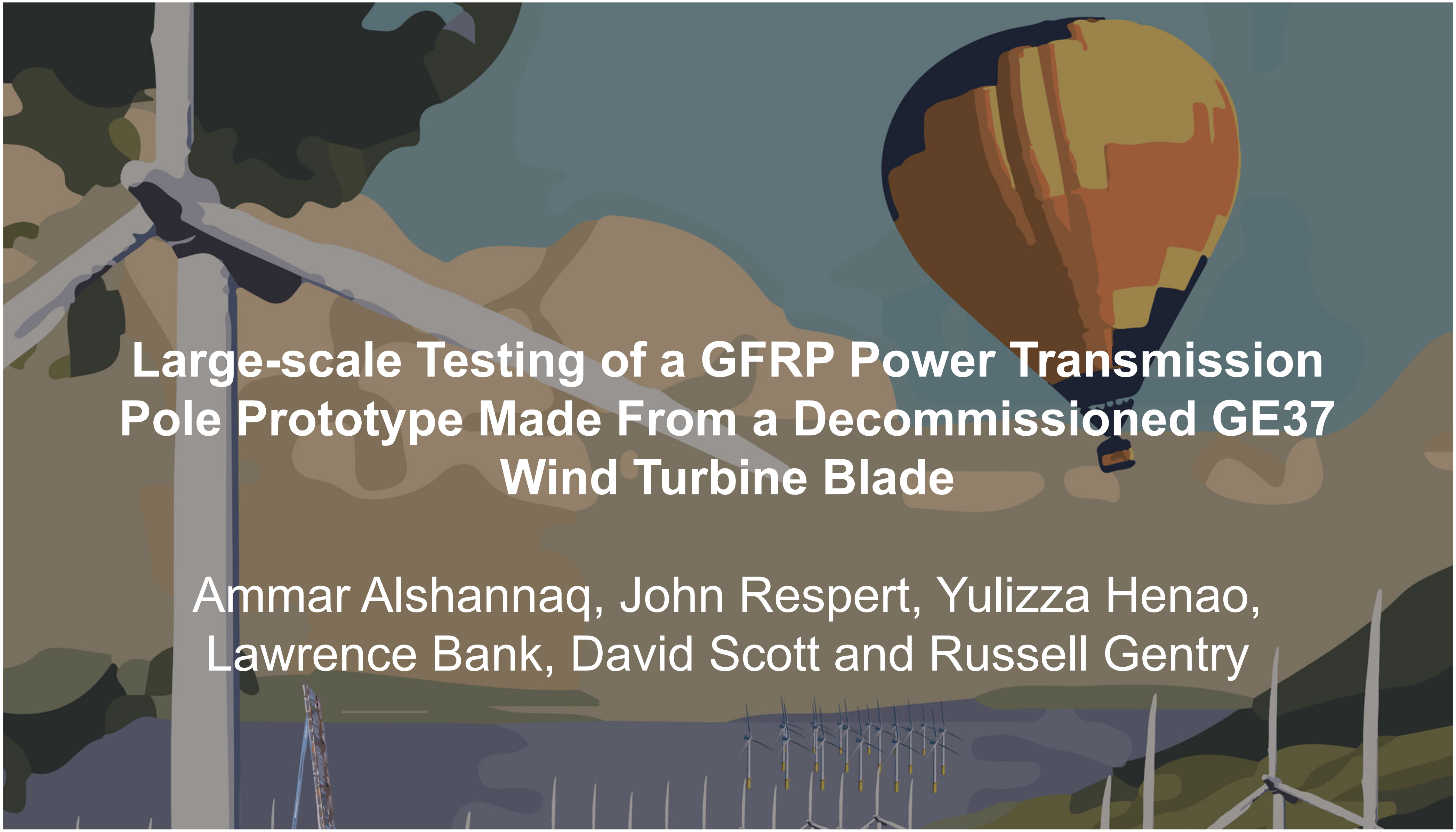
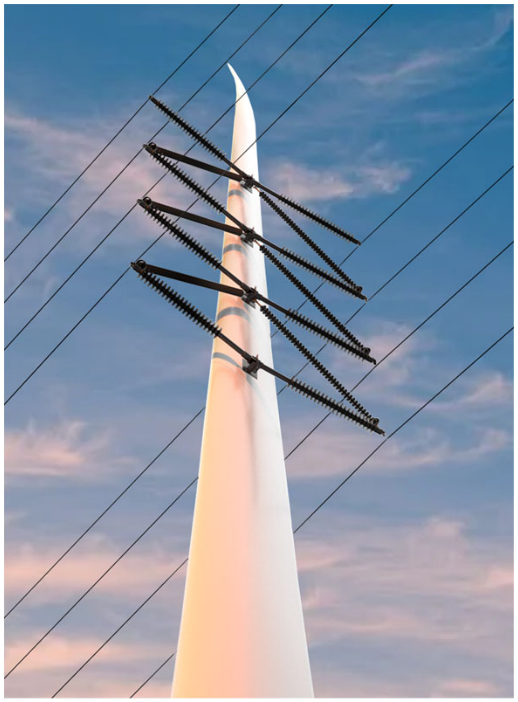


Large-scale Testing of a GFRP Power Transmission Pole Prototype Made From a Decommissioned GE37 Wind Turbine Blade

Ammar Alshannaq, John Respert, Yulizza Henao, Lawrence Bank, David Scott and Russell Gentry

INTERNAL



RE-WIND NETWORK
BLADE REPURPOSING SOLUTIONS
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BladePole

Georgia Tech
THE CITY UNIVERSITY OF NEW YORK
UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh
QUEEN'S UNIVERSITY BELFAST
MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

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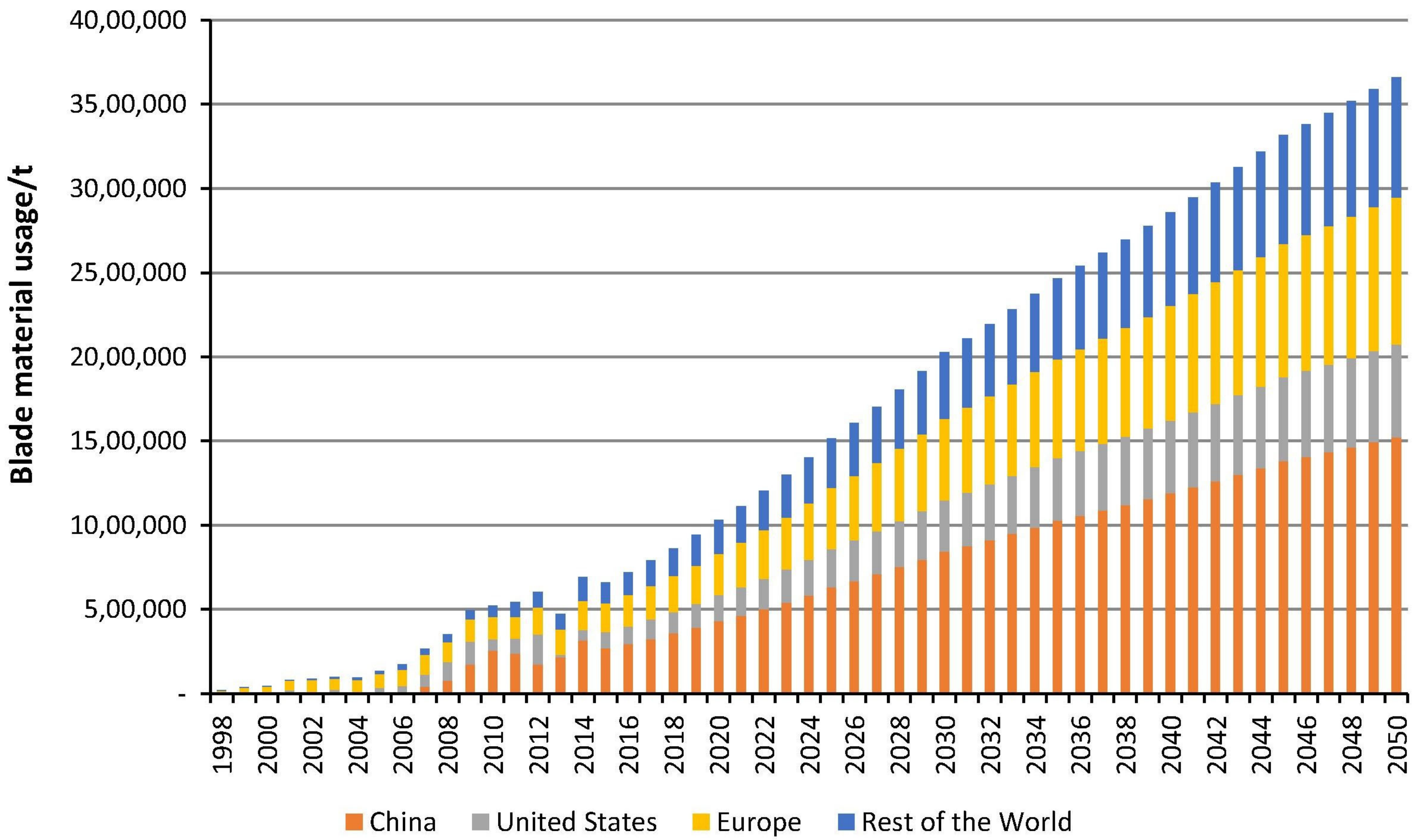
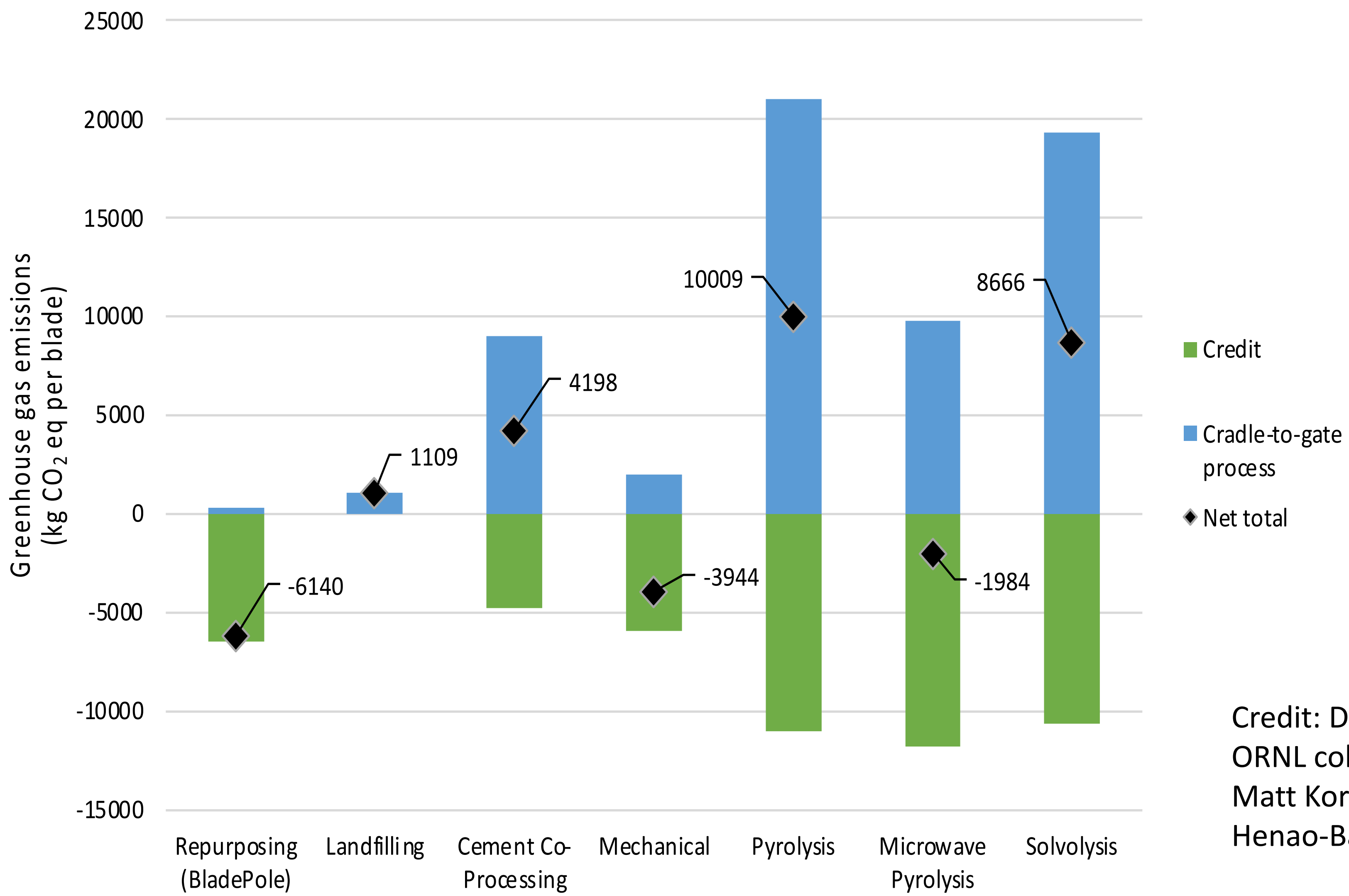
1 Introduction and Motivation

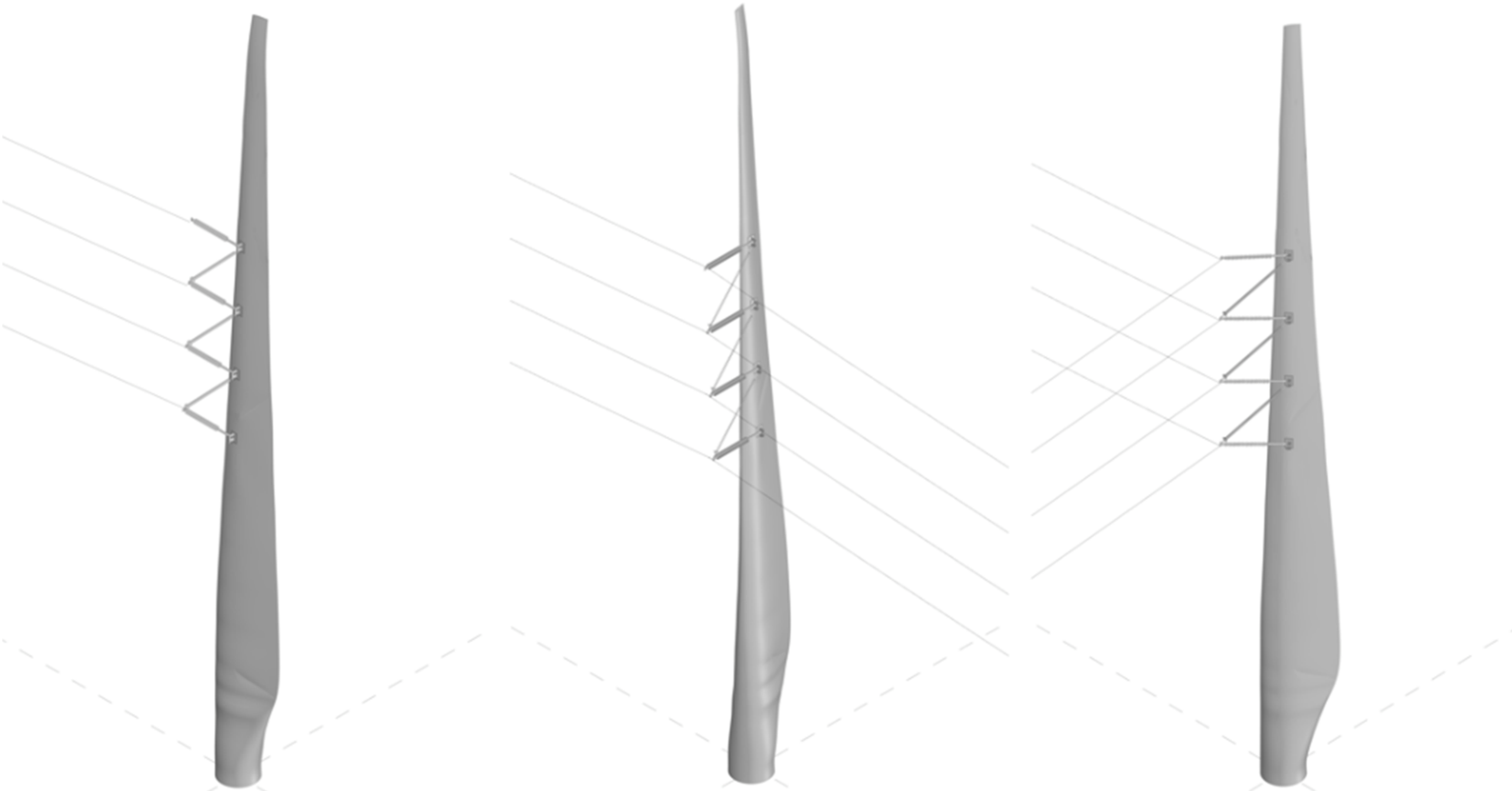


*Liu, Pu, and Claire Y. Barlow (2017). "Wind turbine blade waste in 2050." *Waste Management* 62: 229-240.



Credit: DOE WETO + ORNL collaborators Matt Korey and Yulizza Henao-Barragan

BladePole Configurations

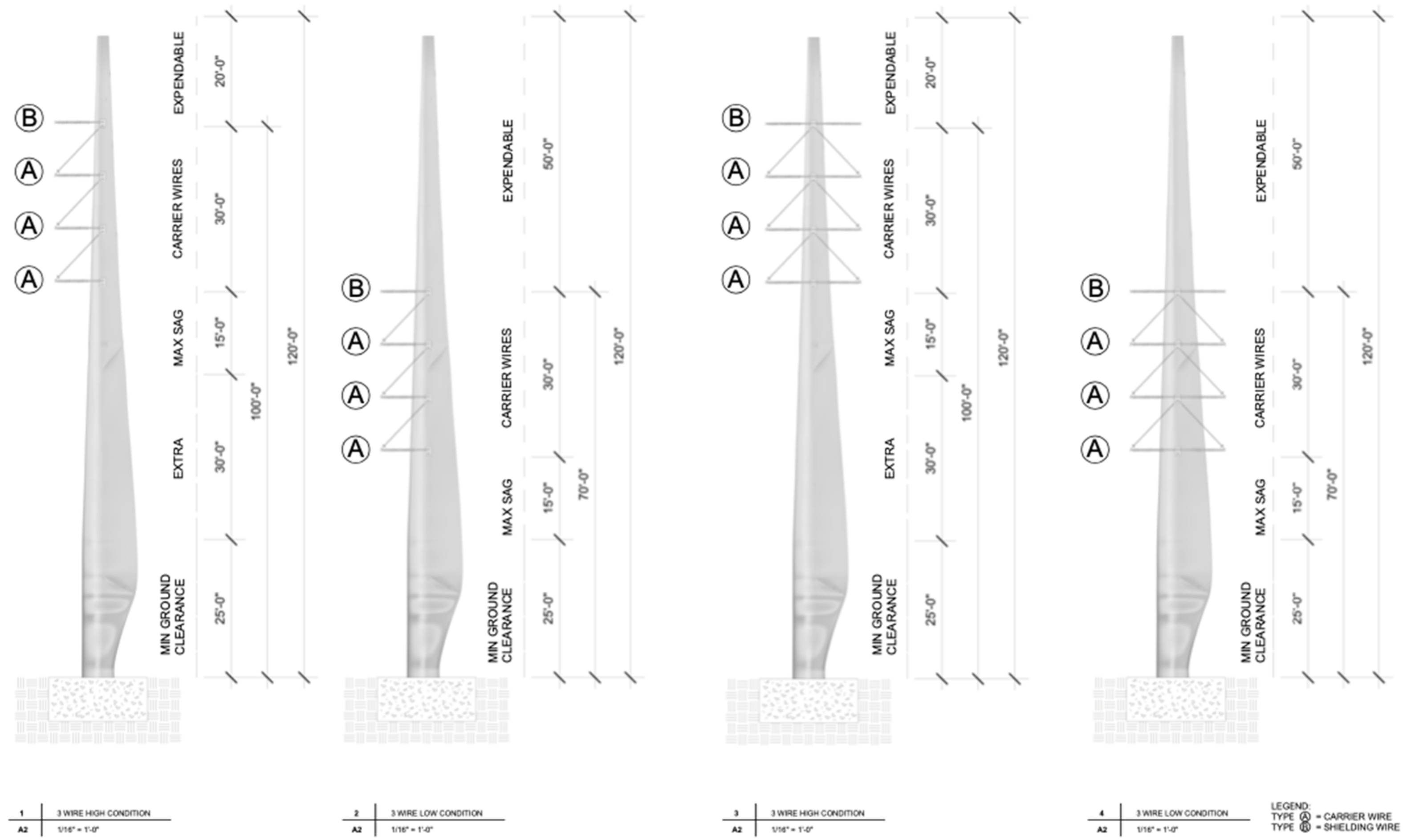


Dead End Pole (≈10%)

Tangent Pole (≈ 70%)

Angle Pole (≈ 20%)

BladePole Configurations

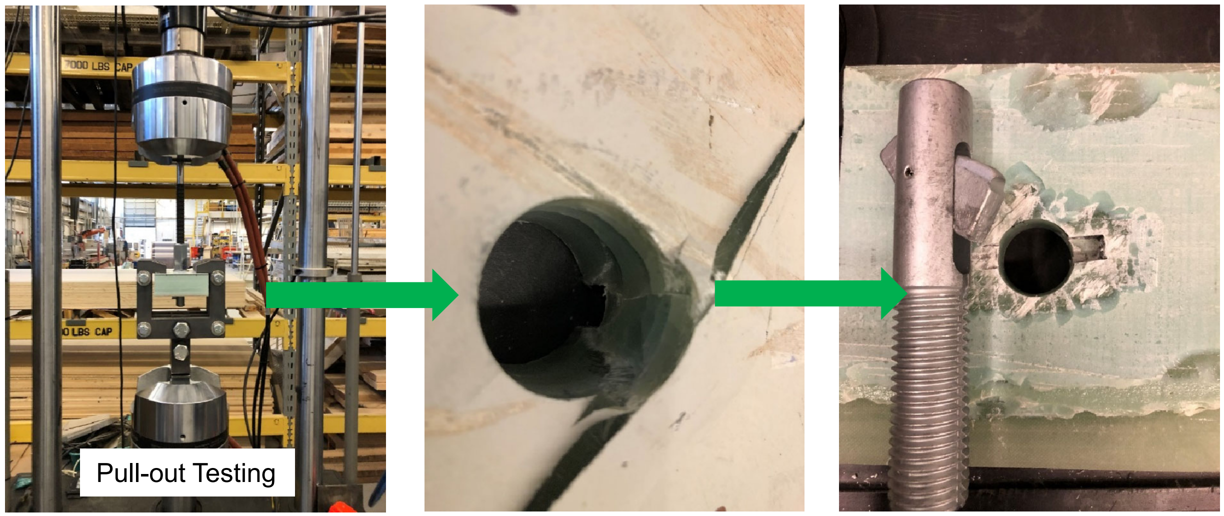


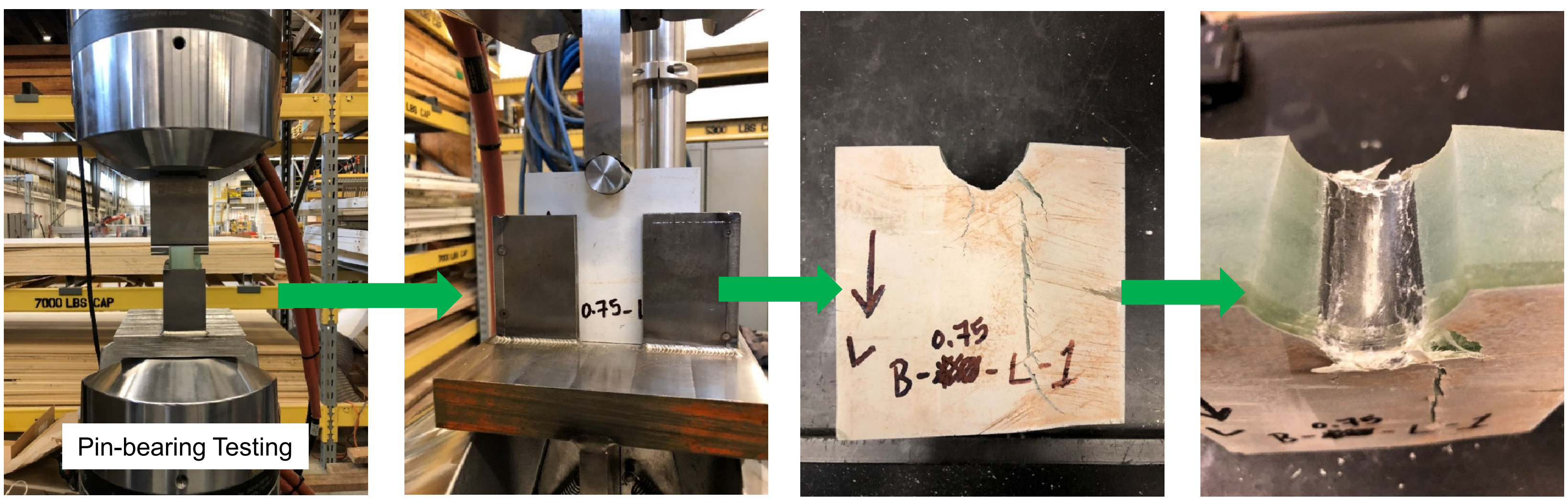
BladePole

February 2022
Full-scale testing of braced line post assemblies for gravity and wind loads.

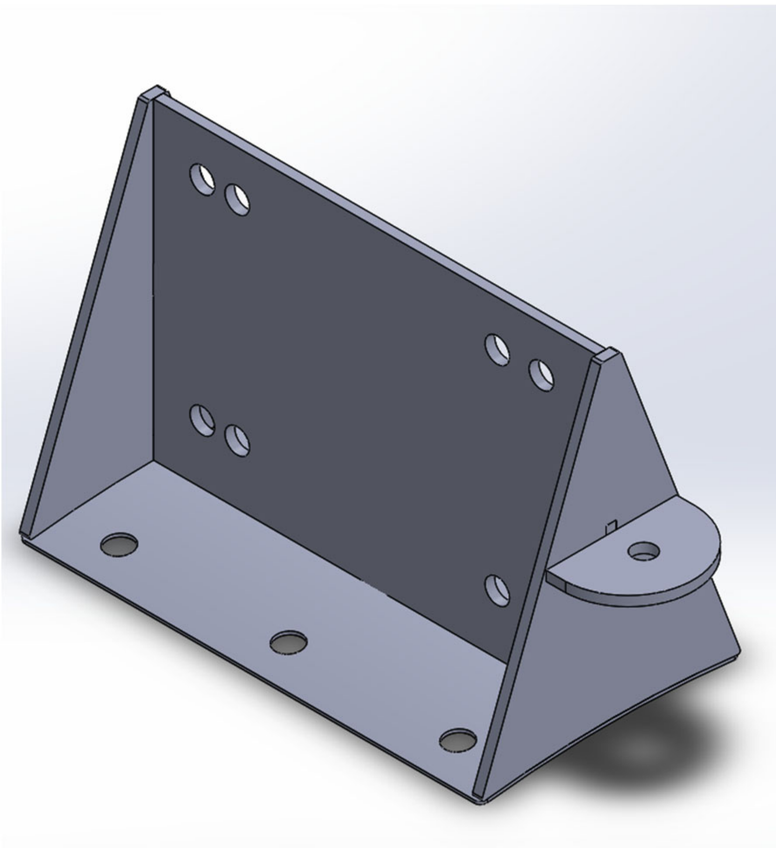
2 Samples Preparation

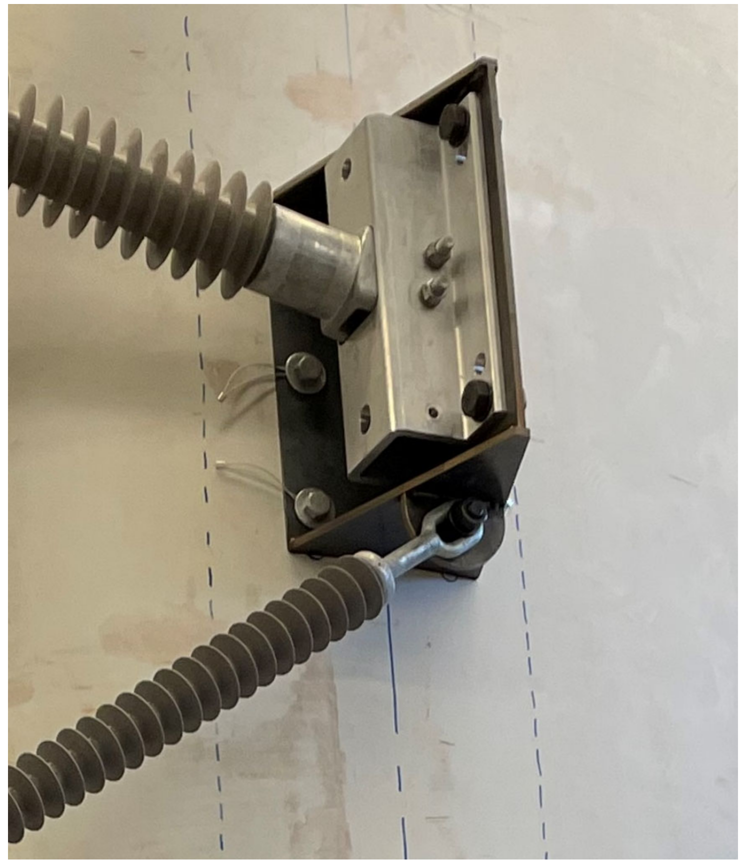
2 Pull-Out and Pin-Bearing Testing





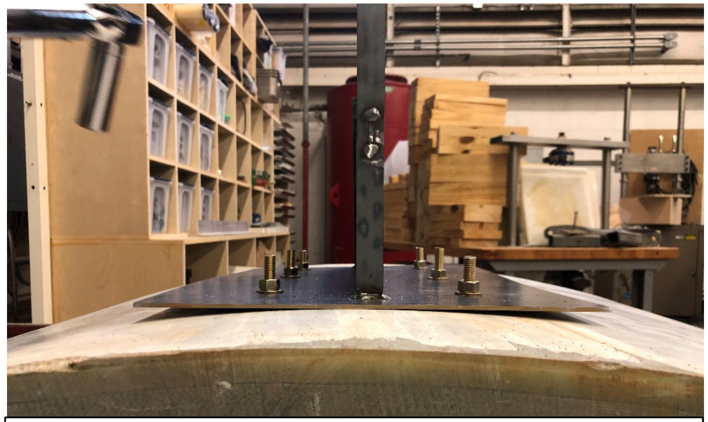
Full Size Connection Design and Testing





Universal Connector: Structural steel interface between the wind turbine blade and conventional off-the-shelf electrical transmission hardware.

Blind Bolting Technology

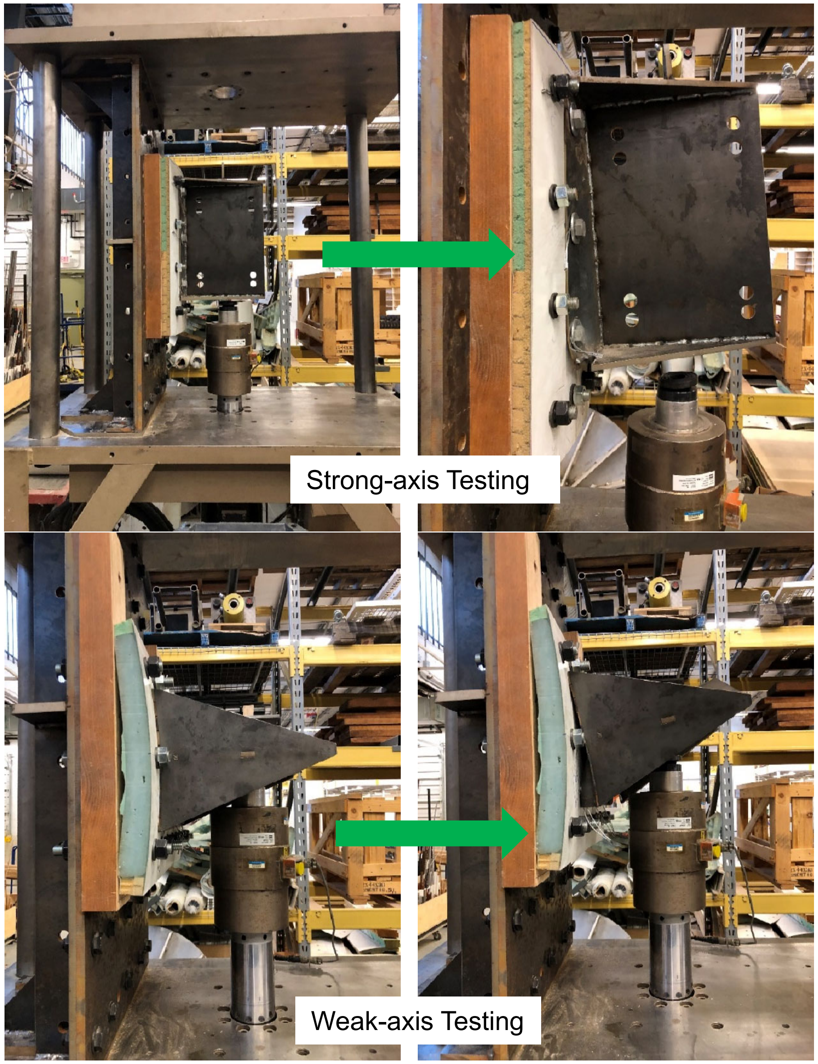


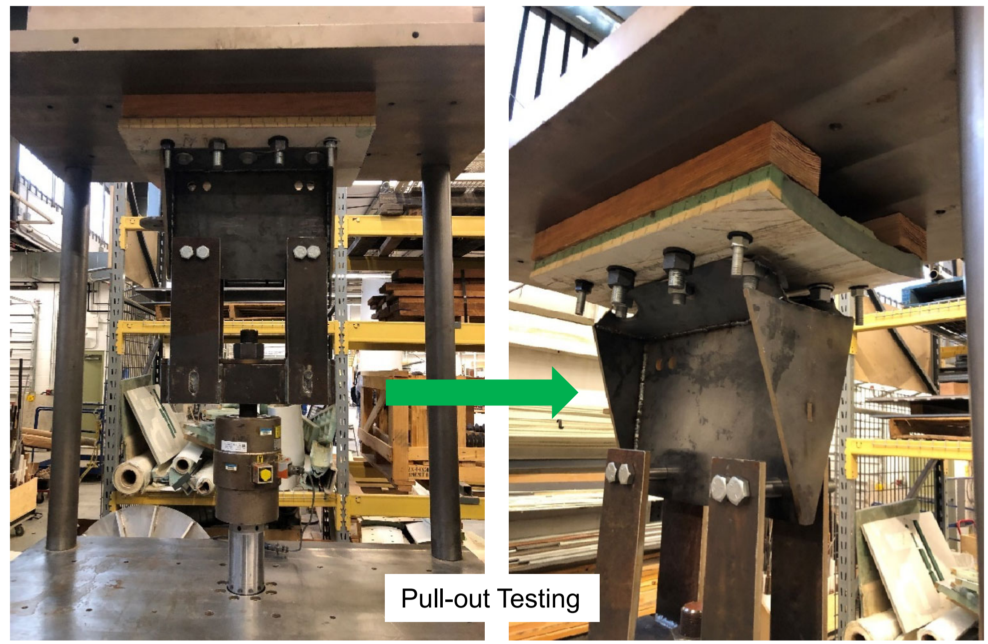
Stud-style anchors for hollow block and brick from McMaster-Carr

BlindBolts

RS BlindNut

2 Full-sized Connection Testing





2 Full-sized Connection Testing

Property	RS BlindNut Capacity (kN)	BlindBolt Capacity (kN)	Demand [a] (kN)	RS BlindNut Overcapacity [b] Factor	BlindBolt Overcapacity Factor
Major-Axis	227.2	260.0	22.2	10.2	11.7
Minor-Axis	99.90	101.0	23.2	4.31	4.35
Pull-Out	189.8	205.9	-	-	-

[a] The demand is calculated from structural analysis of the BladePole with a vertical load of 22.2 kN (5 kip) at the location where the conductors attach to the braced-line posts

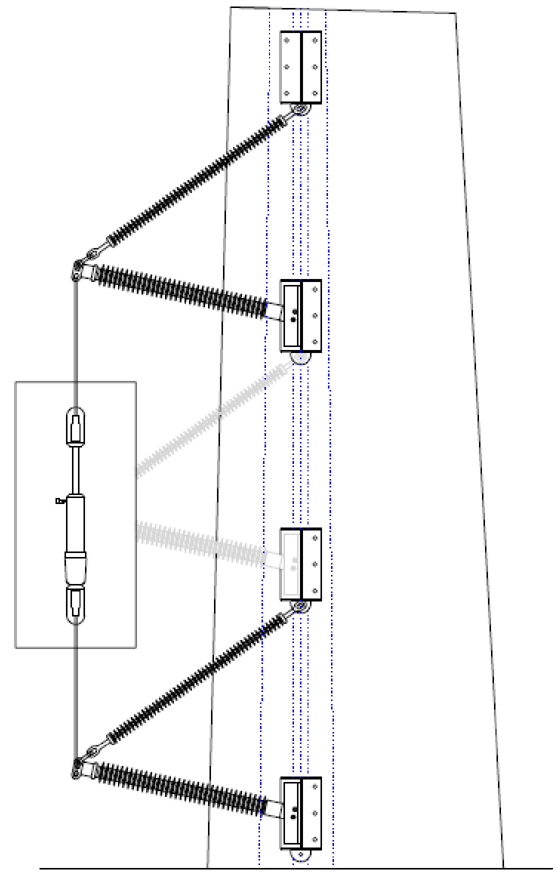
[b] The overcapacity factor is the CAPACITY divided by the DEMAND.

3 Power Transmission Pole Prototype Testing

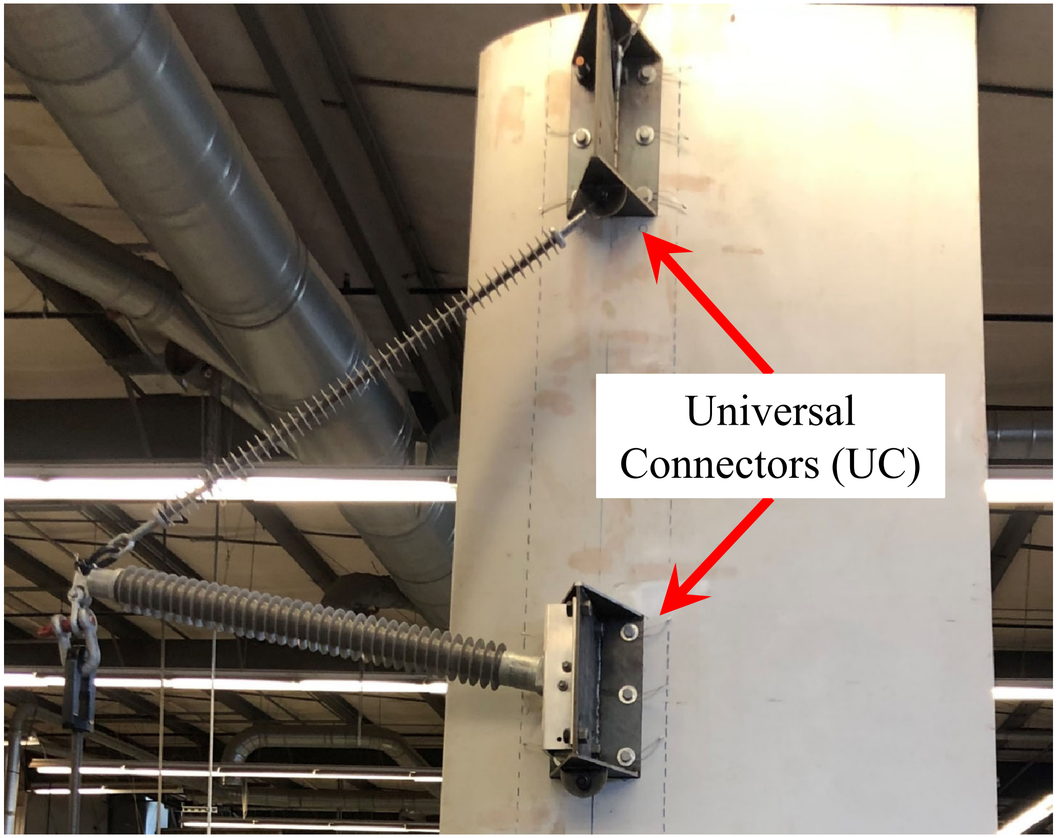
Prototype at DFL

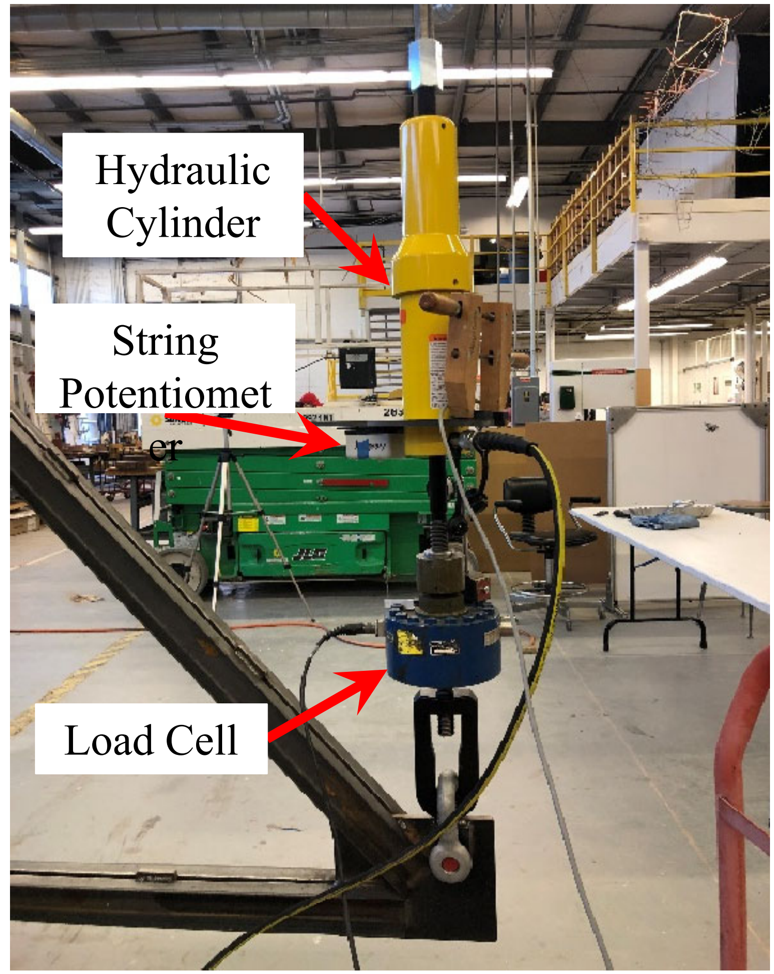
Planned Four-Pole Configuration Field Testing

3 Power Transmission Pole Prototype Testing



3 Power Transmission Pole Prototype Testing



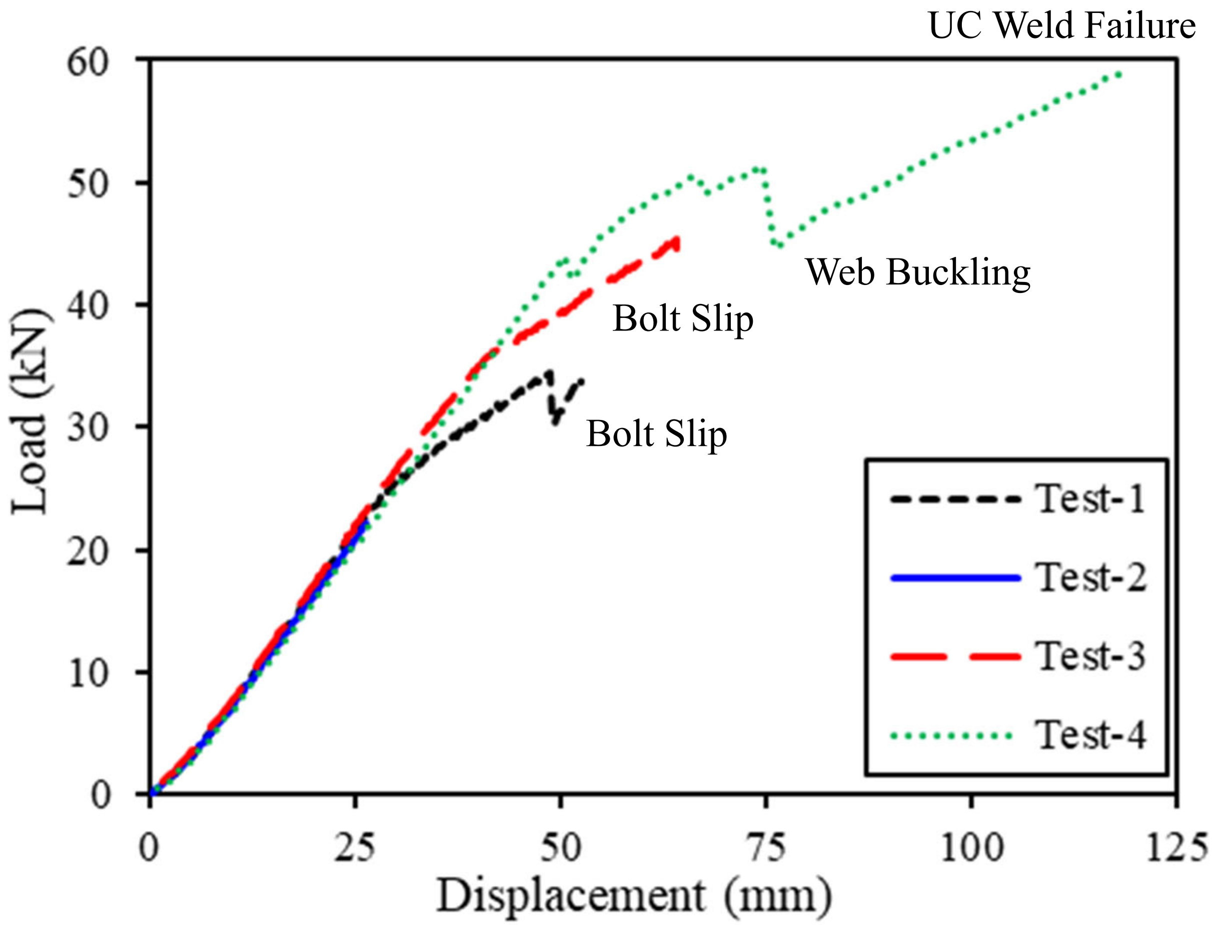


3 Power Transmission Pole Prototype Testing

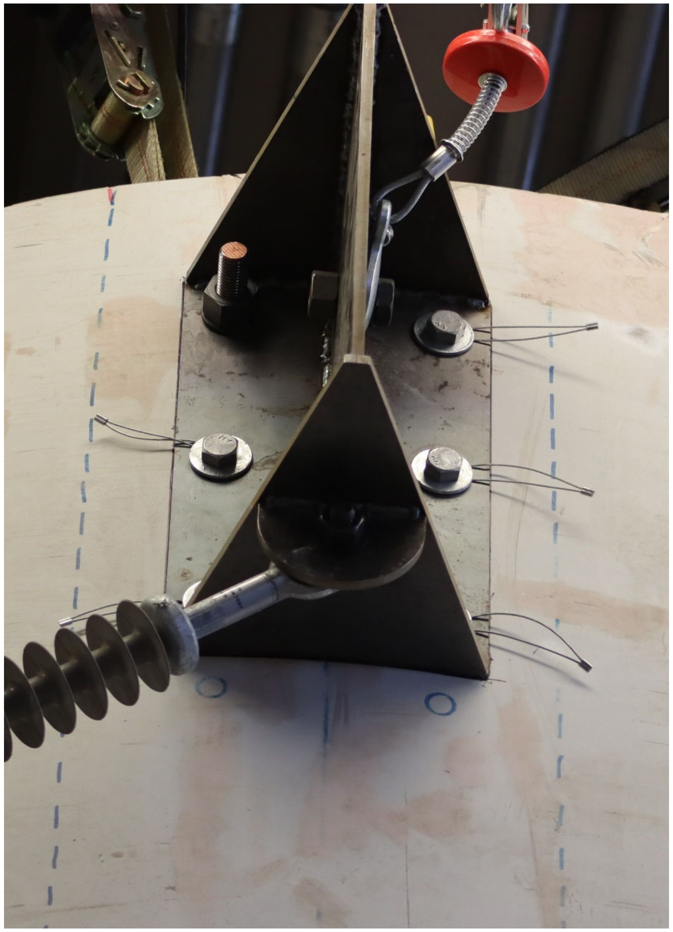
Loading Protocol:

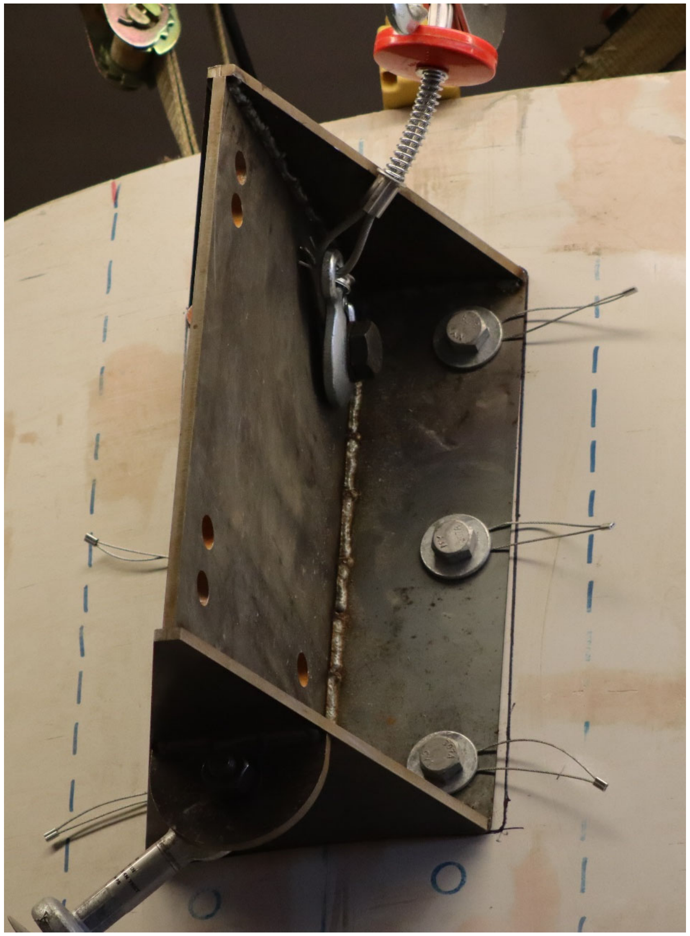
Different tests were performed at different load levels to observe the deflection and failure after each load level:

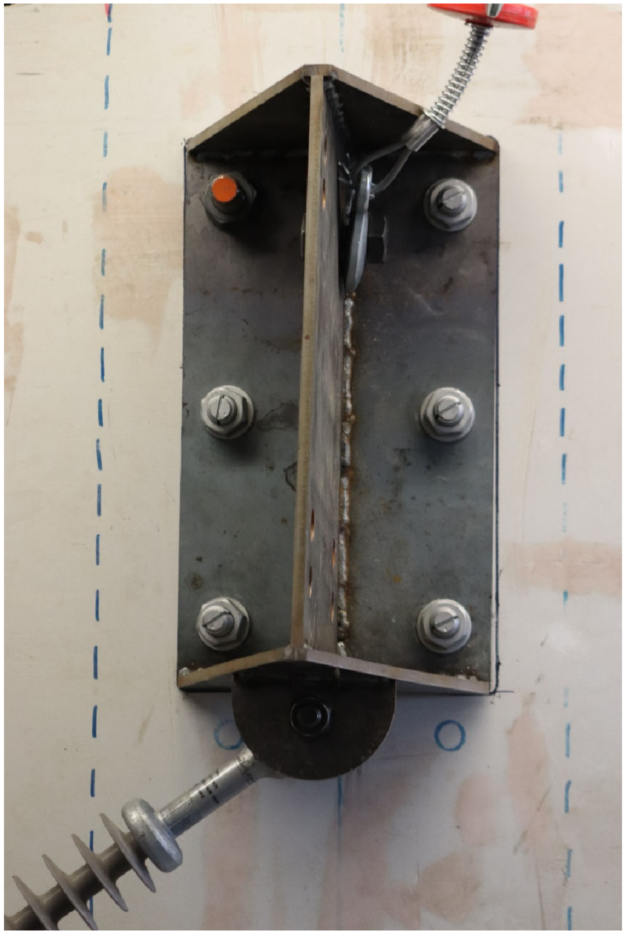
- Test-1 was loaded to 33.4 kN
- Test-2 was loaded to 22.2 kN
- Test-3 was loaded to 44.5 kN
- Test-4 was loaded to 57.8 kN (causing buckling in the shell material)



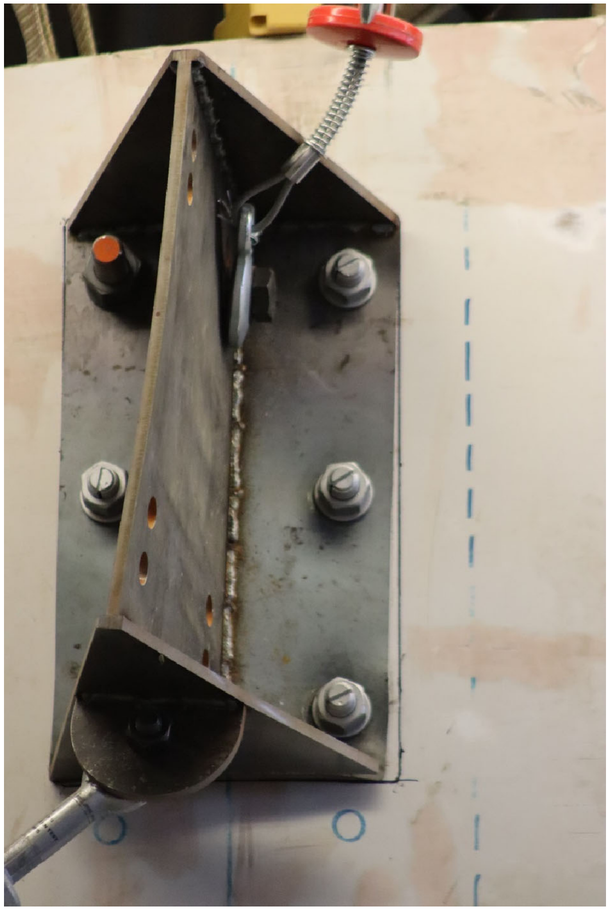
3 Blind Bolt Types Used for Upper UC


Upper Connection – Before Testing

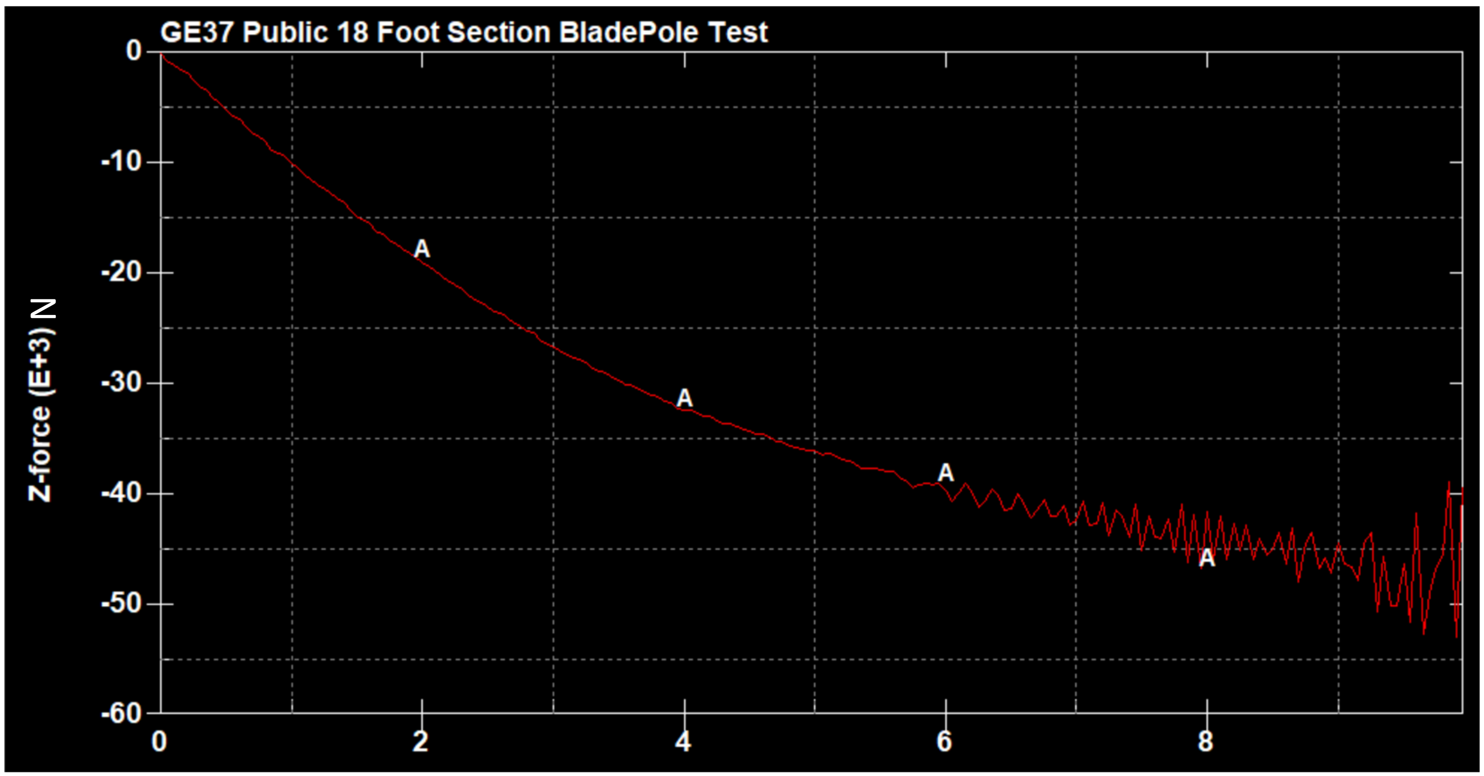

Upper Connection – RS

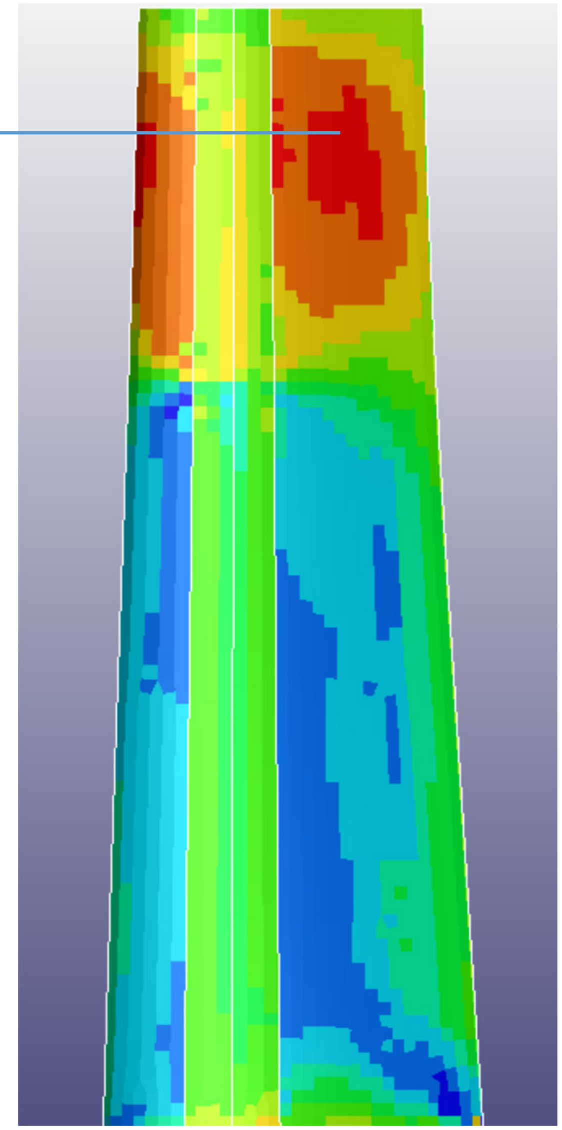

Upper Connection - BlindBolt

3 Testing – BENDING, WELD FRACTURE, and BUCKLING



4.5 Mpa in plane shear stress
[660 psi]





4 Conclusions

- Full-sized connections to the GE37 wind blade's spar cap are structurally safe with a minimum safety factor of 4.3 against bending of the UC and welding fracture which is preferred over GFRP crushing.

- The connections are recommended for the spar cap of the GE37 wind blade due to its central location with respect to the wind blade's cross section (reducing unnecessary eccentricity) and for being **solid** GFRP. Connections to the shell and the webs are not advised due to the sandwich nature of these parts which make them susceptible to crushing under bearing action of the blind bolts on the inside surface.

- The testing of the 5.5-m BladePole prototype revealed that shell shear-buckling near the top UC due to the horizontal couple generated between the upper UC and the one beneath it is critical and need to be addressed in the design process.

- Finite Element Analysis (FEA) is being conducted to predict the expected modes of failure in the BladePole model before field implementation. These modes of failure will vary depending on the load case being studied and its force-resultant on the wind blade's body.