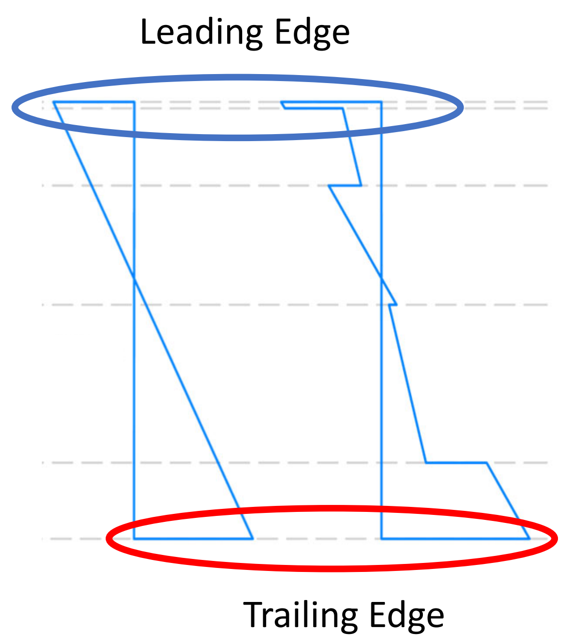



b) Flexural stress (MPa) of uniaxial FRP along single girder.



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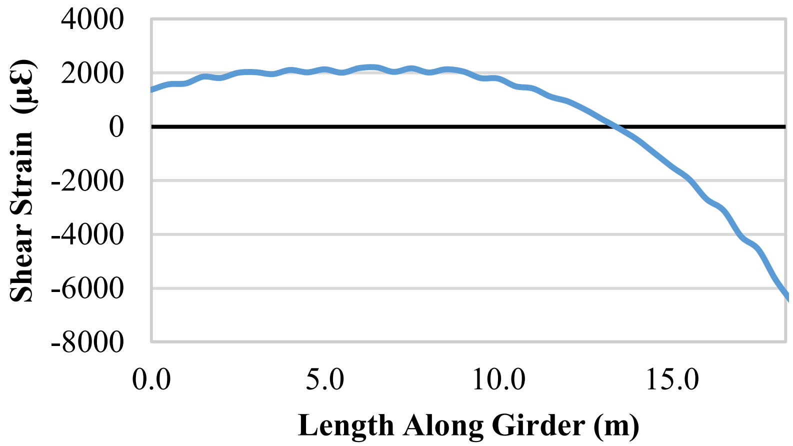
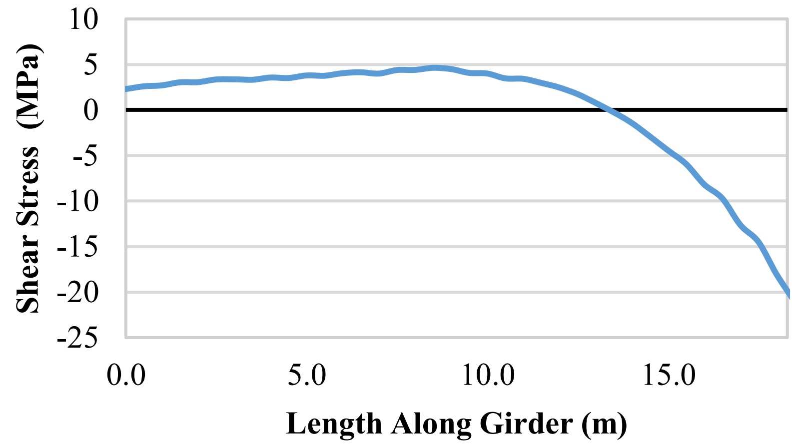
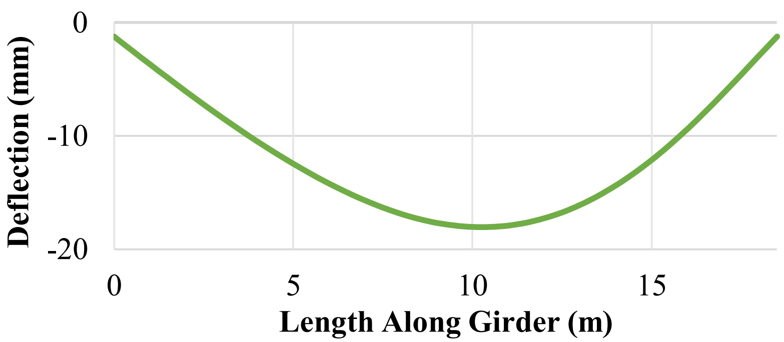



c) Maximum shear strain (microstrain) from torsion along single girder, measured along trailing edge

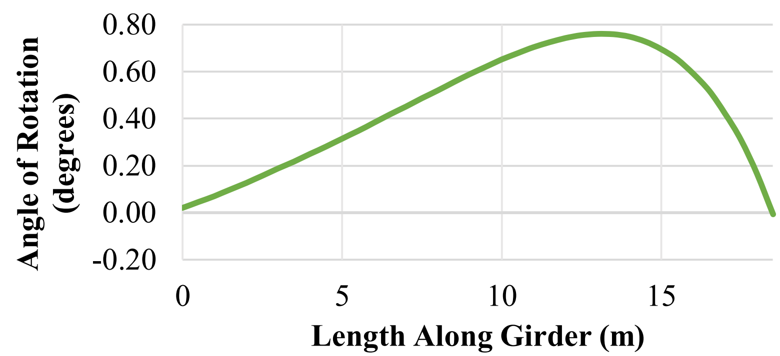



d) Maximum shear stress (MPa) from torsion along single girder, measured at the trailing edge (top of girder).

# Analysis Diagrams For One Blade Torsional Design Option

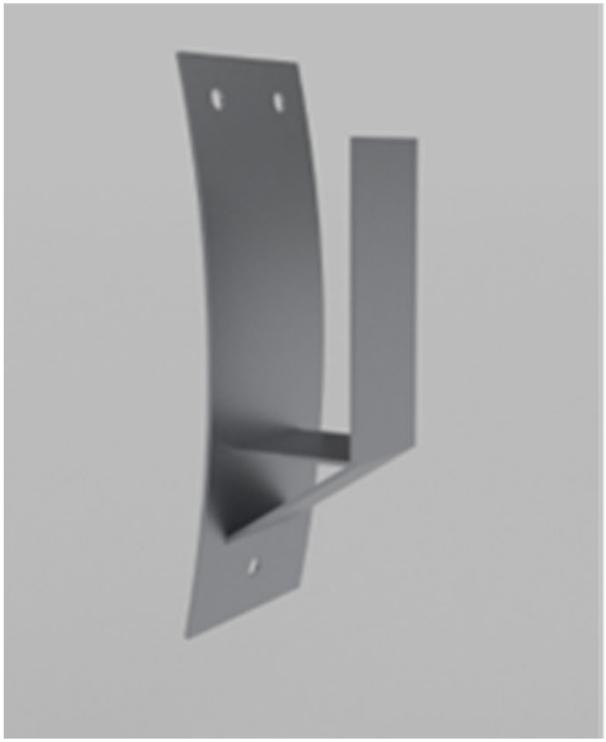


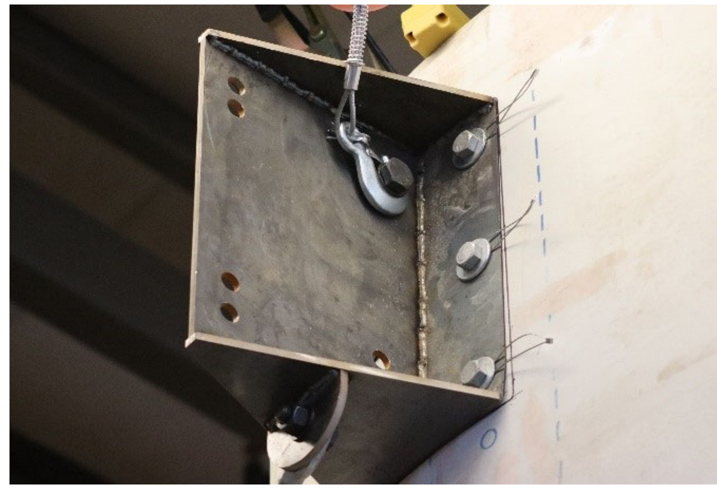

e) Deflection (mm) along single girder.




f) Angle of rotation (degrees) along single girder.

# Universal Connectors





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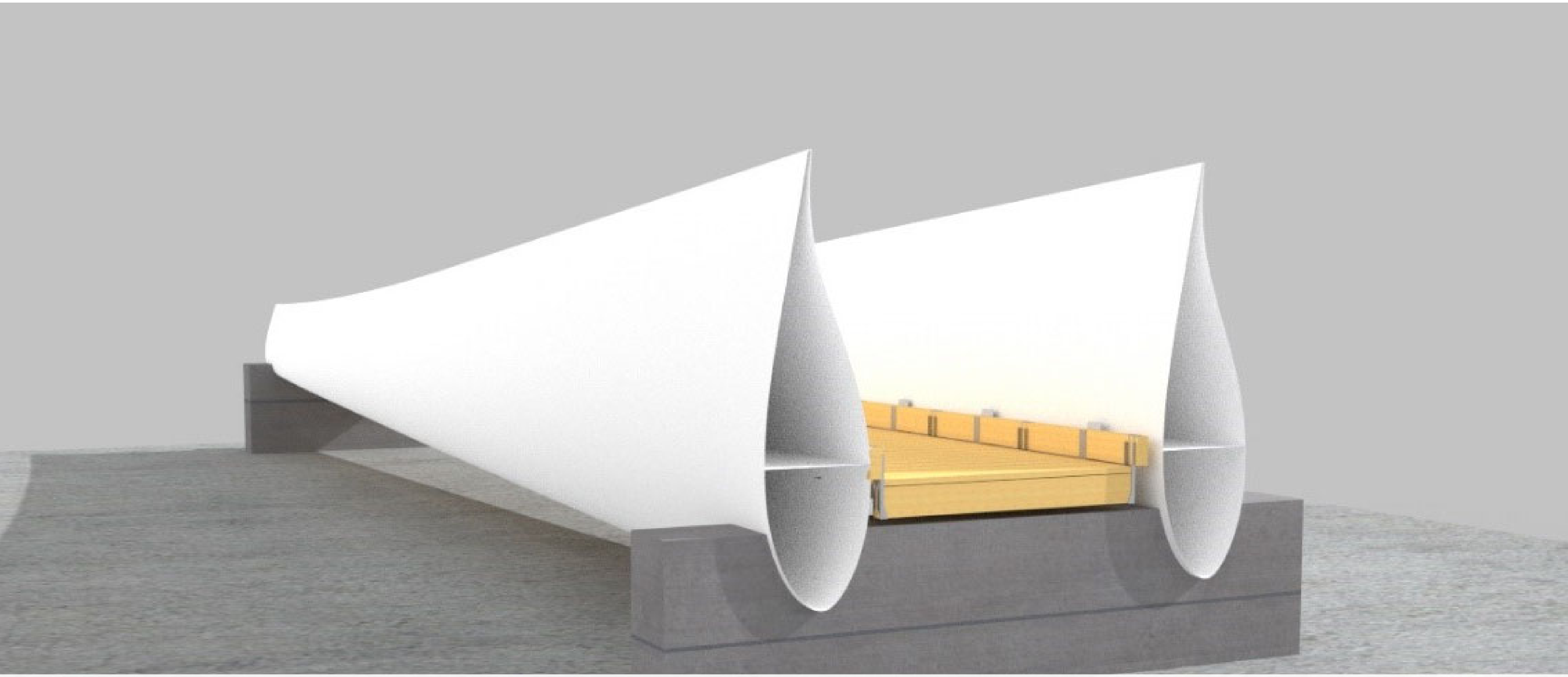
# BladeBridge is Possible!

- Long span repurposed wind turbine blade bridges are exceptionally strong and serviceable for pedestrian use
- Simply supported bridge design option is chosen
- Win-Win-Win scenario for wind turbine companies, communities, and researchers



# BladeBridge to be Tested at GT Structures Lab

# Further Areas of Work

- Understanding natural frequencies and damping ratios of FRP wind turbine blades
- Finite Element Analysis of wind blade girders
- Practical logistics with building this bridge given the difficult site access limitations

# Citations

[1] Martin, C. (2020, February 5). *Wind turbine blades can't be recycled, so they're piling up in landfills*. Bloomberg.com. *https://www.bloomberg.com/news/features/2020-02-05/wind-turbine-blades-can-t-be-recycled-so-they-re-piling-up-in-landfill*

[2] Ruane, K., Soutsos, M., Huynh, A., Zhang, Z., Nagle, A., McDonald, K., Gentry, T. R., et al. (2023). Construction and Cost Analysis of BladeBridges Made from Decommissioned FRP Wind Turbine Blades. Sustainability, 15(4), 3366. MDPI AG. http://dx.doi.org/10.3390/su15043366

[3] Alshannaq, A. A., Respert, J. A., Bank, L. C., Scott, D. W., & Gentry, T. R. (2022). As-Received Physical and Mechanical Properties of the Spar Cap of a GE37 Decommissioned GFRP Wind Turbine Blade. Journal of Materials in Civil Engineering, 34(10), 04022266. https://doi.org/10.1061/(ASCE)MT.1943-5533.0004410

[4] Ruane, K., Zhang, Z., Nagle, A., Huynh, A., Alshannaq, A., McDonald, A., Leahy, P., Soutsos, M., McKinley, J., Gentry, T. R., & Bank, L. (2022). Material and Structural Characterization of a Wind Turbine Blade for Use as a Bridge Girder. Transportation Research Record. https://doi.org/10.1177/03611981221083619

# Thank you!

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