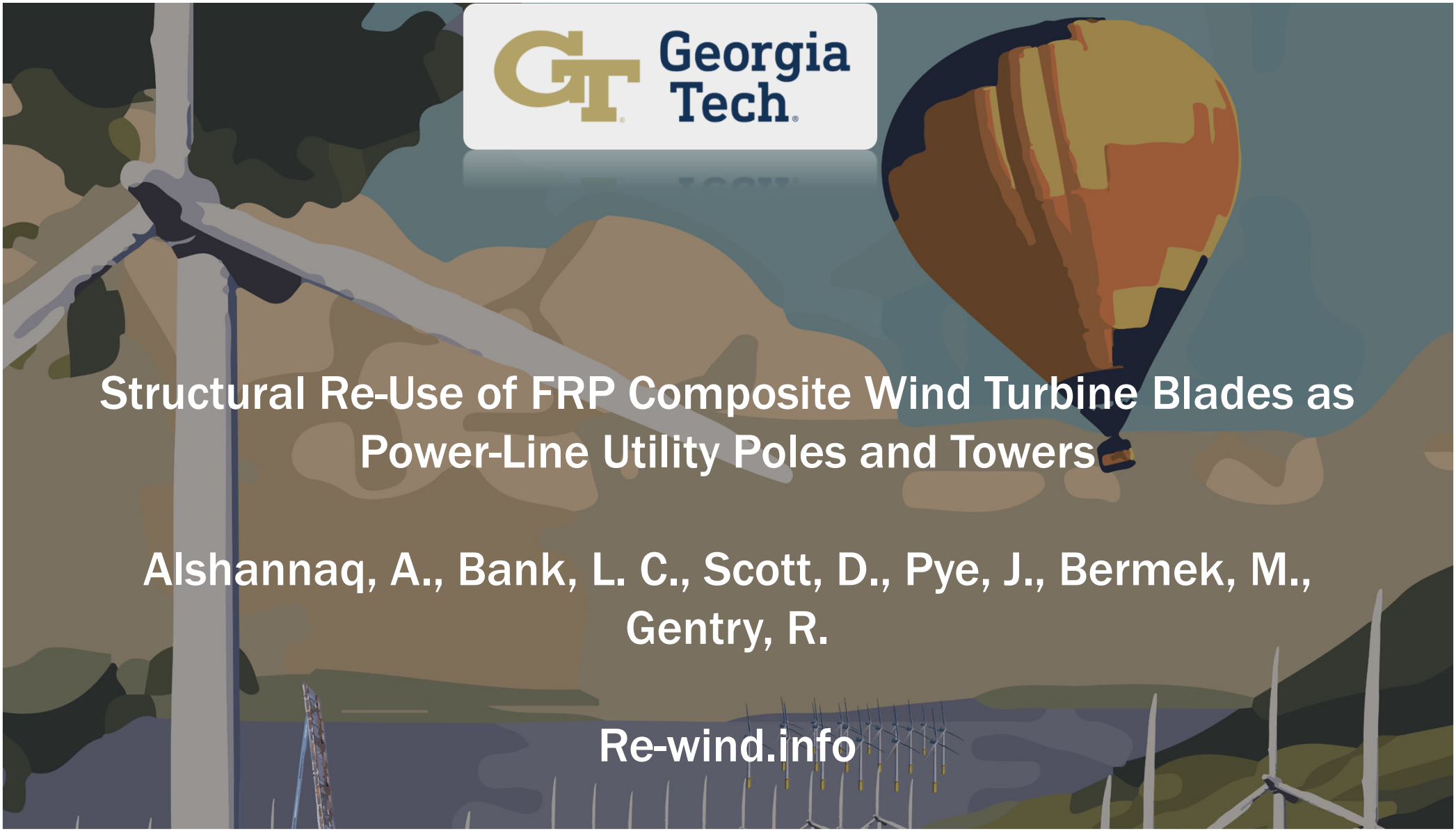


Structural Re-Use of FRP Composite Wind Turbine Blades as Power-Line Utility Poles and Towers

Alshannaq, A., Bank, L. C., Scott, D., Pye, J., Bermek, M., Gentry, R.

Re-wind.info

Decommissioned Wind Blades

Options to Choose From ?

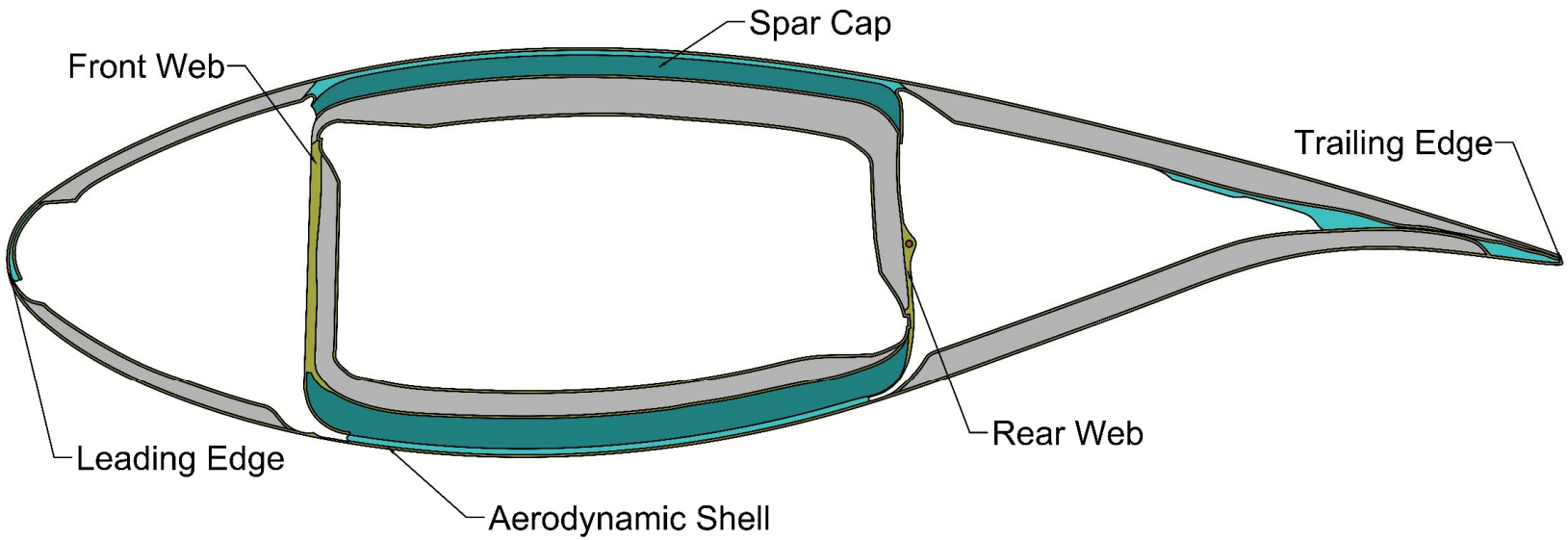
- "DISPOSAL" through incineration or landfilling
  - Environmentally harmful option with little positive societal impact.

- "RECYCLING" using mechanical, thermal and chemical processing
  - Replacements for virgin constituents in new composites or cementitious mortars and concretes.
  - Economical viability and reduced properties are the main drawbacks

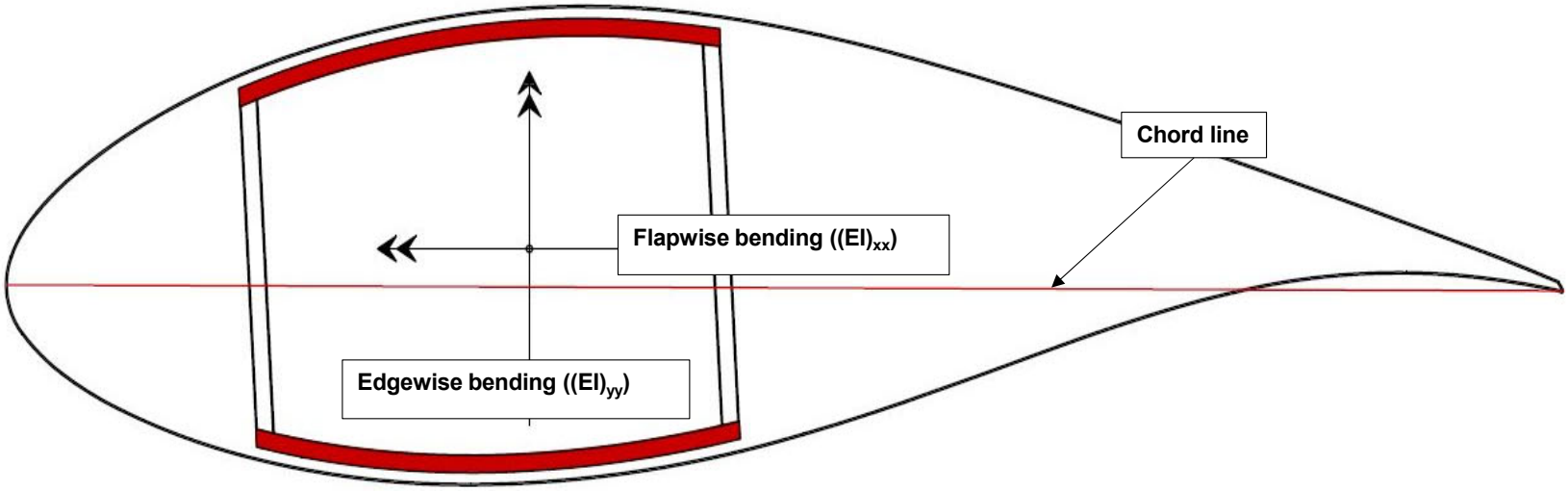
- The most promising option "REPURPOSE".
  - Which includes developing, analyzing, and prototyping applications where large parts of the wind blades are utilized in new or retrofitted civil infrastructure

Wind Blade Geometry

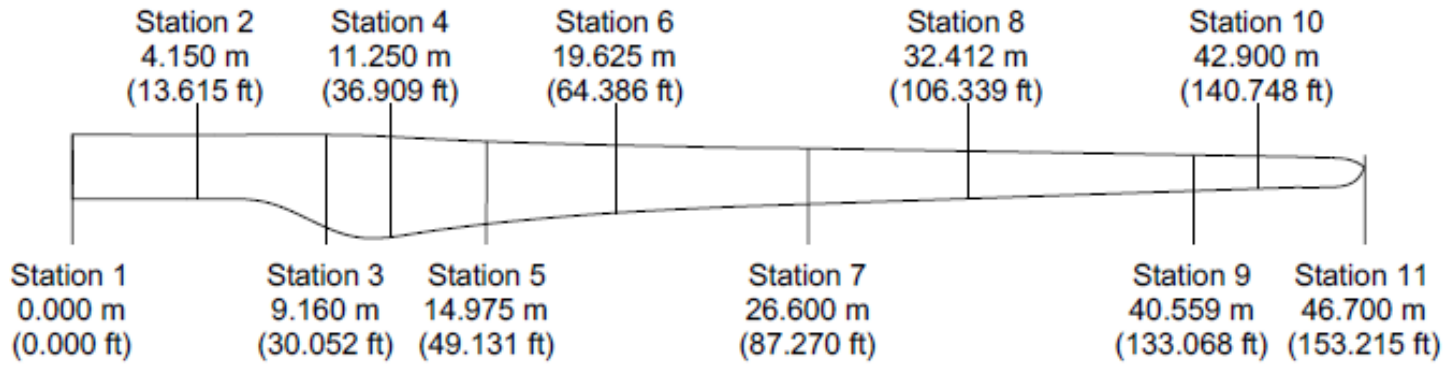
Different Parts Composing Wind Blade's Cross-section

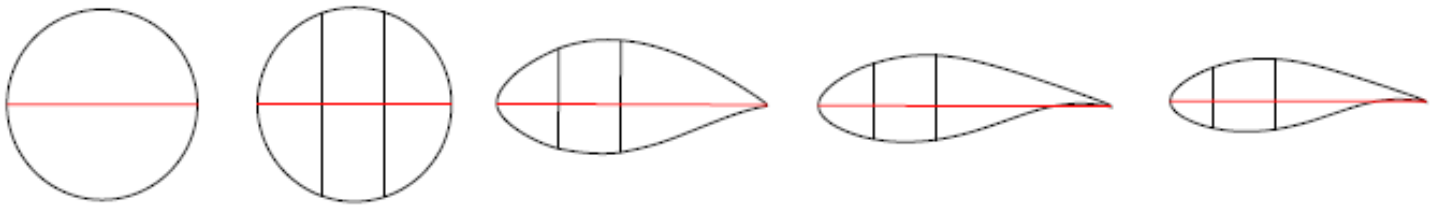


Flapwise and Edgewise Bending



Stations Along the Length





Station 1
0.000 m
(0.000 ft)

Station 2
4.150 m
(13.615 ft)

Station 3
9.160 m
(30.052 ft)

Station 4
11.250 m
(36.909 ft)

Station 5
14.975 m
(49.131 ft)

Station 6
19.625 m
(64.386 ft)

Station 7
26.600 m
(87.270 ft)

Station 8
32.412 m
(106.339 ft)

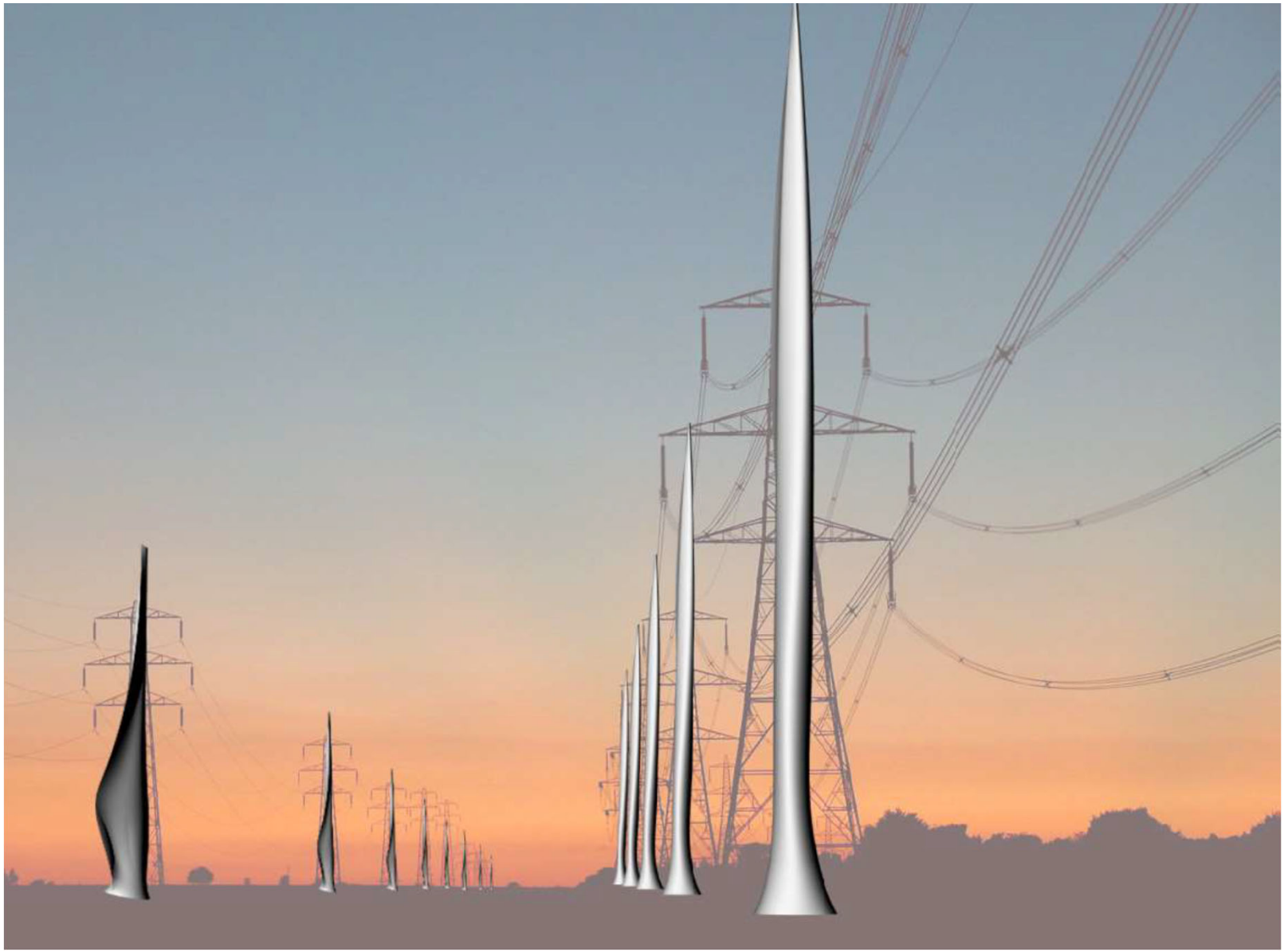
Station 9
40.559 m
(133.068 ft)

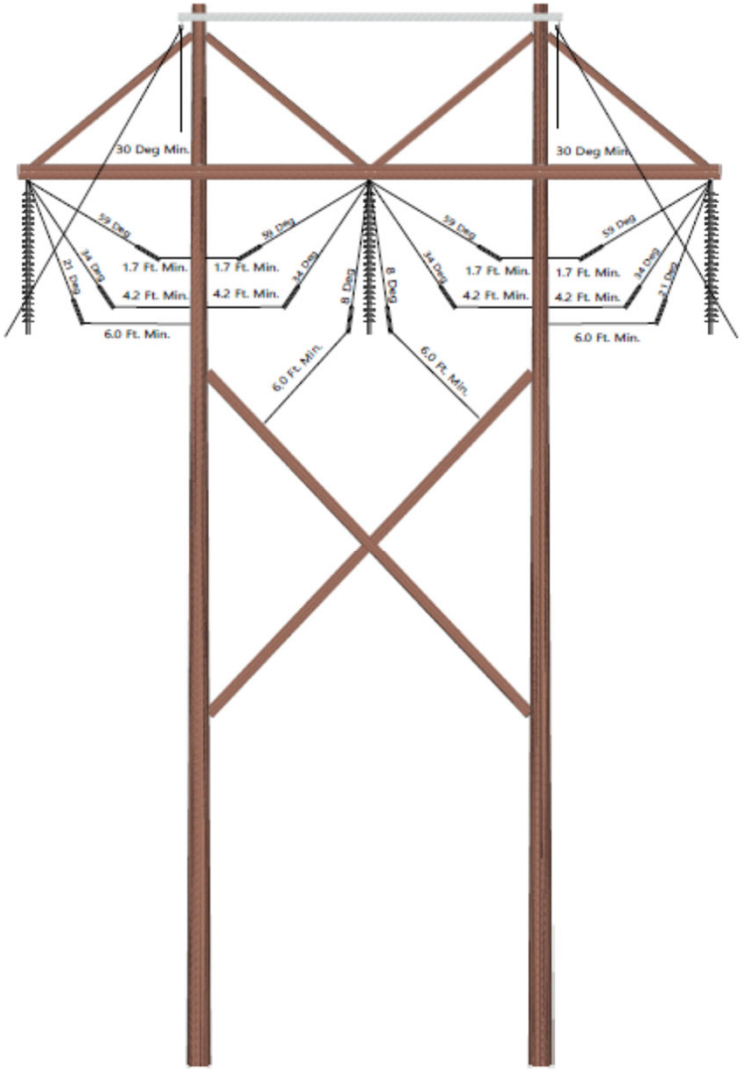
Station 10
42.900 m
(140.748 ft)

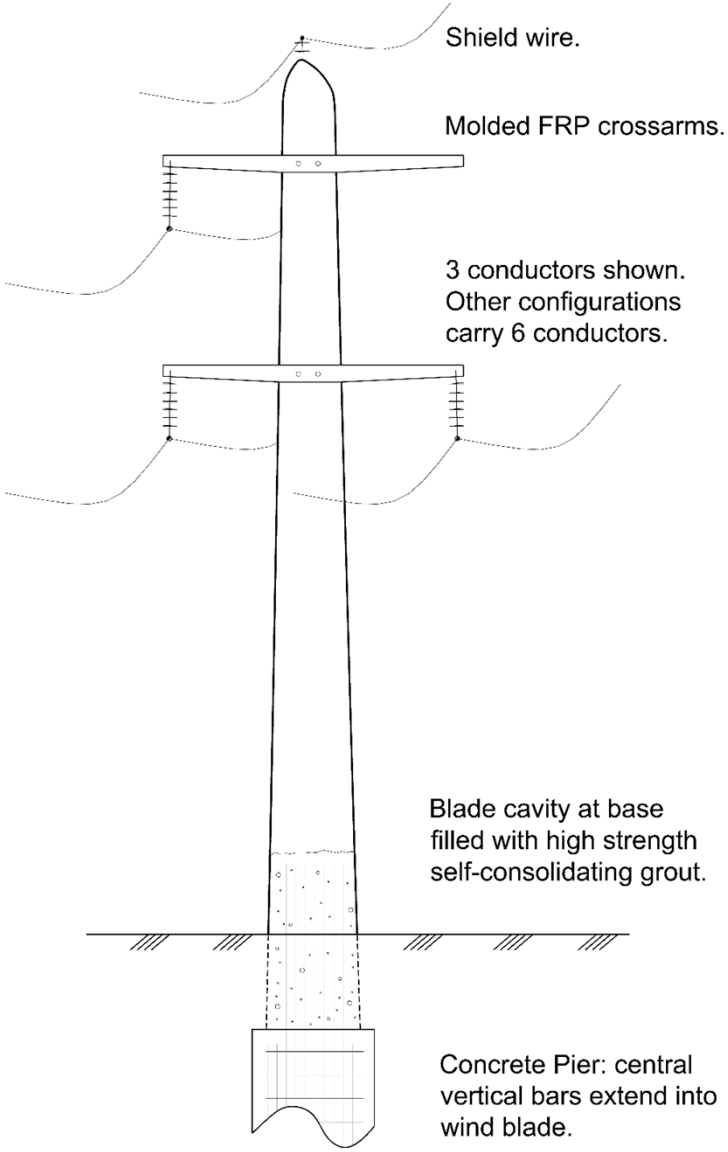
Power Transmission Pole Concept

Motivation

*ACS Competition (https://aestheticcompetition.com/)

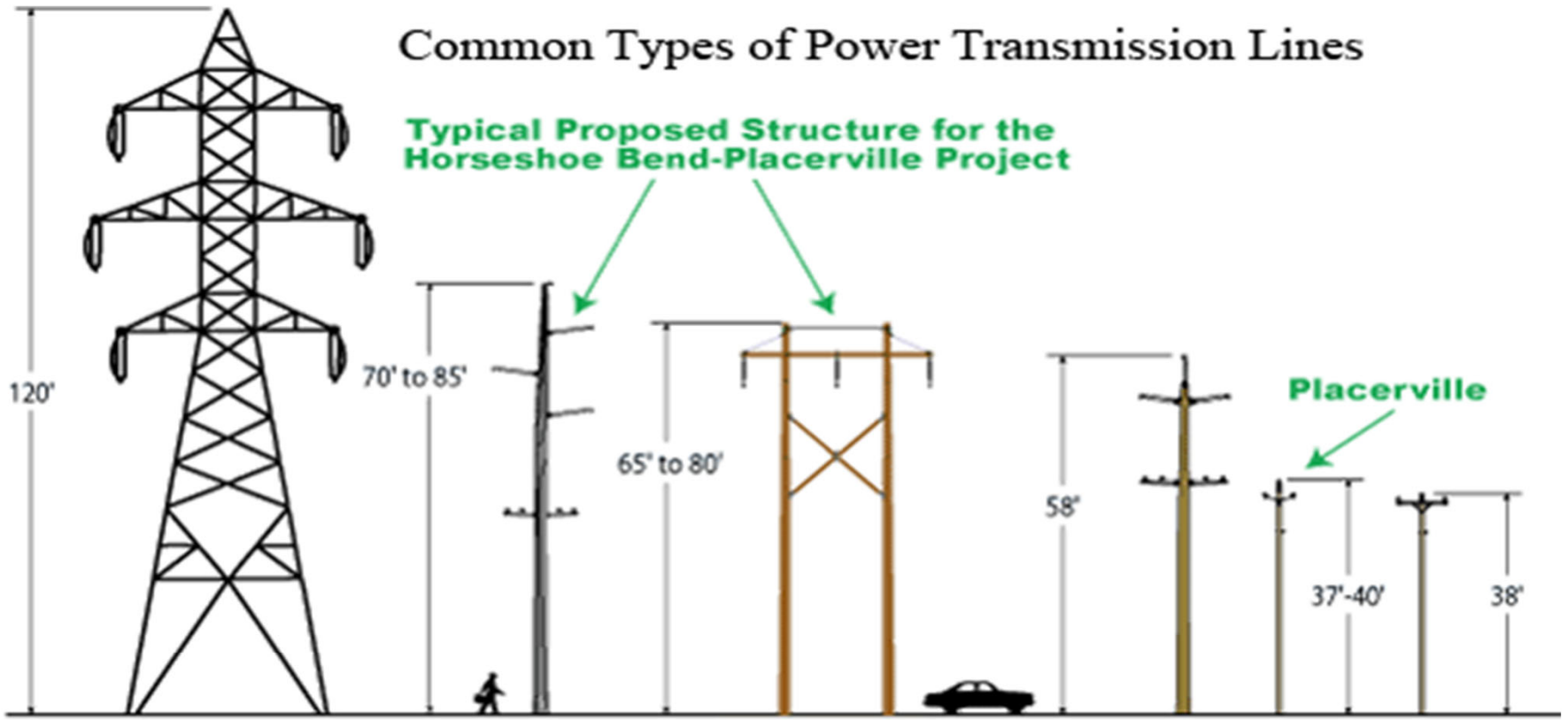


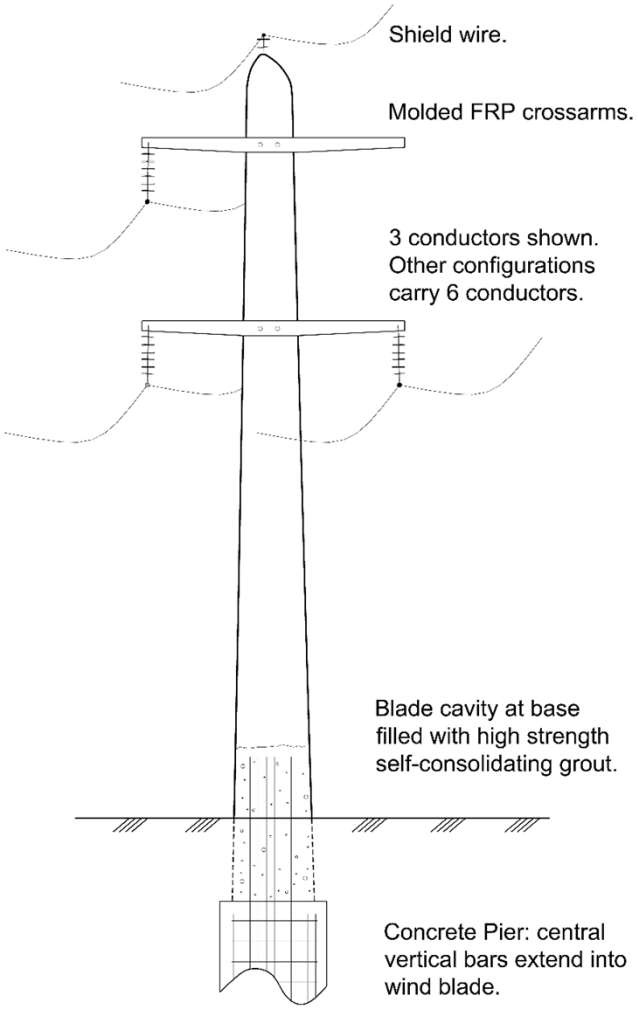


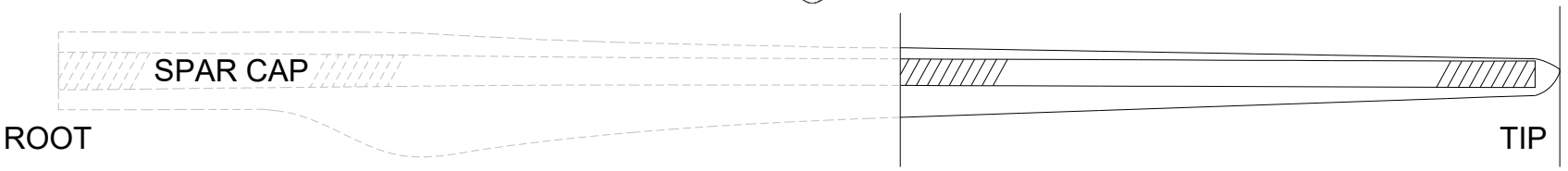


*ACS Competition (https://aestheticcompetition.com/)

Common Types of Power Transmission Lines

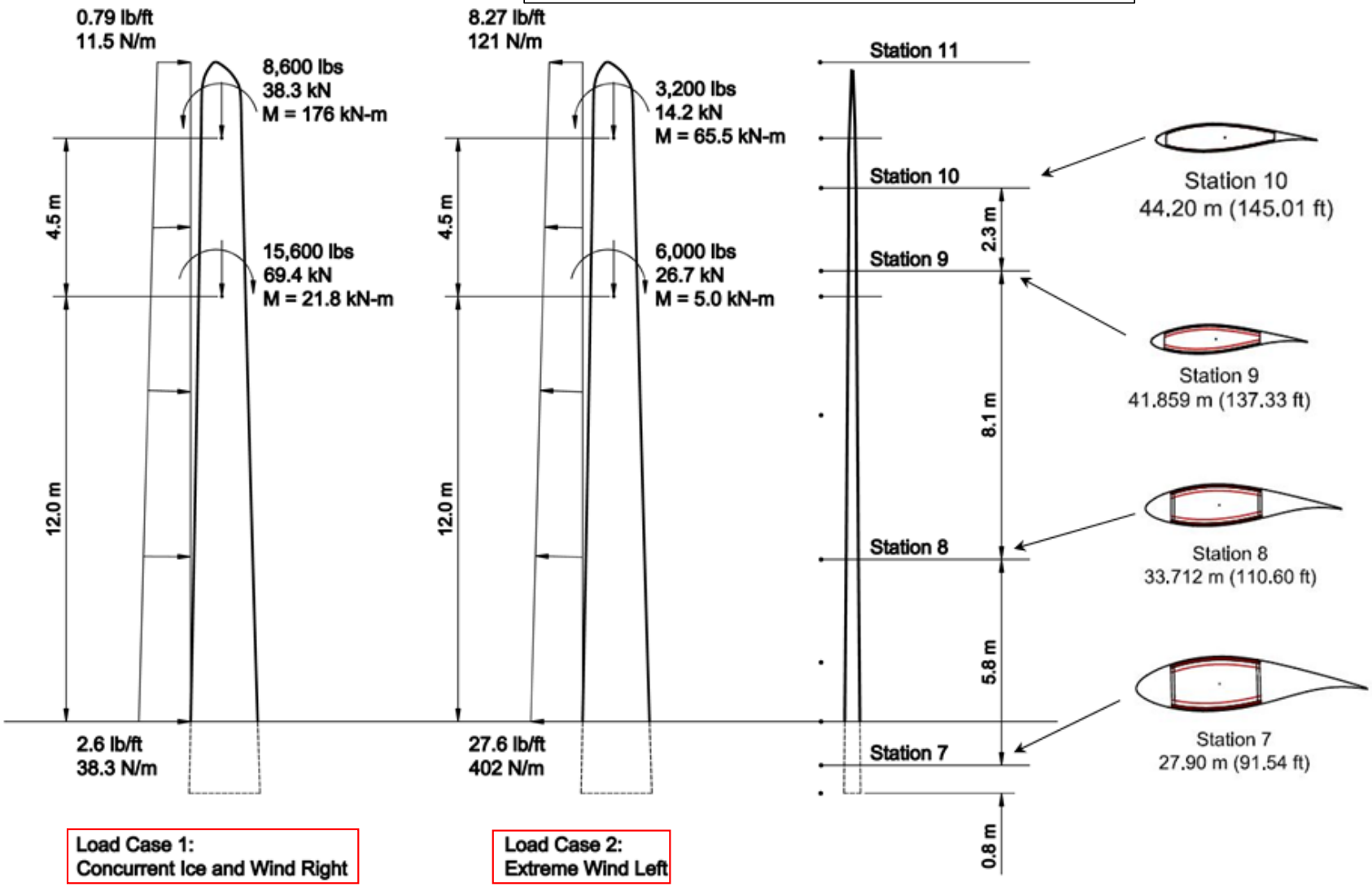



Shield wire.
Molded FRP crossarms.
3 conductors shown.
Other configurations
carry 6 conductors.
Blade cavity at base
filled with high strength
self-consolidating grout.
Concrete Pier: central
vertical bars extend into
wind blade.


SPAR CAP
ROOT
TIP

Structural Analysis of the Power Pole

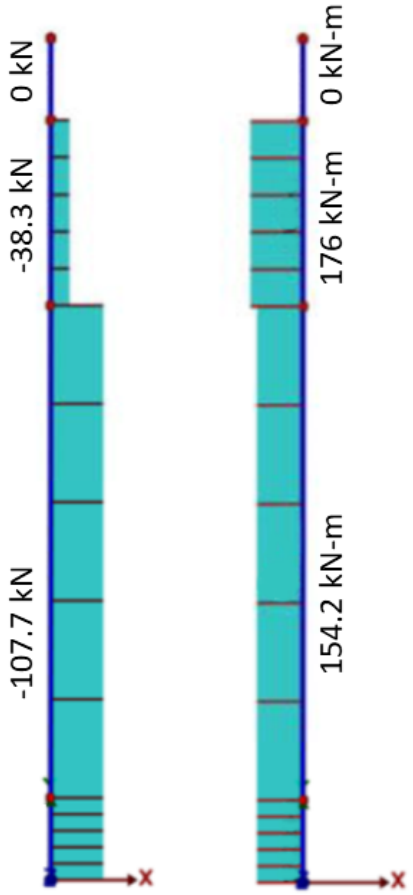
ASCE 74 Load Cases



Load Case 1:
Concurrent Ice and Wind Right

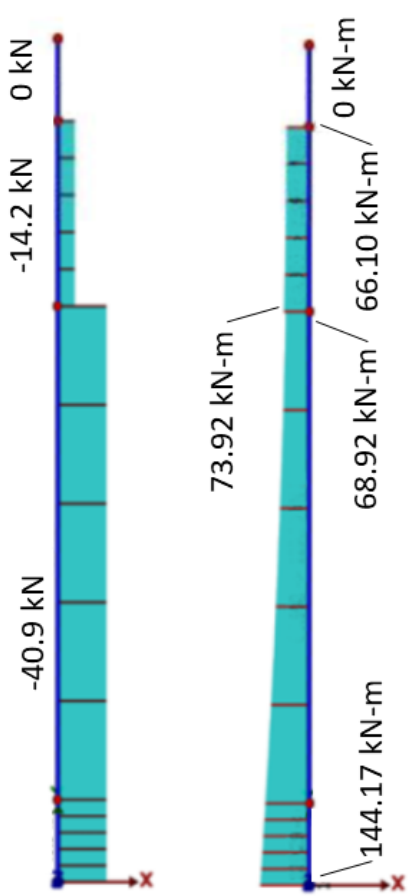
Load Case 2:
Extreme Wind Left

Axial Load and Bending Moment Diagrams



P (kN) $M_{edgewise}$ (kN-m)

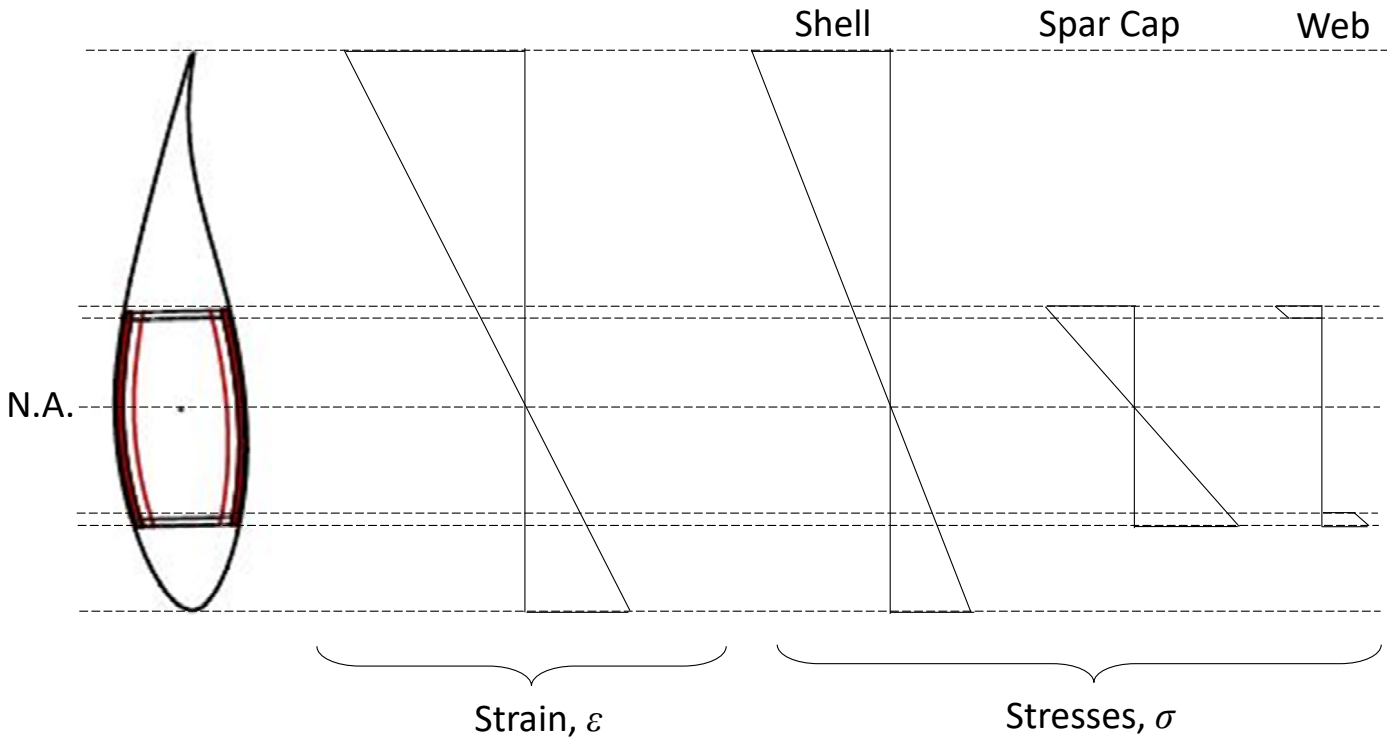
Load Case 1: Concurrent Ice and Wind Right



P (kN) $M_{edgewise}$ (kN-m)

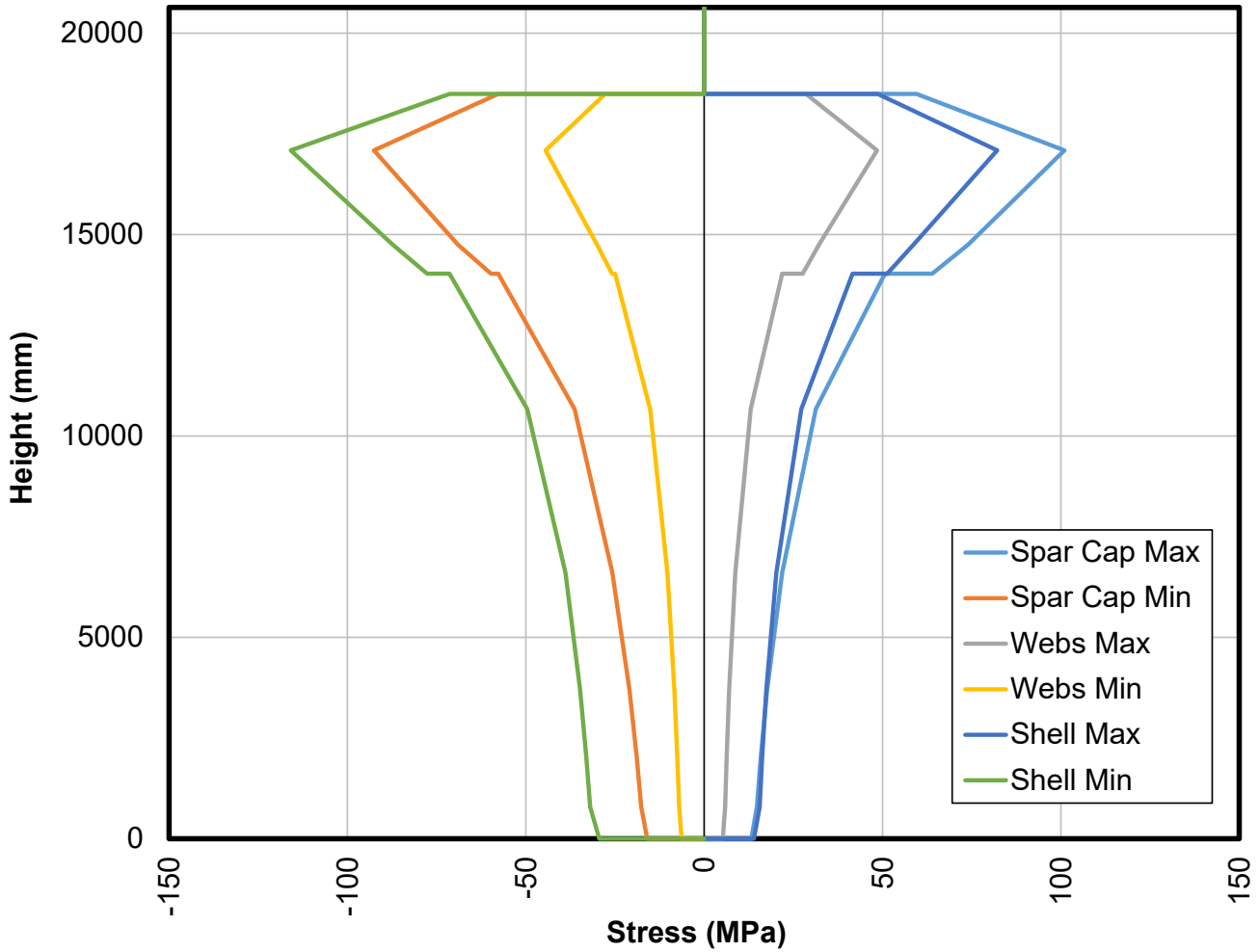
Load Case 2: Extreme Wind Left

Strains and Stresses for Elements in Bending

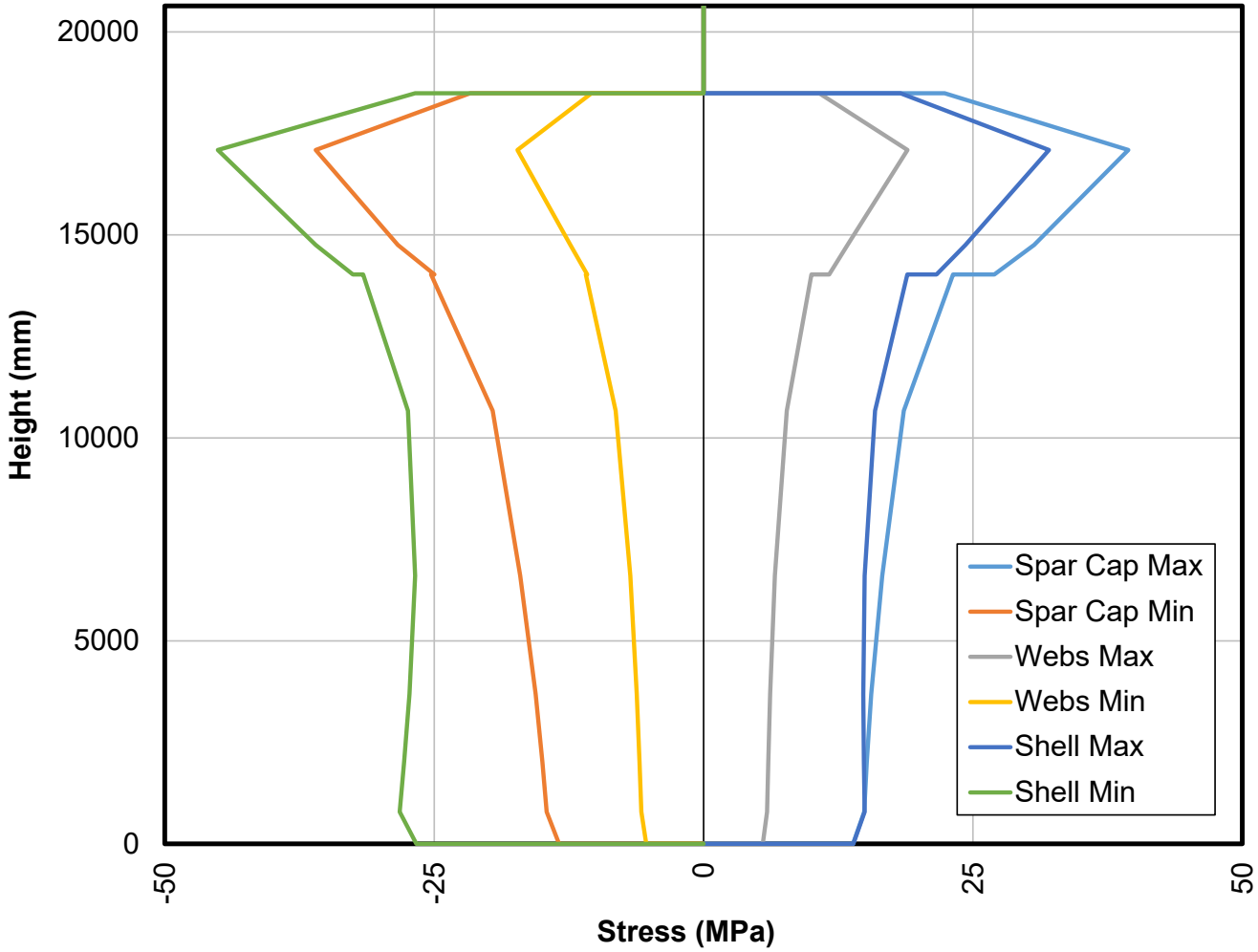


$$\sigma_{element} = \mp \frac{PE_{element}}{EA_{total}} \mp \frac{MyE_{element}}{EI_{total}}$$

Concurrent Ice and Wind Right – (Load Case - I) - EDGEWISE

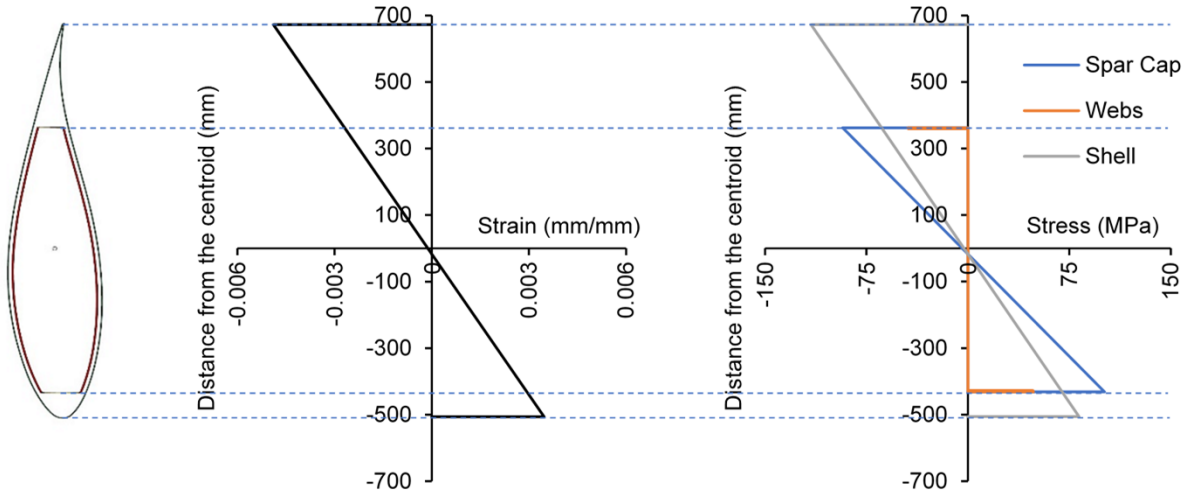


Extreme Wind Left – (Load Case - II) - EDGEWISE

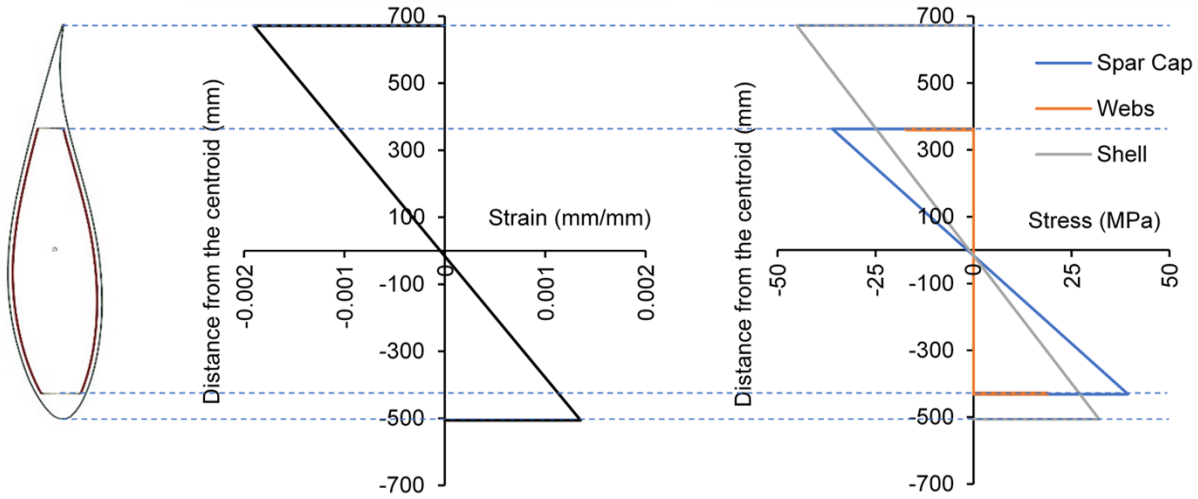


Strain-Stress Distributions From Load Case I And II - EDGEWISE

Load Case I:

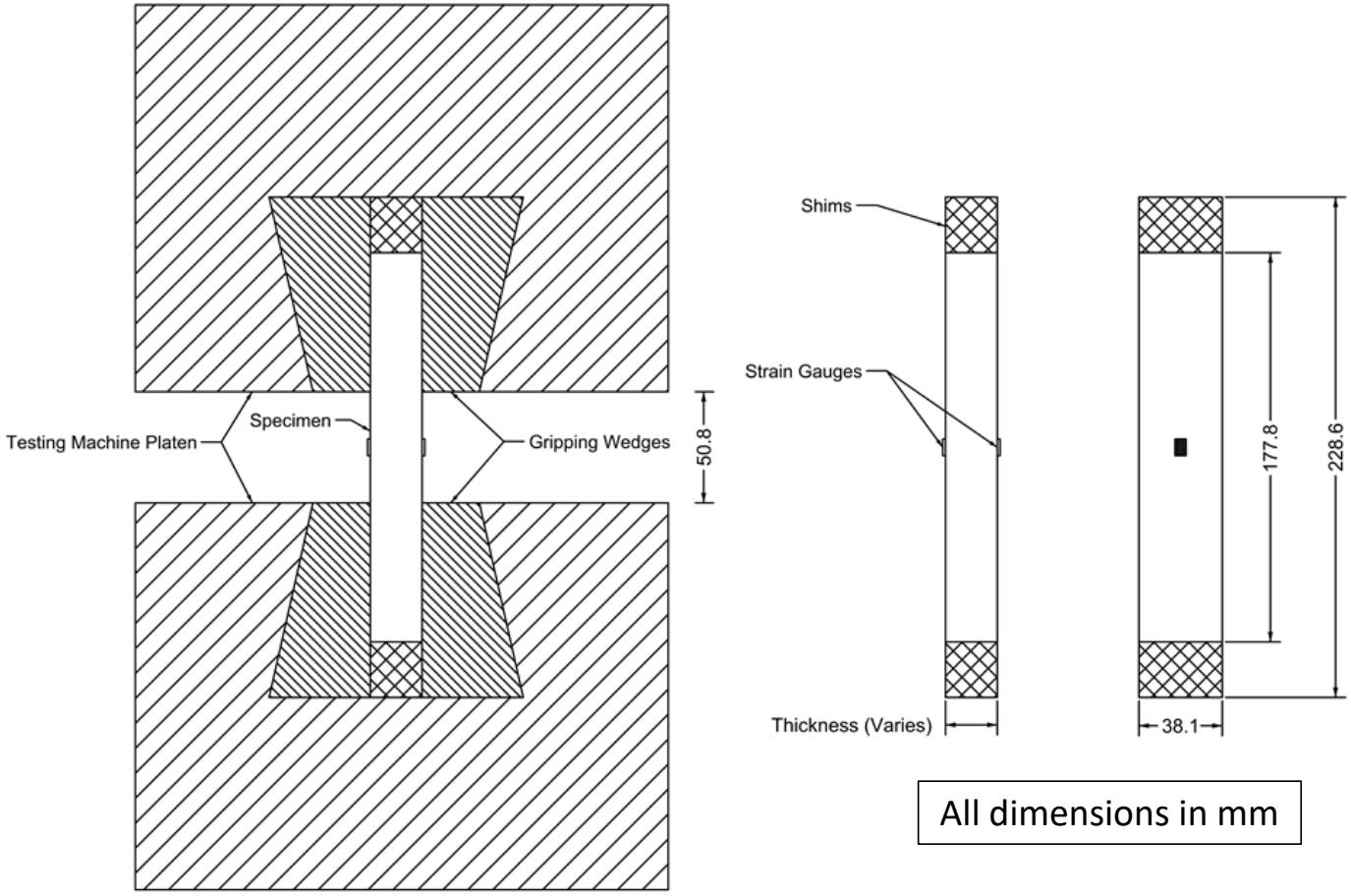


Load Case II:



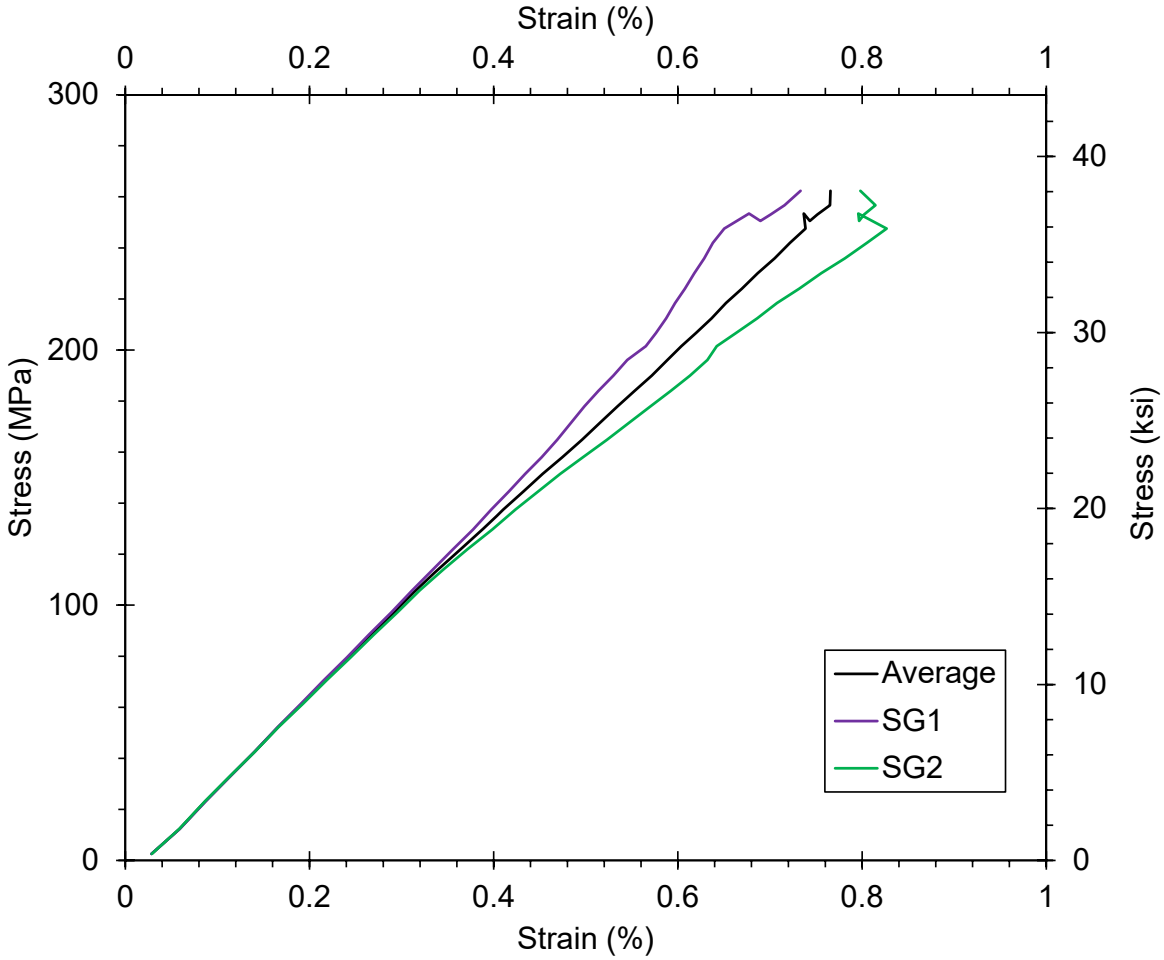
Material Properties and Safety Factors

Compressive Testing Fixture For Wind Blade Specimens

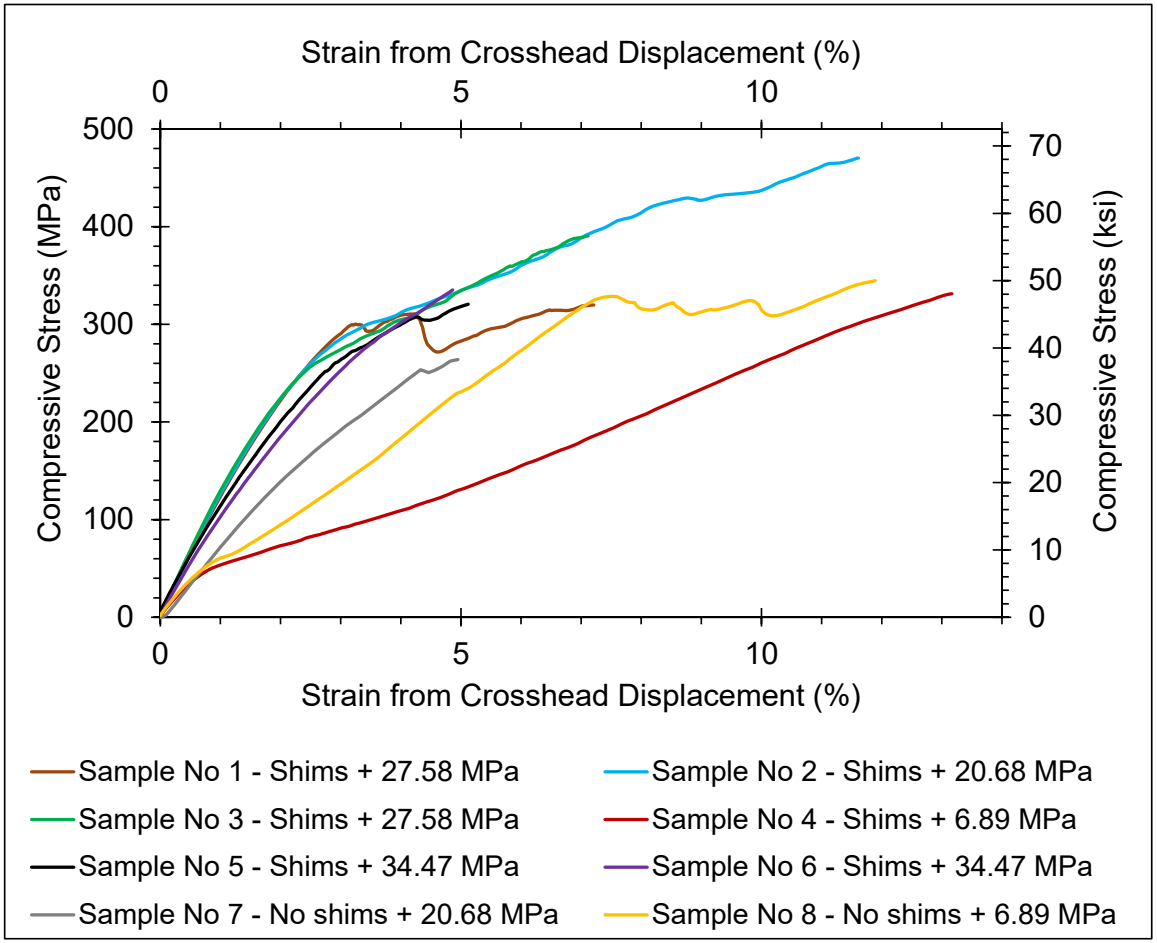


All dimensions in mm

Material Compressive Properties from Spar Cap Specimens (At Station 9)



Material Compressive Properties from Spar Cap Specimens (At Station 9)



	Strength (MPa)	Modulus of Elasticity (GPa)
Average	347	36.1
Coefficient of Variation (COV) (%)	17.5	N/A Sample size of 1

Safety Factors

- Using the average compressive strength of 347 MPa for the spar cap results in a factor of safety (F.S) of 3.75 or a strength utilization ratio of 0.27 for the power pole configuration under the critical load case.

- The compressive strength of the shell was found to be 202 MPa using theoretical modelling in Helius Composite and the corresponding factor of safety (F.S) was 1.75

Concluding Remarks

Conclusions

- This study focused on "REPURPOSE" application, which has been proved feasible in multiple aspects.

- Static analysis of critical load cases taken from ASCE Standards indicated that the blade structure could easily resist the expected loading for this application with **an overall safety factor of [1.75]**.

- Future work will focus on:
  - EXPERIMENTAL TESTING of other parts (shell, web) and other critical material properties (tension, shear, bending, …)
  - LARGE-SCALE PHYSICAL tests for potential reuse application(s).